HPGCL

HARYANA POWER GENERATION CORPORATION LIMITED

1X800 MW SUPER CRITICAL EXPANSION UNIT
DEEN BANDHU CHHOTU RAM THERMAL POWER PLANT
YAMUNA NAGAR, HARYANA

EPC PACKAGE TENDER SPECIFICATION

VOLUME - VI

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

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SELF-RELIANCE IN ENGINEERING

DESEIN

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CONTENTS : CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

CHAPTER – 1

CODES AND STANDARDS

Following is a general listing of Codes and Standards to be used in the design of the Plant. However, all other codes (not mentioned herein) with latest editions / revision and standards along with addendums / amendments, if any, shall also be followed:

1.1 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 Works.

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

1.2 EARTHWORK

a)	IS-1498	:	Classification and identification of soils for General Engineering purpose
b)	IS-3764	:	Safety code for excavation work
c)	IS:7293	:	Safety code for working with construction machinery

1.3 CONCRETE

IS-269	-	Ordinary and low heat Portland cement
IS-383	-	Coarse and fine aggregate from natural sources for concrete
IS-432	-	Mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
IS-455	-	Portland slag cement
IS-456	-	Code of practice for plain and reinforced concrete
IS-460	-	Test Sieves (all parts)
IS-516	-	Methods of test for strength of concrete
IS-1199	-	Methods of sampling and analysis of concrete
IS-1566	-	Hard drawn steel wire fabric for concrete reinforcement

IS-1786	-	High strength deformed steel bars and wires for concrete reinforcement
IS-1834	-	Hot applied sealing compounds for joints in concrete
IS-2386	-	Methods of test for aggregates for concrete (all parts)
IS:2502	-	Code of practice for bending and fixing of bars for concrete reinforcement
IS:3370	-	Code of practice for concrete structures for storage of liquids (all parts)
IS-3414	-	Code of practice for design and installation of joints in Buildings
IS-3935	-	Code of practice for composite construction
IS-4948	-	Welded steel wire fabrics for general use.
IS-5525	-	Recommendation for detailing of reinforced concrete works
IS-6452	-	High alumina cement for structural use
IS-7320	-	Concrete slump test apparatus
IS-7861	-	Code of practice for extreme weather concreting (all parts)
IS-8041	-	Rapid hardening Portland cement
IS-8112	-	High strength ordinary Portland cement
IS-10262	-	Recommended guidelines for concrete mix design
IS-11384	-	Code of Practice for composite construction in structural steel and concrete
IS-11504	-	Criteria for structural design of Reinforced concrete Natural Draft Cooling Tower
IS-11682	-	Criteria for design of RCC staging for overhead water tanks
IS-13920	-	Ductile detailing of RCC structure subjected to seismic loads
SP : 34	-	Handbook on concrete reinforcement and detailing
IS-216	-	Indian Standard Specification for Coal Tar Pitch
IS-226	-	Indian Standard Specification for Structural Steel [Standard quality]
IS-1139	-	Indian Standard Specification for Hot Rolled Mild Steel

		and Medium Tensile Steel and High Yield Strength Steel Deformed Bars for concrete Reinforcement
IS-1200	-	Indian Standard Specification for Method of measurement Cement Concrete Works. Part-II
IS-1200	-	Indian Standard Specification for Method of Measurement of Part-V Formwork.
IS-1609	-	Code of Practice for Laying Damp proof Treatment using Bitumen felts
IS-1791	-	Indian Standard Specification for Batch Type Concrete Mixers
IS-2210	-	Indian Standard Specification FOR Design of Reinforced Concrete Shell Structures and Folded Plates
IS : 2505	-	Indian Standard Specification for Concrete Vibrators, Immersion Type
IS: 2506	-	Indian Standard Specification for Screed Board Concrete Vibrators
IS : 2514	-	Indian Standard Specification for Concrete VibratingTables
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.
IS : 3025	-	Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water used in Industry
IS : 3201	-	Indian Standard Specification for Design and construction of Precast Concrete Trusses
IS : 3370	-	Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids
IS : 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 : 3590	-	Indian Standard Specification for Load Bearing Light Weight Concrete Blocks

IS : 3696	-	Safety Code for Scaffolding and Ladders
IS : 3812	-	Indian Standard Specification for Fly Ash for use as Admixture for Concrete.
IS : 4031	-	Indian Standard Specification for Method of Tests for Hydraulic Cement
IS : 4082	-	Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site.
IS : 4634	-	Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixes.
IS : 4656	-	Indian Standard Specification for Form Vibrators for Concrete
IS : 4925	-	Indian Standard Specification for Concrete Batching and Mixing Plant
IS : 4926	-	Indian Standard Specification for Ready Mixed Concrete
IS : 4990	-	Indian Standard Specification for Plywood for Concrete Shuttering work
IS : 4995 (Part-I&II)	-	Indian Standard Specification for Design of Reinforced Concrete Bins for the Storage of Granular and Powdery Materials
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 : 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 : 7969	-	Safety Code for Storage and Handling of Building Materials
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.

1.4 **FOUNDATIONS**

a)	IS-1904	:	Code of practice for structural safety of building - Shallow foundations
b)	IS-2950	:	Code of practice for design and construction of raft foundations
	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.
e)	IS-9716	:	Lateral dynamic load test on pile
f)	IS-6313 (Part-1 & Part-2)	:	Code of Practice for anti-termite measures and treatment.
g)	IS-1080		Code of Practice for design and construction of shallow foundations on soils (other than raft, ring and shell)
h)	IS-4091	:	Code of Practice for design and construction of foundations for transmission line towers and poles
i)	IS-8009	:	Code of Practice for calculation of settlement of foundations: (All parts).
j)	IS-9556	:	Code of Practice for design and construction of diaphragm walls
k)	IS-11089	:	Code of Practice for design and construction of ring foundation
l)	IS-13301	:	Guidelines for vibration isolation for machine foundations

1.5 **LOADING**

a)	IS-875	:	Code of practice for design loads for buildings and structures
b)	IRS	:	Bridge Rules of Government of India, Ministry of Railways (Railway Board)
c)	IS-1911	:	Schedule of unit weights of building materials

1.6 **MASONRY**

a)	IS-712	:	Building limes
b)	IS-1077	:	Common burnt clay building bricks
c)	IS-1127	:	Recommendations for dimensions and workmanship of natural building stones for masonry work.
d)	IS-1528	:	Methods of sampling and physical tests for refractory materials
e)	IS-1597	:	Code of practice for construction of stone masonry (all parts)
f)	IS-2212	:	Code of practice for brickwork
g)	IS-2116	:	Sand for masonry mortars
h)	IS-2185	:	Concrete masonry units. (all parts – Hollow and Solid concrete blocks)
i)	IS-2250	:	Code of practice for preparation and use of masonry mortars
j)	IS:2572	:	Code of practice for construction of hollow concrete block masonry
k)	IS-2691	:	Burnt clay facing bricks
l)	IS-3414	:	Code of practice for design and installation of joints in buildings
m)	IS-3495	:	Methods of tests of burnt clay building bricks
n)	IS-4441	:	Code of practice for use of silicate type chemical resistant mortars
o)	IS-4860	:	Acid resistant bricks
p)	IS-1905	:	Code of Practice for structural use of unreinforced masonry.

1.7 **DOORS, WINDOWS & VENTILATORS**

a)	IS-399	:	Classification of commercial timbers and their zonal distribution
b)	IS-883	:	Code of practice for design of structural timber in buildings
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

1.8 ROOF & 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 RC 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.
p)	IS-10440	:	Code of Practice for construction of reinforced brick and reinforced brick concrete floors and roofs

1.9 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 water proofed 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.

1.10 **SOIL ENGINEERING**

a)	IS-1498	:	Classification and identification of soils for general engineering purposes
b)	IS-1892	:	Code of practice for sub-structure investigation for foundations
c)	IS-2131	:	Method for standard penetration test for soils
d)	IS-2720	:	Methods of test for soils (all parts)

1.11 **WATER SUPPLY, DRAINAGE & 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 plasti9c cisterns
f)	IS-783	:	Code of practice for laying of concrete piles
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 potable water supplies
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	:	Pre-stressed 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 enameled 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 down pipes for roof drainage.

1.12 PAVING & ROAD WORKS

a)	IS-73	:	Paving bitumen
b)	IS-702	:	Industrial bitumen
c)	IS:1201 to 1220	:	Method of testing tar and bituminous materials.
d)	IRC-15	:	Standard Specification and code of practice for construction of concrete roads.
e)	IRC-58	:	Guidelines for the design of plain jointed rigid pavement for highways

1.13 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

1.14 CHIMNEY

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

1.15 NATUTAL DRAFT COOLING TOWER

a)	CTI	:	Cooling Tower Institute Publication
b)	BS-4485	:	Specification for Water Cooling Tower

1.16 STRUCTURAL STEEL WORK

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 and 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 for symbols for welding

f)	IS-814	:	Covered electrodes for manual metal arc welding for 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 iron work
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	:	Methods of 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	:	Hot rolled low, medium and high tensile Structural steel
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 test for wire-flux combinations for submerged arc welding of structural steel
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 submerged arc welding of structural steel
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 steel
pp)	AWS D.1.1	:	Structural welding code.
qq)	IS-8640	:	Recommendations for dimensional parameters for industrial building.
rr)	IS- 9178	:	Criteria for design of steel bins for storage of bulk material (all parts)
ss)	IS-12843	:	Tolerances for erection of steel structures.

1.17 **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) under-coating, (b) finishing.
j)	IS-5410	:	Specification for cement paint.

1.18 a) Indian Road Congress (IRC) Bridge codes

b) Indian Railways Standard Bridge Rules

1.19 **ENVIRONMENTAL PROTECTION**

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

1.20 CEA guide lines for Civil works for Power Plants of 500 MW and above shall also be followed.

1.21 **Additional code**

IS-269	Ordinary and low heat Portland cement
SP:6	Handbook for structural engineers (all parts)
SP:7	National Building Code of India
SP:16	Design Aids for reinforced concrete to IS:456-1978 SP:20 Handbook on masonry design and construction
SP:22	Explanatory handbook on codes for earthquake engineering (IS:1982-1975 and IS:4326-1976)
SP:24	Explanatory handbook on Indian Standard code of Practice for plain and reinforced concrete.
SP:25	Handbook on causes and prevention of cracks in buildings
SP:32	Handbook on functional requirements of industrial buildings.
SP:34	Handbook of concrete reinforcement and detailing (SCIP)
IRC:37	Guidelines for design of flexible pavements
IRC:73	Geometric design of roads Bridge rules of Government of India, Ministry of Railways (Railway Board)
BS:4485	Structural design of Cooling Towers (part 4)

CHAPTER – 2

SCOPE OF CIVIL & STRUCTURAL WORKS

2.1 This specification is to cover design, preparation of general arrangement, construction as well as fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis.

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

2.3 All materials including cement, reinforcement steel, structural steel etc. shall be arranged by the Contractor.

2.4 The scope shall also including setting up by the Contractor a complete testing laboratory in the field to carry out all relevant tests as per BIS or other international standards required for the civil works for the project.

2.5 The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the Owner / Consultant. For all building and structures, foundations, etc. necessary layout and details are to be developed by the Contractor keeping in view the statutory & functional requirements of the plant & facilities and providing enough space & access for operation, use & maintenance. Certain minimum requirements are indicated in this specification for guidance purpose only. However, the Contractor's offer shall cover the complete requirements of the plant & facilities and providing enough space & access for operation, use & maintenance. Also the Contractor's offer shall cover the complete requirements as per the best prevailing practices and to the complete satisfaction of the Purchaser.

2.6 Description of various items of work under this specification and nature of work in detail are given hereinafter, but not limited to the items listed below. The complete work under this scope is referred to as CIVIL WORKS. Tentative list of various civil works covered under the scope is given below:

1. Turbine building foundation including Turbo-generator foundation and superstructure including service and maintenance bays.
2. Switch Gear and Control Room including Compressor house and D.G. set room.
3. Steam Generator Elevator supporting structure.
4. Foundation for steam generator/SCR / ESP / duct supporting structure.
5. ESP control room.
6. Mill and bunker building including bunker structures & Mill Foundations.

7. Mill reject silo and foundations.

8. Foundations for various fans and foundation for fan handling systems.

9. RCC chimney height shall be calculated as guidelines indicated below (Whichever is higher) with single flue including corrosion protective lining on steel flue, elevator, electrical works, aviation lights etc.

   $H=14Q^{0.3}$ (where Q is SO_2 emission rate in kg/hour)
   OR
   $H=74Q^{0.27}$ (where Q is PM emission rate in Ton/hour)
   OR
   Minimum **150 M** height.

10. Natural Draught Cooling Tower and foundations.

11. Steel Trestles for supporting Ash slurry piping within plant area and dry fly ash transportation pipe rack up to silos near plant boundary.

12. Fly ash silos & foundation.

13. Ash slurry pump house, Ash water pump house, Conveying air blower House, Ash disposal pump house and clarifier.

14. Buffer hopper tower and collector tank tower structure & foundation.

15. Switch gear/MCC and control room for all buildings.

16. Cooling water (CW) pump house, sump including fore-bay.

17. Steel CW ducts from CW pump house to Turbine building, Turbine building to cooling tower including RCC thrust blocks. Intake RCC channel from cooling tower to CW pump house forebay.

18. A raw water pump house to be constructed in one compartment of existing Raw water reservoir to pump the make-up water through MS pipes to Water treatment plant.

19. Complete desilting of both compartments of existing Raw water reservoir inside plant boundary is in the scope of bidder.

20. DM Plant Building, acid/alkali (chemical) storage area with Rcc dyke wall, neutralization pit, and acid/alkali storage tank foundation.

21. Two (2) RCC clarifiers provided with one no. stilling chamber.

22. RCC Gravity filters.

23. Chemical house & chlorine Dioxide building.

24. CPU Generation building.

25. Filter water sump and sludge sump.

26. RCC central monitoring basin (CMB) and effluent disposal pump house.

27. RCC Neutralisation pit.

28. RCC coal settling ponds and tube settler.

29. LDO pump house, LDO transfer pump, LDO tank foundation and LDO pressuringsing pumps.

30. Fire water reservoir, fire water pump house.

31. Filter water reservoir and pump house.

32. Foundation of various water pumps.

33. Foundation / superstructure for wagon tippler, crusher house and pent house etc.

34. Transfer point, conveyor tunnel, conveyor galleries and stacker/reclaimer foundation / superstructure.

35. CHP control room, wagon tippler control room, pump house and MCC room.

36. Switchyard control building and complete civil work for 400/220 kV GIS switchyard, towers, ICT, interconnecting bays from existing switchyard to proposed switchyard.

37. Foundation for all power transformers in Transformer yard and other associated work including paving.

38. Rail track foundation for stacker/reclaimer.

39. Fill over well compacted subgrade for coal storage area as detailed in Ch 14 of this specification.

40. Flue gas disulfurisation system –Tanks and buildings, complete Lime handling system and Gypsum handling system. Foundations of day storage silo and its supporting structure.

41. Foundations for absorber, Absorber recirculation pump house, Duct support foundations, cooling tower etc.

42. Lime crusher house, lime transfer towers & gypsum transfer towers.

43. Lime stone storage day bins and ball mill building.

44. Ball mill foundation.

45. FGD Control room and MCC Building.

46. Gypsum dewatering building.

47. Transformer foundation including fencing and paving etc.

48. Pipe and cable trestles.

49. Gypsum conveyor trestle and galleries.

50. Lime crusher.

51. Lime stone conveyor and galleries.

52. Lime slurry aux. equipment shed.

53. Junction towers.

54. Exhaust flue gas duct structure and foundation.

55. Foundation for surface feeder and hoopers

56. Foundation for gypsum bleed pumps, Blowers and all other pumps and equipments.

57. 7 days storage capacity fully coverd gypsum storage shed and RCC approach road to gypsum storage shed.

58. 15 days storage capacity fully covered lime stone shed with associated RCC roads.

59. All tanks and pump foundations included in FGD system's scope and within FGD battery limit.

60. All facilities/Buildings required for DeNox system is included in the scope of bidder. Some of which are stated below:

    - Ammonia handling RCC control room and MCC Room.
    - SCR Reactor foundation.
    - Civil works for complete DeNox system.
    - Ammonia tank foundation
    - Foundation for ammonia pumps, vaporizers, accumulators, dilution tanks, recirculation pumps etc.
    - Ammonia storage with all associated foundations.
    - Waste Ammonia Dilution system for Boiler ammonia handling system as described below.
      Ammonia storage area sump with two no. of pump sump and motor including piping.Waste water collection sump pit capacity shall be sized to cater ammonia drain from dilution tank. Flooring/internal surface of pit/trench/dyke shall be suitable to handle aqueous ammonia. There should be provision to monitor pH lvl and provision for water dilution of any anticipated waste water/NH3 drain before pumping to ETP.
    - Structural steel compressor shed with suitable access road in Ammonia storage area.

61. Complete Site grading and leveling is in the scope of bidder. Finish ground level of entire plant area shall be RL (+)270.00 M FFL of all buildings shall be 270.50 M.

62. Roads and shoulders.

63. Rain water harvesting pond. The Pond shall be located at the lowest contour of the plant as far as feasible so that it can effectively collect all

the rain water by gravity. HDPE lining and side stream Boulder pitching is also in the scope of bidder.

64. Railway siding system and locomotive shed.

65. Proposed site is having trees all over the site. Cutting and removing the trees and clearing the site from all other obstruction is in the scope of bidder. Necessary permission to cut the trees from relevant department must be obtained by bidder himself at his own cost.

66. Auxiliary buildings

- Service building-3000m^2.(G+3)
- Air washer building.
- Dozer shed and repair shed separately for lime/gypsum and coal handling system as described in chapter 11.

All other civil items not covered above but required for completion and proper functioning of plant shall form part of bidder's scope.

67. Paving, trenches, tunnels, channels, duct banks etc.

68. Structural steel pipe rack and cable racks for pipes and cables for clarified water, D.M. Water, steam pipes, fuel oil pipes etc. with walkways.

69. RCC paving from power house to chimney including Boiler area.

70. RCC track connecting transformer yard to service bay in TG building including cross track in service bay.

71. Parking sheds for four wheelers and two wheelers – Size of shed shall be capable to accommodate minimum 50 No. of 4 wheelers and 2 wheelers each.

72. Security cum main gate complex.

73. RCC storm water drainage system for the entire plant.

74. Service water system pipelines.

75. Miscellaneous civil work and foundation like shed for outdoor pump etc.

76. Rain Water Harvesting should be implemented as per the scheme / design approved. Central ground water Authority / Board or State ground water authority or MoEF authorized agency shall be consulted for finalization of appropriate rain water harvesting technology. The necessary consultancy charges for the above agency for preparing rain water Harvesting method / scheme for the project to be borne by the Bidder.

77. Clearing and removing the buried items if any in the whole proposed plant area and the same is to be deposited to the Client. Any infrastructure buried underground shall be demented/relocated by bidder without any additional cost.

78. The contractor has to fill or excavate the areas to the required formation levels as indicated in the plot plan.

79. Site illumination work including lighting towers shall be provided in Coal yard area, Switchyard area including all other plant areas.

80. Road Weigh Bridge and Control Room- Total 2 nos. One in Fly ash silo area, One in lime/gypsum storage/ proposed store area.

    These shall be RCC framed structure with RCC roof and brick cladding. Adequate windows shall be provided for ventilation & lighting. Roof shall be given liquid membrane water proofing treatment. Flush welded steel doors shall be provided for personnel movement. Toilet facilities shall be provided.

81. All underground structures such as basement, sump and water retaining structures etc.
82. All civil work releated to installation of solar plant within existing/new plant boundary as mentioned in other Vol. of technical specification.

83. RCC sump for collecting boiler blow down and ESP area floor washing **for existing Units # - 1 & 2 and ash silo area washing** is also covered under the scope of bidder and shall be pumped to proposed Ash Handling clarifier.

84. Permanent store of 6000 sqm area shall be provided by the bidder. Out of this 3000 sqm shall be covered building.

85. **The Work also includes:**

(i.) Site surveying.

(ii.) Soil investigation and preparation of soil investigation report and suggestion of type of foundations including design of piles.

(iii.) Implementation of ground improvement and post improvement evaluation of sub surface properties if required.

(iv.) Preparation of Architectural drawings.

(v.) Design, preparation of drawings and construction of all structures.

(vi.) Preparation of as built drawings of all structures and facilities to reflect as built status of construction.

(vii.) Submission of as built drawings in AutoCAD in CDs.

(viii.) Plumbing & sanitary works.

(ix.) Painting.

(x.) Anti-termite and anti-weed treatment in all areas / buildings as per IS: 6313.

(xi.) All temporary roads and approach roads necessary for construction purpose shall be of WBM for a minimum width of 4m.

(xii.) All permanent roads as stipulated in this specification.

(xiii.) Green belt development

(xiv.) Internal/External compound wall is in the scope of bidder.

Successful bidder to erect a temporary curtain wall of approximately 10 M high using structural steel members and sheet to isolate proposed construction site from existing plant. Length of curtain wall is approximately 400m. Although exact length to be verified by bidder during site visit before bidding.

All existing roads of the plants to be used by successful bidder for transportation of material during construction period shall be rebuild after finish of construction activities at site.

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

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

All works shall conform to the specification. The works shall conform to high standards of design, engineering and workmanship. Design and construction shall conform in every respect to all local and state regulations governing such works and to stipulations of Indian Standards unless stipulated otherwise in detail specification.

2.7 Protection and security

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

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

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

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

CHAPTER – 3

INSTRUCTION TO BIDDERS

3.1 DATA TO BE FURNISHED BY BIDDER AT THE TIME OF BID

3.1.1 A write-up on survey to be undertaken indicating grid, intervals for taking spot levels, contour intervals, precision of surveying instruments proposed to be used, drawings that will be prepared, details to be covered by survey etc.

3.1.2 Detail general arrangements / architectural drawings of all buildings and structures showing dimensions, levels, plans, sections, elevations, loadings, materials proposed, types of framings, wall / cladding, floors, roofs, types of finishes etc. This can be provided at the time of detailed engineering.

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

3.1.4 A write-up with drawings on layout of cooling water (CW) system indicating sizes and design loads for CW conduits, seal pit, channels and proposed method of construction etc.

3.1.5 Size, concrete grade and other design parameters and construction details etc. for 275m high RCC chimney with steel single flue. The top most flue can shall be of stainless steel.

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

3.1.7 All deviations from bid document shall be furnished by the Bidder.

3.1.8 List of equipment to be deployed and rates of labour assumed by the bidder and by other sub-contractors to be associated with him is to be furnished.

3.1.9 List of softwares proposed to be used against various areas, for analysis, design, construction etc. their source & along with validation report for the softwares.

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

a) A Level-1 pert chart showing the starting and completion date of all civil construction activities.

b) A Level-2 pert chart showing the time required for preparation of design criteria, for approval of design criteria by Owner, time required for detailed design and drawing preparation and time required for approval of design and drawing by Owner. This part shall taken into account the construction schedule (Level – 1 part).

c) A Level-3 network for all civil works shall be submitted to Owner for monitoring of progress of works at site.

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

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

a) Slump cone apparatus to measure slump.

b) Concrete cube testing machine with adequate number of moulds of (15cmx15cmx15cm) to measure compressive strength of concrete.

c) Vicat apparatus to find initial and final setting time of cement.

d) IS sieves with vibrating machine to determine fineness modulus of coarse and fine aggregate.

e) Abrasion & impact testing equipment for testing coarse aggregate and apparatus to determine flakiness index of aggregates.

f) Complete apparatus for the test of air content of concrete by pressure method as per IS:1199.

g) Density bottle to determine sand bulkage.

h) pH meter for testing pH value of water

i) Thermometer for checking temperature

j) Apparatus for measuring proctor density, water content of compacted soil determining CBR values.

k) All apparatus for determining dry density and water content of sand/soil and aggregates. Any other equipment felt appropriate by the Owner for measurement of paint thickness, testing of structural members, welding etc. The testing machines shall be recalibrated periodically and as directed by Owner/manufactuer / consultant to detect errors. The moulds for cubes shall be checked frequently and made to conform to specifications contained in IS-516.

l) Bidder to submit a report on foundation proposed for various structures, buildings and facilities based on the data available with the OWNER and further data collected by the BIDDER. Allowable safe bearing capacity for open foundation, depth of foundation, need for pile foundations, type ,length and capacity of piles in case piling is required, soil improvement if any required, special precaution against aggressive soil etc shall also be covered in the report.

m) A detailed note on quality plan both for design and construction activity proposed to be adopted for assuring quality of civil and works to be furnished.

n) Any exclusions from the scope mentioned and implied in these specifications, shall be clearly mentioned by the Bidder separately in a section titled “EXCLUSIONS”. All works, other than these, deemed to be in the scope of this contract and shall be executed by the Bidder at no extra cost to the Owner

3.2 **INSPECTION OF SITE BY BIDDER**

3.2.1 Bidder shall inspect the site, examine and obtain all information required and satisfy himself regarding matters and things such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local labour, materials and their rates, local working conditions, weather, sub-soil conditions, natural drainage etc. All required dismantling /recconstrction including strengthening if required/re-erection of existing facilities is under bidder’s scope. No extra claim on any account shall be entertained by owner. Ignorance of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time.

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

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

3.2.3 Proof checking of structural design of following structures shall be got from SERC Chennai or IIT Roorkee by the Contractor at his own cost.

(a) Design of TG Foundation including Non Destructive Testing of TG column and Deck slab after condstruction.

(b) Chimney profile laser testing and Non Destructive testing of Concrete Wind Shell.
Wind Tunnel test for RCC Chimney to be carried out by IIT-KANPUR/SERC Chennai. All the cost of wind tunnel test including travelling expenses to be borne by contractor.

3.3 **CONSTRUCTION TOOLS & MATERIALS SUPPLIED BY CONTRACTOR**

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

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

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

3.3.4 The contractor shall ensure continuous supply of coarse and fine aggregate conforming to the specification for the duration of the contract period and extended period, if any. Adequate stocks are to be ensured before the onset of monsoon, because the approaches to the quarries becomes difficult during monsoon.

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

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

3.3.7 The Owner reserves the right to test any construction material supplied by the Contractor in an established testing laboratory at Contractor's cost.

The Owner reserves the right to instruct the Contractor to remove all materials, which do not meet the specification requirements.

3.4 **WORK EXECUTION AND SUPERVISION**

3.4.1 Contractor shall have at the site accredited and qualified engineers and foremen / supervisors with adequate number of years of experience in execution of similar works and also operators of machinery and equipment, for satisfactory progress and timely completion of the work.

3.4.2 Contractor's Engineer-in-charge of the work at site shall be capable of interpreting the specification and drawings and make adequate site decisions as and when required. He shall also take instructions from the Owner and be responsible for carrying out the instructions.

3.4.3 Contractor shall be fully responsible for the correctness and accuracy of the tests performed, results obtained / tabulated, interpretation of test results and recommendations made. The work shall be executed in a professional manner, with fully understanding of the importance of work for a project of this magnitude.

3.4.4 In the event of occurrence of any accidents at / near the site of the work or in connection with execution of the work, a report shall be made immediately to the Owner, giving full details of the accidents. He shall also report such accidents to all the competent authorities wherever such reports are required by them.

3.4.5 All temporary electrical installation shall be supervised by a qualified electrical supervisor of the Contractor.

3.4.6 Owner reserves the right to order in writing, from time to time, during the progress of the work, removal and re-execution of any work which in the opinion of the Owner, is not in accordance with the specification.

3.4.7 During inclement weather, rains etc. contractor shall suspend all works for such time as the Owner may direct and shall protect from damage all works already in progress or completed just then. All such temporary protective measures shall be at contractor's cost and any damage to works shall be made good by the contractor at his own expense.

3.4.8 Should the work be suspended by reasons of strikes / riots by Contractor's own employees or any other causes whatsoever save and except the force majeure condition, Contractor shall take all precautions necessary for the protection of works and make good, at his own expenses, any damage arising from any of these causes.

3.4.9 During the course of contractor's works, other works either by the Owner or by the Contractors or by both simultaneously will be in progress within the project area. Contractor shall make his best effort to work in harmony with others in the best overall interest of the project and towards its speedy completion.

3.4.10 The Contractor shall be responsible for maintaining cleanliness of the site. The site shall be free of unwanted rubbish or filth, which is hazardous & detrimental to health, and affect safety of the work place.

3.4.11 All material supplied shall conform to the specification. Entry of unwanted materials shall be prohibited.

CHAPTER – 4

SUBMISSIONS

The following documents are to be submitted for the approval of the OWNER / CONSULTANT prior to commencement of fabrication & erection / construction. All drawings shall be of standard sizes (metric system) and shall be made on AUTOCAD. Software used for design shall be validated and established ones like STAAD Pro, NISA, ANSYS AND ETAB. Hard and soft copies of the drawings / document to be furnished to the OWNER/CONSULTANT. The list is not exhaustive but indicative only.

1) The analysis of TG building, Mill building, ESP control room, Chlorination building, Switchyard control building, CW pump house, Raw water pump house, Ash water pump houses and Service building are to be done by developing 3D mathematical model adopting response spectra method of analysis as per IS: 1893, in addition to wind load analysis as per IS: 875 Part-3.

2) Preparation of design drawings with maximum detailing possible and developing all possible connection/joint details for all the buildings within the scope of civil / structural works.

3) General plant layout drawing with coordinates of roads, boundary wall, building and facilities, piping /cable corridors, pipe and cable trestles, provision of landscaping and green belt development, diversion roads and drains, equipment lay down areas etc.

4) Drawing showing underground facilities with coordinates like buried pipes, buried cables, trenches, ducts, sewer, drains, sumps pits, culverts, foundations etc.

5) Soil investigation report based on additional geo-technical investigation carried out by CONTRACTOR along with foundation recommendation for various buildings / structures / facilities.

6) Site Grading and storm water drainage study furnishing levels of various terraces arrangement and details of drains, culverts etc for storm water drainage system.

7) Study note on disposal of sewage and other effluent from the plant to satisfy the statutory requirement.

8) Design basis memorandum for all buildings, facilities, services and structures.

9) Drawing showing loading data at various levels for all buildings and structures.

10) Architectural floor plans, elevations, cross sections and perspective view in colour of all buildings. For main plant building CONTRACTOR shall submit two different schemes along with a report elaborating the underlying philosophy of the proposed architectural concepts.

11) Design calculations and drawings for foundations / substructure and superstructure of all buildings including Turbo generator building, mill & bunker building, control & electrical building, service building, pump houses and other structures.

12) Design calculations including dynamic analysis and drawings for all foundations subjected to dynamic loads like foundations for TG, BFP, Mill, Fans (PA, FD, ID), Crushers etc. Design and drawing of vibration isolation system shall also be furnished in case such system is included along with supply of equipment.

13) Design calculations and drawings for all facilities and services like roads, culverts, bridges, pavings, road / rail crossings, drainage pump house (if required), drains, sewers, sewage pump house, sewage treatment plant, water supply, water tank, sumps, tunnels, trenches, ducts etc.

14) Drawings of all architectural works including claddings, partitions finish schedule, colour scheme (both internal and external), doors and windows, flooring and false ceiling, etc.

15) Design calculations and drawings for plumbing and building drainage and execution for entire plant.

16) Design calculations and drawings for structures & foundations in switchyard, transformer yard, etc.

17) Design calculations and drawings for structures pertaining to condenser Cooling water system.

18) Design calculations and drawings for civil structures / works associated with fuel oil handling system, ash handling system, coal handling system, Ash disposal system, etc.

19) All other designs, details / drawings or any other submissions as indicated elsewhere in this specification and as required by the Owner/CONSULTANT.

20) Details of corrosion protection measures for all structures and their foundations.

21) Total quantity of concrete (grade wise), reinforcement steel (diameter wise) and structural steel (section wise) shall be indicated in all construction drawings.

22) All design and drawings for the Cooling towers.

23) All design and drawings for RCC single flue chimney. **Contractor shall submit all design calculation in Excel/Editable format in addition to PDF copy. In case Chimney has been designed using In-House programme/Software, same shall also be submitted in editable format for review/verification purpose.**

24) All design calculations and drawings for foundation of Boiler and ESP area structures.

25) Shop fabrication drawings of all structural steel work along with design calculations

26) Construction and erection procedure for all major structure with specific reference to main plant building, bunker structures, transfer towers, conveyor galleries, TG foundation and other machine foundations.

27) Write up on various statutory requirements and their compliance for various buildings and facilities.

28) Quality assurance and Quality Control procedures as per attached guide lines. (Refer Vol-II of specification)

29) Copies of all reports on investigation and studies carried out by the CONTRACTOR as per the scope.

30) Soft copies of all design calculation and drawings shall be submitted for records after approval of the OWNER/CONSULTANT.

31) Topographical survey drawings along with location and details of Bench mark, grid and boundary pillars based on detailed survey conducted after the award of work.

32) Write up on proposed sewage disposal system for the toilet in various buildings and scheme for usage/ disposal of the clear water.

33) Write up on proposed treatment and disposal of effluent/waste water generated in the plant and scheme for usage/disposal of clear water.

34) Design calculations and drawings for structures for raw water/make up water system such as, but not limited to, intake, raw water reservoir, pump house, over head tank etc.

35) A write up on dewatering system proposed at the time of construction where deep underground construction such as for Wagon tippler pit, Conveyor tunnels, underground Transfer House, C.W. fore bay and pump house etc. are to be executed. Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be considered. The write up shall include design calculations, drawings and shall be based on IS: 3764 and/or standard book. The cost of dewatering to be borne by CONTRACTOR.

36) Design calculation and fabrication drawing of important structures, such as TG building main framing, bunker building main framing, coal bunkers, crane girders, typical gallery, typical trestle and typical Junction tower for CHP or any other structure specifically called for by OWNER.

37) As Built Drawings: "As-built" drawings shall be prepared by the CONTRACTOR after completion of construction / erection incorporating

all the changes, if any, done on Engineer's instruction/approval. After completion of construction, Contractor shall submit four (4) copies of the all drawings, irrespective of any changes during construction, marked “As Built” with one soft copy in CD each to the Owner. Two (2) copies of:"As-built" drawings A3 size in bound form shall also be submitted.

CHAPTER – 5

GEO-TECHNICAL INVESTIGATION

5.1 Soil investigation report of the existing 2 x 300 MW (Units 1 & 2) adjacent to the proposed site is attached as a reference for the bidders.

The information furnish in geotechnical report is only for the guidance of the bidders. Owner does not take any responsibility for the correctness and interpretation of the result. Any variation of the said information shall not constitute a valid reason in affecting the terms and condition of the bid. The bidder shall fully satisfy himself about the nature of soil expected to be encountered, including the type of foundation, bearing capacity, sub-soil water etc. prior to the submission of his bid.

5.2 As per the attached geotechnical report, It is advised to provide **Pile foundation for boiler foundation, chimney foundation, cooling tower, main plant building structures,TG foundation, mill building foundation, mill foundation, conveyor gallery trestle (of height more than 25m) foundation, junction tower foundation, crusher house foundation, fly ash silo foundation including all other major structures in FGD and other areas. For conveyor gallery (of height less than or equal to 25m) foundation, type of foundation (pile/open foundation) shall be decided based on findings of final geotechnical report.** For ESP and stacker reclaimer foundation if open foundation is feasible as per Approved Geotechnical report, bearing capacity corresponding to 25mm settlement of foundation shall be considered.

5.3 The bidder shall carry out detailed geo-technical investigation in all work areas under bidder's scope for establishing the sub-strata conditions and to decide the type of foundation for the structures envisaged, construction methods, any special requirements/treatment called for/remedial measures for sub soil/foundations etc prior to the commencement of detailed design/drawings. The bidder shall obtain approval of the agency for conducting geo-technical investigation work, field and laboratory testing, schedule proposed by the bidder etc from Owner before undertaking the geo-technical investigation work.

<u>Scheme of Soil Investigation</u>

a) The diameter of borehole shall be minimum 150 mm in soil and 76 mm in rock. The minimum diameter of undisturbed soil sample shall be 90 mm. Drilling in rock shall be done by means of hydraulically operated rig only.

b) Field investigation shall be done in detail. At least 4 boreholes at each structure/building location like TG bay, Boiler house, ESP, A-row, B-row, C&D - row columns, minimum 5 nos each in Switchyard Area, Transformer yard area and fuel oil handling area, minimum 3 nos each in Chimney area and Ash silos area and minimum 2 nos each at all other building/area other than those mentioned above, at least 1 borehole at every 400 m c/c along pipe corridors, ash water re-circulation pipe corridor and one borehole at each pair of ID, FD and PA fan locations and one bore hole at each TP, Pressure meter test in boreholes at TG, Boiler and ESP locations, minimum 10 nos Electrical resistivity test covering

Main plant etc shall be carried out. One borehole shall be carried out at every crossing and bends. Minimum one no cyclic plate load test or seismic refraction test shall be carried out each in TG area, mills area and Bunker Area. Building/structures not mentioned above should also be covered with appropriate test under geo-technical investigation scheme. Adequate number of tests shall be conducted up to sufficient depth for complete determination of sub-strata conditions as approved by the Owner before the execution of work. The depth of boreholes in main plant area shall generally be atleast 20-25 m or 5m in rock with RQD> 50%. Depth of borehole shall be atleast 5 m along pipe corridor and 20m at crossing location.

c) Sufficient number of soil, rock and water samples for conducting laboratory tests shall be collected during field investigation as approved Owner. The laboratory tests shall include but not be limited to the following. Soil samples shall be tested for Grain Size Analysis, Hydrometer Analysis, Atterberg's Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity, Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free swell index, Shrinkage limit, Swell Pressure Test, Chemical Analysis etc. Chemical analysis on soil and water samples shall include determination of carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and substructures. Laboratory tests on rock samples shall be carried out for hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (both at saturated & in-situ water content), slake durability etc.

Standard penetration test (SPT) and collection of undisturbed soil samples (UDS) shall be carried out alternatively at 1.0m intervals and at significant change of strata. The interval shall be increased to 1.5m below 5m depth of boring. UDS shall be replaced by SPT in cohesion less strata. Even in highly weathered / disintegrated rock, where core recovery is poor, SPT shall be conducted. The first SPT in any borehole shall be conducted at 1m depth. **Incase, rock is met at the proposed founding level, bore hole shall be extended up to 10m depth in the rock**

d) Geo-technical Investigation shall be carried out in accordance with the provisions of relevant Indian Standards (latest).

e) On completion of all field and laboratory work, the bidder shall submit a geo-technical investigation report for Owner's approval. The geo-technical investigation report shall contain geological information of the region, procedure adopted for investigation, field & laboratory observations/data/records, analysis of results and recommendation on type of foundation for different type of structures envisaged for all areas of work.

f) Generally, the geo-technical investigation report shall include but not be limited to the following.

i) Plot plan showing the location (coordinates) and reduced level of all field tests.
ii) Geological information of the area.
iii) A true cross section of all individual boreholes and trial pits with reduced level and coordinates showing the classification and

thickness of individual stratum, position of ground water table, different depths etc.

iv) A set of longitudinal and transverse soil/rock profiles connecting various bore holes.

v) Plots of standard penetration test with depths.

vi) Results of all laboratory tests summarized

- For each borehole along with a consolidated table giving the layer wise soil and rock properties. All relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores and trial pits shall be furnished.

vii) For pressure meter tests, the following shall be furnished.

- Field pressure meter, creep and air calibration curves indicating Po, Pf and PI.
- Corrected pressure meter and creep curves indicating Po, Pf and PI along with sample calculation for the corrections.
- Interpretation of values of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of sub-grade reaction along with sample calculations. Calculation for allowable bearing pressure and corresponding total settlement for shallow foundations and load capacity calculation for piles under various modes.

viii) Electrical resistivity of subsoil based on electrical resistivity tests including electrode spacing Vs cumulative resistivity curves.

ix) Suitability of the sub soil for construction of roads/embankments & their stable slopes for embankment and shallow/deep excavations, value of earth pressure coefficient for active/passive/at rest conditions and modulus of elasticity as a function of depth for the design of under ground structures.

x) Suitability of locally available soils at site for filling and back filling purposes.

xi) If expansive soil is met with, then recommendation for removal or retainment of the same under structures/roads etc shall be given. In the later case detailed specification of any special treatment required including specification for materials to be used, construction methods, equipments to be deployed etc shall be furnished.

xii) Protective measures based on chemical nature of sub-soil and ground water with due regard to potential deleterious effects on concrete, steel and other building materials etc. Remedial measures against sulphate attack, chloride attack and acidity shall be dealt in detail. Susceptibility of soil to termite action and remedial measures for the same shall be indicated.

xiii) Susceptibility of sub soil strata to liquefaction in the event of earthquake. If so, recommendation for remedial measures.Identification of any other potential geo-technical problems and their remedial measures.

xiv) Description of measures required for erosion control.

g) Identification of corrective measures required for the improvement of sub-surface conditions such as removal of poor sub soil/material, in-situ densification etc. If ground improvement is recommended then its detailed specification, specification for materials to be used, construction methodology, equipments to be deployed etc shall be furnished.

h) Recommendation on type of foundation to be adopted for various structures duly considering the sub-strata characteristics, water table, permissible total/differential settlement for various structures and equipments, minimum depth and width of foundation etc.

i) For shallow foundations, the following shall be indicated with comprehensive supporting calculations.

j) Net safe allowable bearing pressure for isolated square footings and continuous strip footings of sizes 2.0, 4.0 and 6.0m at different founding depths of 1.0, 2.0, 7.0, 4.0 and 5.0m below ground level considering both shear failure and settlement criteria giving reasons for the type of shear failure adopted in the calculation.

k) Net safe allowable bearing pressure for raft foundations of widths greater than 6 m at 3.0, 4.0, 5.0 and 6.0m depths below ground level considering both shear failure and settlement criteria.

l) If piling is envisaged, then the following shall be furnished with comprehensive supporting calculations.

Type of pile and reasons for recommending the same duly considering the sub-strata characteristics.

m) Design of piles in terms of safe capacity, length, diameter termination criteria etc.

n) Dynamic properties such as dynamic shear modulus, Poisson's ratio, co-efficient of elastic uniform compression etc of the substrata at various depths to be used for design of machine foundations.

o) Modulas of sub grade reaction and modulas of elasticity of the substrata from plate load test results..

5.4 Following field tests shall be conducted:

- Bore holes and standard penetration tests
- Static plate load tests
- -Cyclic plate load test
- -Cross hole shear velocity test
- -Field permeability tests
- -Field density tests

- -Vane shear tests
- -Static cone and dynamic cone penetration tests
- -Electric resistivity tests
- -Pressure meter tests
- -Percolation test
- -California bearing ratio tests
- Block Vibration test
- Standard penetration tests (SPT)
- Trial pits
- Collection of disturbed and undisturbed soil samples.
- Seismic refraction test
- Collection of water samples.

5.5 Bore holes shall be located to cover the entire area. All bore holes shall be sunk up to a depth of 20.0 to 40.0 m as indicated in table bellow.

S. No	FACILITY		MINIMUM NO. OF BORE HOLES (INDICATIVE)	DEPTH IN 'M' (INDICATIVE)
1	TG HALL		1	40
2		A - ROW	2	40
3		B - ROW	2	40
4		C-ROW	2	40
5	TRANSFORMER YARD		6	40
6	BOILER, PA/FD FANS		6	40
7	MILLS		4	40
8	ESP AND ESP CONT. ROOM		3	2*30+1*40
9	ID FANS		2	30
10	CHIMNEY		2	40
11	AWPH,ASPH		1	30
12	COOLING TOWER		2	40
13	CWPH,CW PIPES, DM PLANTS		3	30
14	SWITCH YARD, CONTROL BUILDING		2	30
15	CHP (WAGON TIPPLER TPs, CONVEYORS ETC.)		10	2*40+8*30
16	PWS		4	20
17	RAW WATER RESERVOIR		2	20
18	AWR FACILITIES AND ASH DYKE		1	30
19	FO TANKS, FOPH, ETP		3	20
20	ASH SILOS		1	30
21	ASH PIPE RACK		8	4*20+4*30
22	COMPRESSOR HOUSE & DG BUILDING		1	30
23	SERVICE BUILDING		1	30

5.6 Dynamic Cone Penetration Test (DCPT)

The test equipment and procedure shall meet the requirement of IS: 4968 (Part II). The driving shall not be done for more than 30 cm at a time after which it shall be stopped for a minute or two. The tests shall be terminated when the blow counts exceed 35 for 100 mm. penetration when the cone is dry and 20 for 100 mm. penetration when the cone is penetrated by circulating slurry.

The results shall be reported in a suitable tabular form giving below counts for every 30 cm. penetration supplemented by a graphical plot of blow count versus depth.

5.7 In rock strata, core recovery, Rock Quality Designation (RQD) and Room Mass Rating (RMR) shall be noted carefully for each run, immediately after cores are taken out of barrel.

5.8 Following laboratory tests shall be conducted: (preferably on Undisturbed soil samples and if UDS is not possible, on remoulded soil samples)

i) Grain size analysis

a)Hydrometer analysis

b)Sieve analysis

ii) Field density and moisture content.

iii) Specific gravity.

iv) Chemical analysis of soil and ground water including sulphates, chlorides, pH value etc.

v) Chemical analysis of 2:1, water: soil extract of the samples giving SO_3 content.

vi) Consistency Index: Liquid limit, plastic limit, plasticity index, shrinkage ratio.

vii) Consolidation test giving all relevant information.

viii) Swelling pressure and free swell index for expansive soils.

ix) Unconfined compressive strength on undisturbed soil samples

x) Direct shear test.

xi) Triaxial compressive strength tests:

a) Unconsolidated undrained test

b) Consolidated undrained test

c) Consolidated drained test

xii) Moisture density relations for Standard Proctor and Modified Proctor tests.

xiii) Crushing strength, specific gravity, unit weight, water absorption test of rock specimens of NX size.

xiv) Permeability test.

xv) Shrinkage limit test.

xvi) Tests to determine CBR values for design of roads at various location and depth.

5.9 The Bidder shall carry out the topographical survey of the area within leveling boundary to establish existing ground levels before commencing the detailed design and site leveling activities. All levels shall be established with reference to the permanent bench mark existing near the plant site. Base on field observations the bidder shall prepare detailed survey maps showing topographical details and contour levels and submit the same to Purchaser / consultant for approval. If any deviation in the soil parameters is found in Geotechnical investigation done by the Bidder, it will not form any basis of extra claim.

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FINAL REPORT ON :

GEOTECHNICAL INVESTIGATION FOR CONSTRUCTION OF COAL BASED 2x300 MW DEEN BANDHU CHOTU RAM THERMAL POWER STATION AT YAMUNA NAGAR (HARYANA)

VOLUME-III : MAIN PLANT

STRUCTURES : TG FOUNDATION + STG BUILDING, BOILER, SWITCHYARD, DM PLANT, WTP, ETP, WTP PH AND WORKSHOP

Submitted to:

M/s. Reliance Energy Ltd.
Reliance Energy Tower
A-2, Sector 24
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ILLUSTRATIONS

1.0 INTRODUCTION

1.1 Project Description

M/s. Reliance Energy Limited is constructing a Coal Based 2 x 300 MW Deen Bandhu Chotu Ram Thermal Power Station at Yamuna Nagar, Haryana. The various facilities planned include the station building, TG, NDCT, CWPH, Chimney, ESP, Mill Bay, Boiler, DM Plant and Reservoir, Coal and ash handling plants, etc. A large ash disposal area is also planned. The project will cover an area of about 414 hectares. A layout plan showing the locations of the various tests is illustrated on Fig.1.

1.2 Purposes of Study

The purposes of this study are to evaluate the stratigraphy at the site to provide recommendations for design and construction of foundations for the proposed plant and associated facilities. To accomplish these purpose, the study was conducted in the following phases:

(i) drilling seventy four boreholes from 10 to 40 m depth or refusal, whichever is earlier, in order to evaluate the stratigraphy and to collect soil samples for laboratory testing;

(ii) conducting ten static cone penetrometer tests to 20 m depth or refusal with 20 tonne capacity machine, whichever is earlier to obtain additional data for foundation analysis ;

(iii) conducting seven plate load tests at specified depth below existing ground surface to assess the load settlement behaviour under loading;

(iv) conducting twelve earth resistivity tests;

(v) conducting nine field permeability tests to determine the field permeability of soil;

(vi) conducting pressuremeter tests in eight boreholes;

(vii) conducting six no. of cross hole shear wave tests;

(viii) conducting about 955 m seismic refraction test.

(ix) conducting two field CBR tests.

(x) excavating nine trial pits for visual inspection;

(xi) installing one cassagranda piezometer at 10 m below ground level;

(xii) testing selected soil samples in the laboratory to determine pertinent index and engineering properties of the soils; and

(xiii) Collecting samples from borrow areas for determining index properties.

(xiv) analyzing all field and laboratory data to develop geotechnical recommendations for foundations.

1.3 Report Format

The report is presented in six volumes as listed below:

Volume - 1	:	Boundary Wall
Volume - 2 to 4	:	Main Plant Area and Associated Facilities
Volume - 5	:	Seismic Refraction Test and Cross-hole Shear Wave Tests
Volume - 6	:	Ash Dyke Area

The initial section of this volume of our report designated as Volume - III presents brief description of the field procedures used alongwith a list of various laboratory tests conducted. This is followed by geology of the area along with a generalized site stratigraphy. Various concepts used for engineering analysis are then presented. Recommendations for foundations system for various structures follow. This report closes with a summary of our principal findings and recommendations. The table and illustrations following the report text present all field and laboratory data

The following table presents a list of various units for which the results are presented in this volume.

S. No.	Units	Scope
1	TG Foundation + STG Building	BH-28, 29, 30, 31, 32, 33, 34, ERT- 3, PMT-1, 3, 6
2	Boiler	BH - 35, 36 ERT - 5, PLT - 3, SCPT-3 PMT-2, 5
3	Switch Yard	BH-37, 38, 39, 40 ERT - 1, 2, PLT - 4
4	DM Plant	BH-41
5	WTP	BH-42, FPT – 2
6	ETP	BH – 43, SCPT – 8
7	WTP PH	BH – 44
8	Work Shop	BH – 45

2.0 FIELD INVESTIGATION

2.1 Soil Borings

The borings were progressed using a shell and auger to the specified depth or refusal, whichever is encountered earlier. A total of six mechanical shell and auger rigs were deployed to execute this work. Where caving of the borehole occurred, casing was used to keep the borehole stable. The work was in general accordance with IS:1892-1979.

Standard Penetration Tests (SPT) were conducted in the boreholes at 1.5 m depth intervals by connecting a split spoon sampler to 'A' rods and driving it by 45 cm using a 63.5 kg hammer falling freely from a height of 75 cm. The tests were conducted in accordance with IS:2131-1981. The number of blows for each 15 cm of penetration of the split spoon sampler was recorded.

The blows required to penetrate the initial 15 cm of the split spoon for seating the sampler is ignored due to the possible presence of loose materials or cuttings from the drilling operation. The cumulative number of blows required to penetrate the balance 30 cm of the 45 cm sampling interval is termed the SPT value or the 'N' value. The 'N' values are presented on the soil profile for each borehole.

Refusal to further boring penetration was considered when the 'N' values exceed 100 or when practical refusal to further penetration by shell and auger was encountered.

Disturbed samples were collected from the split spoon after conducting SPT. The samples were preserved in transparent polythene bags. Undisturbed samples were collected by attaching 100 mm diameter thin walled 'Shelby' tubes and driving the sampler using a 63.5 kg hammer in accordance with IS:2132-1986. The tubes were sealed with wax at both ends. All samples were transported to our Delhi laboratory for further examination and testing.

2.2 Groundwater

Groundwater level was measured in the boreholes 24 hours after drilling and sampling was completed. The measured water levels are recorded on the individual soil profiles.

2.3 Static Cone Penetration Test

The static cone penetration is a specialized penetration test to obtain a profile of soil resistance with depth. The test was conducted using our skid mounted 20 tonnes capacity, hydraulically operated mechanized, HEICO make static cone penetrometer.

The cone penetrometer used is the mechanical cone with friction jacket type, that measures the total resistance to penetration, cone tip resistance and cone plus friction resistance. The cone used has a 10 sq.cm. end area with a 60 degree apex angle. The friction jacket has a surface area of 150 sq.cm.

The cone penetrometer system is anchored to the ground using four augers installed about 1 to 1.5 m into the soil. The cone is pushed hydraulically into the ground at a constant rate of about 10 mm per second. The test was conducted in general accordance with IS 4968 Part III.

The total force required to advance the cone tip and the cone plus friction jacket is recorded at every 20 cm intervals. The individual cone penetrometer soundings are conducted till the specified depth is reached or when the total resistance equals or just exceeds the maximum capacity of the cone penetration system (20 tonnes) or when the ultimate pullout resistance of the anchors is reached. Results are presented as plots of cone tip resistance, friction resistance of jacket as well as friction ratio versus depth.

At this site pebbles / cobbles were met at about 7.0 ~ 8.0 m depth and is about 4 to 5 m thick. The cone encountered resistance to further penetration in this strata. Application of load on the cone tended to damage the cone and rods rather than push the cone vertically downward.

To obtain technically useful geotechnical data, the matter was discussed with M/s. Reliance Energy Limited and M/s. Desein and the following procedure was adopted.

(1) The test was stopped on reaching pebbles / cobbles layer.

(2) A borehole was drilled at the test location. It was advanced to the bottom of pebbles / cobbles layer.

(3) The test was then re-started below the pebbles / cobbles layer and continued to refusal (20 T capacity)

2.4 Plate Load Tests

Plate load tests were performed at the site at locations at specified depths. The test procedure was in general accordance with IS:1888-1982.

Dead load was used to provide the reaction. The plate was loaded by pushing up against the dead load using a 50 ton capacity hydraulic jack. Three dial gauges measured the plate settlement with reference to a stable reference bar. The load is applied cyclically in small increments upto a maximum loading intensity of 8 kg / sq.cm. or 40 mm settlement of the plate, whichever occurs first.

Each load was held until the time rate of settlement became negligible (less than 0.02 mm per minute). The plate was then unloaded and the rebound was recorded. The next increment of load was then applied and the procedure of loading and unloading the plate was repeated till the maximum applied pressure of 8.0 kg/cm^2 load was reached or until the total settlement exceeded 40 mm.

Test results are presented as a graphical plot of bearing pressure on plate versus the measured settlement on natural scale as well as on log-log scale.

2.5 Electrical Resistivity Tests

Electrical resistivity of the soil at the site was determined at the locations specified. The electrical resistivity test is used for shallow subsurface exploration by means of electrical measures made at the ground surface. Resistivity measurements are made by driving four electrodes about 10 to 15 cm in to the ground at a pre-selected electrode spacing. We used the Wenner electrode configuration for this study.

The four electrodes were spaced at equal distance along a line. The test procedure is in accordance with IS:3043:1987.

Measurements are made by causing a current, 'I', to pass through the earth and distribute within a relatively large hemispherical earth mass. The portion of the current that flows along the surface produces a voltage drop, 'V'. The resistance 'R', ratio of voltage drop 'V' to current 'I' is directly measured by Digital Earth Resistance Tester. The resistivity is determined from the following equation: -

$$\rho = 2 \pi a R$$

where:

ρ = apparent resistivity, ohm-m

a = Spacing between the electrodes, metres

R = Resistance, ohms

Results are presented as logarithmic plot of apparent resistivity versus electrode spacing.

2.6 Pressuremeter Test

Pressuremeter test was conducted using AIMIL's Menard's pressuremeter with a capacity of 80 bars. The test is conducted in a NX size borehole at different depths. The borehole was advanced by rotary drilling.

A pressuremeter is a cylindrical probe that has an expandable flexible membrane designed to apply a uniform pressure to the walls of a borehole. A pressuremeter consists of two main elements : a radially expandable *cylindrical probe* which is placed inside a borehole at the desired test elevation and a *monitoring unit* which remains on the ground surface.

The probe has an inner membrane called the measuring cell and an outer guard cell. Water is used to inflate the measuring cell whereas gas (carbon dioxide) is used in the guard cell. A coaxial connecting hose carries water and gas to the probe from the monitoring unit.

The monitoring unit has a volumeter to measure volume change and pressure gauges to measure the water pressure in the measuring cell and gas pressure in the guard cell. A pressure differential of 1 bar is maintained between the measuring cell and guard cell to protect the measuring cell.

Pressure and volumetric displacement are monitored during the test. These data are used to produce a pressure versus volume change curve from which design parameters are determined. The parameters interpreted from the test include the limit pressure and the soil modulus of elasticity. A profile of limit pressure and modulus of elasticity is obtained by conducting the test at different depth in the borehole. Test results are presented on Figs. PMT-1 to PMT-25.

As the boulder / pebbles layer is encountered between 7-13 m depth, two tests are conducted at shallow depths above boulder layer and two tests are conducted below boulder layer. No tests are conducted in pebbles / boulders layer.

2.7 Field Permeability Test

Field permeability test was done by the falling head method. The borehole is drilled and cleaned upto the test level with partially sunk casing leaving a suitable uncased length of borehole below the casing. The standpipe was filled with water upto its top. Hydraulic head was measured at the start of the test. With the help of stop watch drop in head after suitable intervals of elapsed time was measured. The field coefficient of permeability was computed using the following equation as given in IS:5529:1969 Part-I:

$$k = (d^2 / 8L) [\ln (L / r) \ln (h_1 / h_2)] / (t_2 - t_1)$$

where :

- k = mean coefficient of permeability
- d = diameter of intake pipe (stand pipe)
- r = radius of hole
- L = length of test section
- h_1 = head at time t_1
- h_2 = head at time t_2

3.0 LABORATORY TESTS

The laboratory testing programme was aimed at verifying the field classifications and developing parameters for engineering analysis. All testing was performed in accordance with the current applicable IS specifications.

The following table present a list of the various tests conducted on selected soil and water samples recovered from the boreholes alongwith IS code of practice:

Laboratory Test	IS : Code Referred
Natural moisture content	IS : 2720 (Part-2)-1973
Grain size analysis	IS : 2720 (Part-4)-1985
Liquid & Plastic limit	IS : 2720 (Part-5)-1985
Specific Gravity	IS : 2720 (Part-3)-1980
Unconsolidated Undrained Triaxial shear test	IS : 2720 (Part-11)-1971
Consolidated Undrained Triaxial Shear Test	IS : 2720 (Part-12)-1981
Unconfined Compression Test	IS : 2720 (Part-10)-1991
Permeability of soils	IS : 2720 (Part-17)-1986
Sulphate content in soil	IS : 2720 (Part-27)-1977
Determination of pH value of soil	IS : 2720 (Part-26)-1973
Chemical analysis of water & soil-water extract	IS : 3025-1964

All test results are presented on individual soil profiles and the illustrations.

4.0 GENERAL SITE CONDITIONS

4.1 Geology

The Indo-Gangetic alluvial tract[1] is in the nature of a synclinal basin formed concomitantly with the elevation of the Himalayas to its north. It was formed during the later stages of the Himalayan Orogeny by the buckling down of the northern border of the peninsular shield beneath the sediments thrust over it from the north.

The widely accepted view with regards to this region is that a sag in the crest formed between the northward drifting Indian continent and the comparatively soft sediments accumulated in the Tetheyan basin when the latter was crumpled up and lifted into a mountain

[1] *Krishnan, M.S. (1986), "**Geology of India & Burma**", CBS Publishers, New Delhi.*

system. As the northward drift of Indian Sub-continent continued, the more consolidated and metamorphosed older strata and granitic magmas intruded into them and slide southwards, impelled partly by gravity and partly by compressive force. The northern border of the Peninsular Shield in the foot-hills region is now overlain by 500-1000 m of Pleistocene to Recent strata, and by a varying thickness of Shiwaliks (upto 5000 m thick) or Dharamsalas (upto 4000 m).

The older alluvium is rather dark coloured (locally called "Bhanger") and is generally, rich in concretions or nodules of impure calcium carbonate (kankars). The kankars are of all shapes and sizes, varying from small sand sized grains to big grains and big lumps. The age of the "Bhanger" alluvium is Middle to Upper Pleistocene.

The newer alluvium (locally called "Khadar") is light coloured and poor in concretions. It contains lenticular beds of sand and gravel as well as peat beds. It is merged by insensible gradations into the Recent or deltaic alluvia and its age is Upper Pleistocene to Recent.

4.2 Site Stratigraphy

The soils at the site are alluvial in nature. The stratigraphy encountered at structure locations included in this Volume are fairly uniform, consistent and similar to that given for structures in our Volume-2 report (except NDCT). The stratigraphy discussed below represents the general trends of the various layers encountered together with SPT and SCPT profiles.

Clayey Silt / Sandy Silt is met at the ground level which extends to about 2.0 m depth (RL 267.0 m). Fine to medium sand is then encountered to 7.0 to 8.0 m depth (RL 262~RL 261.0 m). Below this, fine to coarse sand intermixed with pebbles / cobbles is met to 12.0 ~ 14.0 m depth (RL 257.0 ~ RL 255.0 m). The pebbles / cobbles have been recovered during drilling. As per our assessment, the actual size of pebbles / cobbles may range from 80 ~ 150 mm. Below this layer, clayey silt is encountered to 20 m depth. This underlain by fine sand to 30 m depth. Clayey Silt is then met to 35 m depth (RL 234.0 m). Fine sand / Silty fine sand is met to final explored depth of 40 m (RL 229 m).

SPT N-values generally range from 8 to 11 to 5. 0 m depth with some local loose pockets of SPT values of 6-7 at borehole locations 31, 32, 34, 41 and 44. SPT values then range from 15 to 30 to 10.0 m depth (RL 259.0 m). In the layers containing pebbles / cobbles, occasional high SPT values of 50 to 100 are encountered. Below 10.0 m depth, SPT values range from 35 to 50 to 16.0 to 18.0 m depth (RL 253~251 m). SPT values generally exceed 50 below this depth.

Static cone tip resistance value range from 100 to 200 T/m^2 to 3.0 m depth (RL 266.0 m) and from 400 to 600 T/m^2 to 9 m depth (RL 260.0 m). Cone tip resistance values then range from 500 to 700 T/m^2 to 12 m depth (RL 257.0 m) and from 700 to 1000 T/m^2 to 18.0 m depth (RL 251.0 m). Cone tip resistance value then decrease to 350 to 500 T/m^2 from 18 to 20 m depth and it exceeds 1000 T/m^2 below 20 m depth (RL 249.0 m).

4.3 Groundwater

Based on borehole data groundwater is encountered between 2.8 to 3.8 m depth (RL 266.2~265.2 m) below existing ground level at the time of our field investigation (November~December, 2004). Fluctuations may occur in the measured ground level due to seasonal variations in rainfall or surface evaporation rates and flow of water in the Yamuna River.

5.0 FOUNDATION ANALYSIS AND RECOMMENDATIONS

5.1 General

A suitable foundation for any structure should have an adequate factor of safety against exceeding the bearing capacity of the supporting soils. Also the vertical movements due to compression of the soils should be within tolerable limits for the structure. We consider that foundation designed in accordance with the recommendations herein will satisfy these criteria.

5.2 Foundation Type and Depth

The average ground level of the area of TG Foundation + STG Building, Boiler, Switchyard, DM Plant, WTP, ETP, WTP pH and

Workshop is about 269.0 m. As per the information provided by M/s. Reliance Energy Limited, Noida the finished ground level is at about RL 270.0 m. So, a filling of about 1.0 m will be required except in switchyard area where very minimum filling / cutting is required.

The surficial soils are loose in nature with N values as low as 10 to 3.0 m depth. For 25 mm settlement, plant facilities may be designed below 4 m existing ground level.

Alternatively, RCC bored cast-in-situ piles may be used to support heavy structural loads. In our opinion, driven pile may meet refusal on the pebbles / cobbles layer at about 7-12 m and are therefore not recommended.

Open foundations bearing on improved ground are also a feasible foundation system. We suggest the following two alternative ground improvement schemes :

By these schemes, we expect that net allowable bearing pressure will be increased by about 50 percent.

(i) **Provision of Rammed Stone Columns / Granular Piles**: Rammed stone columns extending to about 8 m depth below existing ground level may be provided to improve the soil bearing capacity. Field tests will be required to confirm the efficacy of the scheme.

(ii) **Deep Dynamic Compaction**: Deep dynamic compaction is suitable for compacting loose sands. In this method, a suitable heavy weight is dropped from a suitable height. The shock wave created helps to compact the sand. The weight is dropped on a grid pattern with subsequent passes staggered along the grid lines. In case the scheme is selected, static cone test before and after compaction should used to assess the ground improvement achieved under quality assurance plan.

The above schemes will also result in a low liquefaction potential of the shallow soils. In case these schemes are adopted, the geotechnical design of the system should be completed with extensive field testing and trial runs before adopting it for the various facilities.

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5.3 Interpretation of Plate Load Test

PLT-3 has been conducted in Boiler area at RL 265.216 m and PLT-4 has been conducted in Switchyard area at RL 266.753 m.

In the Boiler area, test was conducted at interface of water table level, so measured settlements are very large. Plunging failure at a loading intensity of about 7.0 T/m^2 has occurred. In our opinion, the test results have been influenced by the capilary water, which has probably caused apparent loosening effect. The settlement of prototype foundations may be substantially less provided that construction is taken up simultaneously with dewatering. Therefore the interpretation of foundation behaviour based on results of PLT-3 may lead to a conservatively low value of bearing capacity. However, SPT, SCPT and pressuremeter data has been used for the analysis of the boiler area.

In the Switchyard area, the interpreted ultimate bearing capacity of the test plate is 22 T/m^2. Applying a safety factor of 2.0 on the ultimate bearing capacity, the safe load bearing capacity of the 60 cm size square foundation is about 11.0 T/m^2.

The test results have been extrapolated 2 to 3 m wide square footings using the following equation given in IS : 1888-1982.

$$\frac{S_f}{S_p} = \left[\frac{B_f\ (B_p+0.3)}{B_p\ (B_f+0.3}\right]^2$$

Additional factors have also been applied to account for saturation of soils / rise of groundwater and variation in soil conditions. The interpreted settlement of 2-3 m wide foundation in the Switchyard area at RL 266.7 m is tabulated below together with the summary of test results.

Location	Applied Bearing Pressure, T/m^2	Measured Settlement of 60 x 60 cm size Test Plate, mm	Interpreted Settlement of 2-3 m Wide Foundation at RL 266.7 m, mm
PLT-4	5.0	3.0	17.0
	10.0	6.0	33.5
	12.0	8.0	44.6
	15.0	9.0	50.2
	20.0	14.0	78.0

Reviewing the test results, the safe bearing capacity of the soils at RL 266.7 m in the Switchyard area may be taken as about 20.0 T/m^2 for a permissible total settlement of 75 mm.

The safe load carrying capacity interpreted from the plate load test should be reviewed in conjunction with borehole, SCPT data and pressuremeter data to the final value for design.

5.4 Open Foundations

Soil parameters used for foundation analysis are as follows:

$c = 0$	$\phi = 30°$	$\Upsilon = 1.70$	
$N_c = 30.14$	$N_q = 18.40$	$N_\Upsilon = 22.40$	General Shear Failure
$N_c' = 15.87$	$N_q' = 7.11$	$N_\Upsilon' = 6.24$	Local Shear Failure

Concepts for analysis of bearing capacity and settlement of open foundations is explained in Section 5.2 of our Volume-II report. For the soil conditions encountered at the site, average of general and local shear failure has been used for analysis.

Settlement analysis has been performed in accordance with IS 8009 Part-1. Based on a detailed analysis for foundations as explained in Volume-II of report, the net allowable bearing pressures computed from SPT data have been cross checked with the SCPT profile and pressuremeter data.

We recommend the following values of net allowable bearing pressure for 50 mm and 75 mm, settlement for small size foundations.

Foundation RL, m	Foundation Width, m	Design N - Value	Recommended Net Allowable Bearing Pressure, T/m^2	
			50 mm Settle-ment	75 mm Settle-ment
268.0	1	6.5	5.0	7.6
	2	7.0	4.5	6.8
267.0	1	8.5	11.0	16.5
	2	9.5	8.6	13.0
266.0	1	10.0	16.5	24.0
	2	11.5	13.2	20.0

For bigger size foundations our net allowable bearing pressures are recommended at 4.0 m below existing ground level.

Location	Foundation RL, m	Design N Value	Recommended Net Allowable Bearing Pressure, T/m² of Settlement		
			25 mm	50 mm	75 mm
TG Foundation + STG Bldg., Boiler, Switchyard, DM Plant, WTP, ETP, WTP pH and Workshop	265.0	17.5	10.0	21.5	30.0
	264.0	19.0	12.5	25.0	36.0
	263.0	20.5	14.3	28.0	42.0

The above values include a bearing capacity safety factor of 2.5. Since filling is planned in most areas covered above, the net load applied on the foundation should consider the effect of surcharge load of the fill.

As per our assessment, about 80 percent of the total settlement will occur during construction itself. We anticipate that about 90-95 percent of the estimated settlement may occur within about 6 months of construction.

5.5 Definition of Gross and Net Bearing Pressure

For the purposes of this report, the net allowable bearing pressure should be calculated as the difference between total load on the foundation and the weight of the soil overlying the foundation divided by the effective area of the foundation. The gross bearing pressure is the total pressure at the foundation level including overburden pressure and surcharge load. The following equations may be used -

$$q_{net} = [(P_s + W_f + W_s) / A_f] - S_v$$

$$q_{gross} = q_{net} + S_v = (P_s + W_f + W_s) / A_f$$

where:

q_{net} = net allowable bearing pressure

q_{gross} = gross bearing pressure

P_s = superimposed static load on foundation

W_f = weight of foundation

W_s = weight of soil overlying foundation

A_f = effective area of foundation

S_v = overburden pressure at foundation level prior to excavation for foundation.

It may please be noted that safe bearing pressures recommended in this report refer to ***"net values"***. Where filling is done, it should be treated as a surcharge over the foundation.

5.6 Bored Piles Analysis

Bored cast-in-situ RCC piles are a suitable foundation system for the proposed facilities. Soil parameters used for computing pile capacity by static analysis as per IS 2911 Part 1 Section 2 are as follows:

Depth, m		Soil Classification	c, T/m^2	ϕ°	γ, T/m^3
From	To				
0	1.0	Fill	--	--	--
1.0	3.0	Sandy Silt / Clayey Silt	6.0	0	1.67
3.0	8.0	Fine Sand	0.0	30	1.75
8.0	14.0	Pebbles with Sand	0.0	32	1.85
14.0	21.0	Clayey Silt	10.0	0	1.90
21.0	24.5	Fine Sand	0.0	34	1.95
24.5	31.0	Fine Sand	0.0	35	2.00
31.0	34.5	Clayey Silt	15.0	0	2.00
34.5	40.0	Silty Fine Sand	0.0	36	2.00

Based on the results of the static cone penetration test, the following average design cone tip resistance (q_c) has been selected for the analysis.

Depth, m	Design q_c, T/m^2	Minimum q_c, T/m^2	q_c / f_s
0-1.0	-	-	-
1.0-4.0	200	100	100
4.0-10.0	600	400	100
10.0-13.0	700	500	100
13.0-16.0	900	700	100
16.0-19.0	1000	700	100
19.0-20.0	400	380	100
20.0-21.0	700	500	100
21.0-22.0	1300	1000	100
22.0-23.0	1600	1300	100
23.0-30.0	2500	1600	50

The following table summarizes our analysis for safe capacity of bored cast-in-situ piles at different cut-off levels using c-ϕ values and SCPT values. The analysis concepts are explained in Section 5.4 & 5.5 of our Volume-II report.

Pile Dia-meter, mm	Pile Cut-off-Level, m	Pile Length Below Cut-off-Level, m	Computed Axial Compressive Capacity, (T)		Computed Uplift Capacity, (T)	
			Using c-ϕ Values	Using SCPT Values	Using c-ϕ Values	Using SCPT Values
450	267.5	15	42	69	29	48
		18	50	80	35	59
		20	68	91	41	70
		22	79	113	48	92
	266.5	15	43	73	30	52
		18	56	84	37	62
		20	74	100	44	79
		22	87	124	50	102
	265.5	15	46	74	32	53
		18	66	89	40	67
		20	78	110	47	89
		22	90	134	50	112

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Pile Diameter, mm	Pile Cut-off-Level, m	Pile Length Below Cut-off-Level, m	Computed Axial Compressive Capacity, (T)		Computed Uplift Capacity, (T)	
			Using c-ϕ Values	Using SCPT Values	Using c-ϕ Values	Using SCPT Values
600	267.5	15	60	102	40	64
		18	71	116	49	78
		20	112	131	59	94
		22	136	160	71	122
	266.5	15	62	107	42	69
		18	85	121	52	83
		20	127	143	64	105
		22	152	174	76	137
	265.5	15	65	109	44	71
		18	110	128	58	90
		20	134	156	69	118
		22	159	188	81	150
750	267.5	15	78	102	50	80
		18	92	116	61	98
		20	147	131	74	117
		22	185	160	89	153
	266.5	15	81	145	50	86
		18	110	163	65	104
		20	174	192	80	132
		22	208	230	95	171
	265.5	15	85	148	55	89
		18	145	171	72	112
		20	182	207	87	148
		22	217	102	246	187
1000	267.5	15	111	212	66	107
		18	130	235	81	130
		20	235	261	104	156
		22	345	308	131	204
	266.5	15	115	220	70	115
		18	165	243	89	139
		20	300	280	116	175
		22	398	332	143	228
	265.5	15	120	223	74	118
		18	231	254	101	150
		20	341	302	128	197
		22	376	354	156	250

6.0 INTERPRETATION OF ELECTRICAL RESISTIVITY TEST RESULTS

Electrical resistivity tests were conducted as per IS:3043-1987. Test results are presented graphically on Fig. Nos. ERT-1 to ERT-4 and are summarized below:

ERT No.	Coordinates	Suggested Mean Resistivity for Design, ohm-m
ERT-3	1544N, 1094E	65
ERT-5	1422N, 1189E	20
ERT-1	1391N, 922E	60
ERT-2	1518N, 957E	70

The electrical resistivity data may also be used as an indicator of potential for corrosion of buried metallic pipes and other utility lines. Reviewing the data, we are of the opinion that the corrosion potential is expected to be mild. No specific protection measures (such as Cathodic protection, etc) are considered warranted. However, underground pipes and utilities should be coated adequately.

7.0 FOUNDATION CONSTRUCTION CONSIDERATIONS

7.1 Excavation

For temporary open cut excavations for foundation construction, we recommend following side slopes :

- Excavation to 3.0 m depth	:	side slopes of 1-vertical on 0.4 to 0.8-horizontal
- 3.0 to 6.0 m depth (simultaneously with dewatering).	:	side slopes of 1-vertical on 0.8~1.2 horizontal with 1.5 m wide berm at 3m depth.

The excavation slopes should be monitored by the engineer. In case excessive sloughing or caving occurs, the slopes may be flattened further to ensure stability.

In case open excavations foul with other structures, consideration may be given to provision of sheet piles or diaphram walls.

7.2 Dewatering

Dewatering to about 0.2-0.3 m below groundwater level for foundation construction may be done by pumping from sumps. For open excavation, dewatering may be done using a vacuum well point system. Alternatively, pumping from shallow wells can also be done for effective dewatering. In order to ensure dry condition and to avoid slushy conditions during concreting, the water table should be lowered at least 0.3 m below the level of the excavation.

7.3 Foundation Level Preparation

The exposed foundation bearing surface should be watered and compacted properly using light manual rammers/rollers. The surface should then be protected from disturbances due to construction activities so that the foundations may bear on the natural undisturbed ground. We recommend the placement of a 50 to 75 mm thick "blinding layer" of lean concrete prior to laying the foundations to facilitate placement of reinforcing steel and to protect the soils from disturbance.

7.4 Fill Compaction

We recommend that good earth (silty sand / sandy silt of low plasticity) should be used as fill. Filling should be done in layers not exceeding 150~200 mm in thickness at a moisture content equal to ± 1% of optimum moisture content. Compaction should be done to at least 95% of the maximum dry density determined in accordance with IS 2720 Part VII (Standard Proctor).

7.5 Pile Construction

For construction of bored piles, a properly mixed drilling mud should be used to control the caving of the borehole during drilling and concreting.

Use of tremie concreting is recommended in order that the groundwater does not mix with the fresh concrete. The concrete should be coherent, with a minimum cement content of 400 kg/m^3 for M25 grade of concrete and should have a slump of about 140 to 180 mm. The piling works should be executed by a specialist agency with sufficient experience in such works.

7.6 Pile Load Tests

In case pile foundations are planned, we recommend that load tests be conducted on piles in order to confirm the static capacities and to ensure proper performance of the piles. A programme of initial load tests and routine load tests should be drawn up and sufficient number of piles should be tested in accordance with IS : 2911 Part-IV in order to ensure that the safe load on the pile is either equal to or greater than the working load on the piles.

7.7 Chemical Attack

Chemical test results on soil and groundwater are presented on Table 47. The results indicate that the soils contain less than 0.13 percent sulphate and less than 0.05 percent chlorides. The groundwater contains 361 to 412 mg / litre of sulphates and 170 to 260 mg / litre of chlorides. The pH value of soil is between 8.2 to 8.4 and that of groundwater is between 7.5 to 8.0 indicating somewhat alkaline condition.

IS:456-2000 recommends that precautions should be taken against chemical degradation of concrete if the sulphates content of the soils exceeds 0.2 percent or if the groundwater contains more than 300 mg per litre of sulphates (SO_3).

Comparing the test results with these specified limits, the sulphate content of the soils is less than the specified limit groundwater is above the specified limit.

Groundwater is met at shallow depth and likely to influence foundation concrete. Therefore, the soils may be considered to be in Class 2 classification as per IS 456-2000 which indicates a medium corrosion potential.

In our opinion, the groundwater is marginally aggressive to concrete. We recommend the following measures as a good practice to limit the potential for chemical attack :

(1) For open foundations and pile caps the concrete should contain a minimum cement content of 330 kg/m^3. Cement content in piles should be at least 400 kg/m^3. Ordinary Portland cement may be used for foundation concrete.

(2) Water cement ratio in foundation concrete should not exceed 0.50-0.55.

(3) A clear concrete cover over the reinforcement steel of at least 40 mm should be provided for all foundations.

(4) The concrete for open foundations and pile caps should be densified adequately using a vibrator so as to form a dense impervious mass.

7.8 Variability in Subsurface Conditions

Subsurface conditions encountered during construction may vary somewhat from the conditions encountered during the site investigation. In case significant variations are encountered during construction, we request to be notified so that our engineers may review the recommendations in this report in light of these variations.

8.0 SUMMARY OF PRINCIPAL FINDINGS AND RECOMMENDATIONS

M/s. Cengrs Geotechnica Private Limited is currently conducting a detailed geotechnical investigation for the Deen Bandhu Chotu Ram Thermal Power Plant, Yamuna Nagar, Haryana. This Volume-III report presents our engineering recommendations for TG Foundation + STG Building, Boiler, Switchyard, DM Plant, WTP, ETP, WTP pH and Workshop.

Based on available data, the generalized stratigraphy for the structures covered in this report are as under.

Reduced Level, m		Soil Description	Range of N-Values	Range of q_c Values, T/m^2
From	To			
269.0	267.0	Sandy silt / clayey silt	8-10	200
267.0	262.0	Fine sand	10-12	600-700
262.0	256.0	Pebbles with sand	30-50	--
256.0	249.0	Clayey Silt	35-50	700-1000
249.0	245.5	Fine Sand	> 50	1300-1600
245.5	239.0	Fine sand		--
239.0	235.0	Clayey Silt		--
235.0	229.0	Silty Fine Sand		--

Groundwater was met between RL 266.2 m to RL 265.2 m. We understand that a finished ground level will be 270.0 m. We recommend following alternative schemes :

Open Foundations: Open foundations are feasible only for lightly loaded structures or for structure at / below 4-5 m depth. We recommend a net bearing pressure of 14.3 T/m^2 at RL 263.0 m for TG Foundation + STG Building, Boiler, Switchyard, DM Plant, WTP, ETP, WTP pH and Workshop. Net allowable bearing pressures foundations at various levels are given in Section 5.4 of our report.

Pile Foundations : Bored cast-in-situ piles are recommended to support heavy structural loads. For 600 mm dia piles with cut-off-level at RL 267.5 m, we recommend safe axial compressive capacities of 89 T for 18 m long pile and 122 T for a 20 m long pile. Capacities for piles of various diameters and at various cut-off-levels are given in Section 5.8 our report.

Ground Improvement : Ground improvement may be done by provision of rammed stone columns or by deep dynamic compaction. These techniques can result in substantial increase in safe bearing capacity of open foundations.

9.0 CLOSURE

We appreciate the opportunity to perform this investigation for you and have pleasure in submitting this report. Please contact us when we can be of further service to you.

for CENGRS GEOTECHNICA PRIVATE LIMITED

Ravisundaram

Sanjay Gupta

(RAVI SUNDARAM)
DIRECTOR

(SANJAY GUPTA)
MANAGING DIRECTOR

CHAPTER – 6

GENERAL REQUIREMENT OF BUILDINGS & STRUCTURES

The CONTRACTOR shall obtain and be conversant with all laws, by-laws and regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The CONTRACTOR shall provide all the required drawings and documents for such statutory approvals.

6.1 ROOF ACCESS

All roofs shall be provided with access thorough a staircase / cage ladder. Minimum 1000 mm wide access path shall be provided with tiles to approach equipment on roof.

6.2 PLATFORM AND WALKWAYS

Platforms shall be provided to all major equipment, not directly accessible from - the floors, for maintenance. Platforms and connecting walkway shall have a minimum width of 500 mm. However, in case of space restriction, the minimum allowable clear width shall be 600 mm. Platforms in front of the entry shall be at least 900 mm wide. Platforms located close to each other shall be connected with walkways.

All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consists of 8 mm thick steel plate projecting 100 mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached.

Continuous walkway at least 750 mm (Wherever occurs) wide shall be provided along the crane girder level with handrails, on both side of the building. Approach to EOT crane shall be ensured by Cage ladder or staircase.

Finished floor level boiler area / transformer yard area shall be kept 200mm lower than the finished floor level of power house building.

6.3 EDGE PROTECTION

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corners expected shall be provided with angles of minimum size L 50x50x5 with lugs for edge protection e.g. alround the cut-outs/ openings in floor slab, edges of drains supporting grating covers, edges of. RCC cable/ pipe trenches supporting covers, edges of manholes supporting covers and supporting edges of precast covers etc.

6.4 ANCHOR BOLTS AND INSERTS PLATES

Anchor bolts shall be designed for working stress, in tension and shear, for embedded length of the anchor bolts and pipe sleeves. Shear and crushing strength of concrete shall also be checked. Increase in allowable stress for loading including seismic and wind loads shall not be permitted in design of anchor bolts.

Insert plates shall be designed / checked for shear and bending moment. All lugs shall be checked for tension. Bond strength of concrete shall also be checked. Lugs using steel flats minimum 25x6mm shall preferably be fillet welded to the plate to transfer full strength of the lug.

Insert plates required for the equipment supplied by BTG vendor will be supplied by BTG supplier and same shall be fixed in position under this contract and supply and fixing of all the balance inserts shall be under the scope of this contract.

6.5 VERTICAL HEADROOM

All accessible areas shall be provided with minimum clear headroom as follows, unless otherwise specified.

Finished floors to ceiling (buildings)	3000 mm
Doors, Walkways, Platforms, Stairs etc.	2200 mm
False ceiling of office areas	2400 mm
Above false ceiling	1000 mm
Safety cage for ladders	2500 mm
Access for fork lift trucks	2800 mm
Main roads / Railway crossings & crane access	8000 mm
Other plant roads and truck access	5000 mm
Cable & Pipe rack (except at road and rail crossings)	3000 mm
Cable spreador floor	2400 mm

6.6 ANTI TERMITE TREATMENT

Pre-constructional anti termite treatment shall be given to all vulnerable areas and shall include column pits, wall trenches, foundations, filling below the floors etc. as per IS: 6313 and other relevant Indian Standards.

6.7 STAIRS AND LADDERS

6.7.1 Steel Stairs

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75°. All stairs normally shall have not more than 13 risers in one flight. Channels (minimum MC200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of chequered plate/grating, with suitable nosing, and spaced equally so as to restrict the rise to maximum 180 mm. Effort shall be made to keep the riser height 150-160 mm

6.7.2 Steel Ladders

Ladders shall be provided to platforms, walkways, instruments and equipments which do not require frequent access. Ladders shall preferably be vertical and its angle with vertical shall not exceed 5^{o}. Ladders shall be of minimum 450mm clear width with 20mm diameter MS rungs spaced at 300mm (maximum). Ladders shall be provided with a safety cage of minimum 750mm diameter clear when the top of ladder is more than 4.5m above the landing level. However safety cages shall start at 2.5m above the lower landing level.

6.7.3 RCC Stairs

All stairs shall have maximum riser of 180mm and a minimum tread of 250mm. However, for Public buildings riser shall be limited to 150mm and tread width of 300mm. Minimum width of stairs shall be 1200mm generally. All stairs normally shall have not more than 15 risers in one flight. Aluminum angle nosing with minimum 50x25x3 angle or PVC nosing shall be provided for edge protection of RCC stairs.

6.8 HANDRAILS

Handrails shall be provided at appropriate places to ensure safety e.g. around all floors/roof openings, projections / balconies, walkways, platforms, steel stairs etc.

All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS:1161 galvanized using 750 gm/sq.m. Handrails for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkway surface and the intermediate rail 450 mm below the top rail. Toe guard made of M.S. Flat (Min.100x6mm) shall be provided for structural flooring. For concrete floor an integral concrete kerb to be provided. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850 mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30 m, three rail systems with top rail at 1500 mm shall be adopted with toe guard.

For RCC stairs, handrails with 20 mm square MS bar balustrade with suitable MS flat & aluminum / Teakwood handrail shall be provided, unless specifically mentioned otherwise.

6.9 EXPANSION/CONSTRUCTION JOINTS

Expansion and construction joints shall be provided wherever required. All expansion and construction joints of water retaining structures in RCC shall be made watertight using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops may be used for the base slabs and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 6mm and minimum width 225mm. At other joints these shall be150mm wide.

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 shall be used as joint filler. For joint treatment of coal handling system structure, refer chapter 14.

6.10 BRICK / STONE MASONRY AND PARAPET WALL

All masonry works shall be designed in accordance with relevant codes as applicable. Structural design of load bearing and non load bearing walls constructed with fly ash bricks shall be in accordance with criteria specified by section-4 of National Building Code of India, Part-VI and codal provisions.

All walls shall be non-load bearing in filled panel walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change room, first aid rooms and toilets, which may be half brick thick. RCC bands (transoms and mullions) shall be provided wherever necessary to curtail the unsupported length / width of the wall.

50mm thick DPC (1:1.5:3) with water proofing admixture shall be provided at plinth level before starting masonry works. Water proofing compound shall be Zydex, Sikka or similar make.

Fly Ash Bricks having minimum 75 kg/sq.cm compressive strength shall be used for non-load bearing superstructure brick work. Cement and sand mortar 1:5 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided. Transoms shall be provided at lintel / door height. The spacing of mullions shall not exceed 2000 mm centre to centre. The size of transoms / mullions shall be minimum 115mm square with four numbers, 8 mm dia bars and 6mm stirrups 150 mm centers.

Almost all the brickwork shall be plastered with cement mortar. Brickwork in superstructures uncovered by plaster shall be executed by skilled mason. Courses shall be truly horizontal and vertical joints truly vertical. Wooden straight edges with brick course graduations and position of window sills and lintels shall be used to control uniformity of brick courses. Masons should check workmanship frequently with plumb, spirit level, rule and string. All brick work shall be cleaned at the end of day’s work. In case of face bricks involvement the brickwork shall be in composite shape with face bricks on the exposed face and balance in routine bricks, maintaining the bond fully; using carborandum stone for rubbing down. Where face bricks are not needed, 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.

For partition walls two reinforcement bars shall be placed at every fourth layer. Chicken wire mesh shall be provided at the junction of RCC & brick work.

The masonry works shall be cured for a period of 14 days after laying and plaster shall be cured for a period of 7 days.

Type, thickness and height of external wall, facing the transformer yard to take care of fire accidents in transformer yard shall be according to the requirements of Tariff Advisory Committee.

All upstands and parapet walls on roof shall be of RCC construction, minimum height of parapet walls shall be 750mm and thickness 125 mm.

Wherever metal cladding is specified, for initial 3 m height from the ground level, minimum one brick thick masonry wall (230mm) shall be provided.

Contractor to set up Fly ash brick manufacturing plant at site at a location as approved by engineer in charge of the project.

6.11 WATERPROOFING OF UNDERGROUND STRUCTURES

All underground structures (other than Coal handling system) like basements, pump house sumps, liquid retaining/conveying structures etc. shall have plasticiser cum waterproofing cement additives conforming to IS:9103. In addition, limits on permeability as given in IS: 2545 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum two coats of bituminous painting of grade 85/25 conforming to IS:702 mixed with 1% antistripping compound as per IS: 642. Bitumen shall be applied @ 1.7 kg/sq.m (minimum) for water / damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that water proofing grouting can be injected later in case of leakage. All liquid retaining/ conveying structures including sumps of Pump House shall be tested for water tightness as per IS: 3370 & 6494 and in case of soakage, leakage, seepage the same shall be rectified by chemical injection grouting as specified.

Underground structures of **Coal handling system shall** be provided with following waterproofing treatment:

Water proofing of underground portion of Wagon tippler, tunnels, and underground portion of transfer houses shall be done by providing the following treatments:

Chemical injection grouting for inner faces (details as specified else- where).

Polymer modified cementitious coating on earth side face as per the following.

On the outer surface of walls, frames and roof slabs coming in contact with earth, polymer modified cementitious coating in two layers as specified and as per manufacturer"s specifications shall be provided directly on the concrete surface.

50 mm thick P. C. C. (1:2:4 with 10 mm nominal size stone aggre- gates) shall be provided under the raft i.e. over the lean concrete, followed by polymer modified cementitious coating in two layers (slurry mix application) as per manufacturer"s specification. 50 mm thick P.C.C. (1:2:4) with 10 mm nominal size stone aggregates shall then be laid over the polymer modified cementitious coating before laying the raft.

6.11.1 Chemical Injection Grouting

Minimum 12 mm dia NB threaded nozzle of suitable length, shall be provided over the surface and along the construction joint line in a grid pattern at a spacing not exceeding 1.5 m c/c before concreting operation. Adequate precaution shall be taken to keep the nozzles plugged at both ends to prevent them from getting closed by concrete.

For fixing of any nozzle in set concrete suitable size hole shall be drilled, preferably using repercussive hammer drill electrically operated, in grid pattern and grouting nozzle shallbe fixed in these holes.

After the nozzles are fully set, neat cement slurry admixed with water soluble nonshrink polymer / monomer based chemical shall be injected through the network of nozzles with low pressure grout pumps at a pressure of about 2.0 Kg/cm^2. Cement slurry shall be prepared by mixing cement with non-shrink polymer/monomer @ 500 gm/50 kg bag of cement and water, ensuring that Water: Cement ratio does not exceed 2 (by weight). Wetter the structure, lesser should be the water cement ratio. The property of the polymer/monomer should be such that when it is mixed with water @0.5% by weight of water, the viscosity of the resultant solution (water and polymer/monomer) should not be more than 1.2 centipoises.Plasticizing agent shall be added wherever required. The grouting shall be started at very low pressure and increased gradually to a required pressure. The grouting shall continue, till the hole refuses to take any further grout, even at an increased pressure. Applied pressure shall not be more than the designed strength of the concrete. After completion of grouting operation, the nozzles shall be sealed properly to the satisfaction of the Engineer.

All liquid retaining / conveying structures including sumps of pump house shall be tested for water tighteness for as per IS-3370 and 6494 and in case of leakage, seepage, the same shall be rectified by chemical injection grouting as specified above.

6.11.2 Polymer Modified Cementitious Coating

6.11.2.1 Materials

Modified liquid polymer blend shall be a dispersion containing 100 % acrylic based polymer solids. Polymer shall be mixed in the ratio of 1 cement: 0.5 polymer (for minimum solid content of polymer 30%).

Portland cement based dry powder.

Clean, fine specially prepared quartz sand approximately 0.6 mm size.

Material for chemical injection grouting & polymer modified cementitious coating shall be of SIKA, CICO, FOSROC or approved equivalent.

6.11.2.2 Mixing

The liquid polymer shall be stirred well and cement based powder shall then be added slowly to make a Slurry Mix. For preparation of Brush Topping Mix, quartz sand shall be added slowly and mixed well till a homogeneous mixture is obtained. The mix shall be used within half an hour of the preparation.

Addition of quartz sand may not be necessary, in case dry power contains the same.

6.11.2.3 **Properties of Coating**

It must adhere to wet surface.

It should develop adequate bond strength, with the concrete surface, not less than 2 N/mm^2.

Co - efficient of permeability shall be about $5x10^{-10}$ cm/sec

Water absorption after continuous soaking shall not be more than 1%.

The materials shall be permeable under water vapour.

The material shall be resistant to acids and alkalies present in the soil and underground water with normal pH value between 4 and 14.

The co - efficient of thermal expansion of the material shall be close to that of concrete.

6.11.2.4 **Application**

The concrete surface shall be cleaned and made free from grease, oils or loosely adhered particles. The surface shall be damp without any free water. For exterior underground part, application (b) pertaining to Brush topping Mix shall be followed.

(a) For Slurry Mix

A minimum of 2 coats shall be applied on the surface. The first coat being applied, when the surface is still damp and left to harden for 4 to 6 hours. After 4 to 6 hours of the application of second coat, it shall be finished by rubbing down with a soft dry sponge. The coverage shall not be less than 1 : 1 Kgs. / m2 in the 2 coats. A lap of 75 mm shall be provided at the joints.

The coating shall be air dried for 4 to 6 hours and, thereafter, cured for 7 days aftern the application of last coat.

(b) For Brush Topping Mix

This shall be applied in two coats. A primary coat of slurry mix can also be first applied on the surface as first coat. After the coating has dried up, a coat of Brush Topping Mix shall be applied over it with a push broom or any other similar brush. It shall be left in broom finished condition. The nominal thickness shall be 1.5 mm and minimum thickness shall be 1.0 mm. A lap of 75 mm shall be provided at the joints. It shall be ensured that no pinhole exists and rebrushing shall be done to cover the pinholes, if any.

The Coating shall be air dried for 4 to 6 hours and thereafter cured for 7 days after the application of last coat.

Rate of application of coating shall be established to achieve the required thickness.

6.12 PAVING

Area Paving in Main Plant Block

RCC paving of minimum 150 mm thick with M25 grade concrete, over an underbed as specified herein shall be provided for areas mentioned below. RCC paving shall be designed as rigid reinforced concrete pavement for the crane/ vehicular/ equipment movement loads which the paving has to bear. The underbed for paving shall consist of preparation and consolidation of sub-grade to the required level, laying of stone soling of 200mm compacted thickness for normal duty paving and 400mm compacted thickness for heavy duty paving with 63 mm and down aggregate with interstices filled with selected moorum followed by 75 mm thick PCC of M7.5 grade with 40 mm nominal size aggregate. Paving areas shall be provided with the metallic hardener floor finish as specified elsewhere in the specification.

Entire main plant area from chimney to transformer yard as enclosed within the peripheral roads of the main plant area shall be provided with paving (on chimney side, paving shall be upto the edge of the storm water drain by Bidder.

Passages shall be provided inside the main plant block connecting to the outer periphery road to have access to the various facilities/buildings. The passage areas shall be provided with heavy duty paving for movement of heavy vehicles. The top surface of the passages shall be finished with 50 mm thick metallic hardener topping.

Heavy duty paving shall be provided for the areas in the Mill bunker building, equipment lay down area in the TG hall and handling areas for PA/FD fans with 50 mm thick metallic hardener topping.

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

Lightly loaded areas such as corridors below trestle and other areas in the main plant block where no heavy traffic movement is envisaged shall be provided with normal duty paving .

All other area inside the main plant block shall be provided with normal duty paving. <u>2.5 m wide paving around periphery of all sumps and underground tanks without metallic hardener shall be provided</u>.

Suitable drains shall be provided to dispose off storm water as well as floor wash of the main plant block. The paving shall be provided with slope of 1:500 to dispose the surface water/wash water to the nearest drain. Drains shall be provided to dispose the floor wash water of ESP to a sump of suitable size. Further, the overflow from the sump shall be drained to the nearest storm water drain.

To dispose off sewage from ESP area, Main Plant Building, Control Room & transformer yard area provision of suitable sewerage system as per latest Govt. norms must be done by the bidder.

Entire switch yard area shall be provided with 150mm thick gravel filling which shall consist of 75mm thick stone metal filling of 40mm stone aggregate on the top and 75mm thick filling of 20 mm stone aggregate below. Each layer shall be compacted by using half tonne roller with 4-5 passes and suiltable water sprinkling .Before laying the garvel fill, the top layer of soil shall be treated for anti weed considering the types of weeds found in the vicinity , Anti-weed/ Soil sterilization such as manufacturer's name, their specification, test certificate etc. for Owner's approval. Any modification if required in the proposed anti-weed treatment chemicals, shall have to done by the contractor at no extra cost to the owner .The contractor shall be required to furnish a performance guarantee shall commence from the date of completion of work or date of handing over , whichever is later.

6.13 SECURITY GATE

Emergency Gate shall be provided in addition to the main gate. Main Gate shall have two separate entries; one for project site and other for trucks movement. Gate latches shall be arranged for padlocking with the padlock accessible from both sides of the gate. Padlocks shall be provided and the key shall be in accordance with the Purchaser's requirements.

Cantilever type motorized sliding gate shall be furnished at the main plant entrance. The gate shall be operable by push button at both the guard house and the security office in the Administration / Plant Service area, and by card reader or key switches.

The road near the main entrance to be widened additionally by 7.5 m on either sides of the road for parking of vehicles for security check.

Suitable median arrangements to be made.

Security cabin to be provided on either sides of the road near the main gate.

Elevated platform either in steel structure / Brick work or RCC to carry out checking on Lorries/Tippers by security personnel while the vehicles getting in or going out from the premises

6.14 FENCING

Fencing with toe wall and steel gates shall be provided around the transformers & Switchyard. Fencing shall comprise of P.V.C coated GI chain-link fencing of minimum 8G (including PVC coating) of mess size 75mm and of height 2.4 m above the toe wall. The diameter of steel wire for chain link fence (excluding P.VC. coating) shall not be less than 12G. Fence post shall be of precast R.C.C. of minimum M20 grade. All corner posts will have two stay posts and every 10th post will have transverse stay post. Suitable R.C.C foundation for the post and stays shall be provided based on prevailing soil condition. Gates shall be with locking provisions. The walls of fly ash bricks shall be provided between fence post all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50mm thick with PCC coping (1:1.5:3) and shall extend minimum 300mm below the formation level. The toe wall shall be plastered on both sides and painted with two coats of cement paint of approved colour and shade. Toe walls shall be provided with weep holes at suitable spacing.

Removable type of fencing shall be provided at suitable location to permit entry and exit of equipment.

6.15 **WATCH TOWER**

Watch Tower shall be constructed with RCC frame work. Floor of tower shall be at least 6m above graded level.

Covered area for each tower shall be approx. 25 sqm. Number of towers shall be such that the complete periphery of the plant can be watched from the towers but in no case the number of towers shall be less than twelve.

6.16 **PLINTH PROTECTION**

All buildings shall be provided with 750 mm wide plinth protection all round. It consist of 50mm thick PCC M20 grade with 12mm maximum size aggregate over 200mm thick stone soling using 40mm nominal size ramped, consolidated and grouted with fine sand.

6.17 **RAISED FLOORS / FALSE FLOOR**

Where indicated on the technical drawings, the contractor shall furnish and erect removable modular panels conforming to the following requirements:-

a) Material

Composite panels made of high density 675 kg/m3 waterproof chipboard and aluminium sheets for protection of the interior face. The panel edges shall be slightly chamfered (5°) and protected by an aluminium profile or other conductive material.
Topping shall be made of high pressure laminate 1.3 mm thick.

b) Size of the panels

i) Nominal size shall be 600 x 600 mm.

ii) Tolerance : 0.2 mm width and length
0.3 mm diagonal
0.2 mm thickness

iii) Minimum thickness of the panels 40 mm.

c) Loading

i) 5 kN/m2: The maximum allowed deformation shall be 2 mm under 5 kN point load.

ii) Minimum height of the free space between sub-floor and raised floor surface for control rooms shall be 1.0 metre.,except if noted otherwise in the execution drawings.

d) Substructure

i) The substructure shall consist of adjustable pedestals and stringers. The pedestals are to be fixed by bolts to the concrete base slab floor. The stringers are bolted to the pedestal so that large cut-outs are possible.

ii) The whole system shall be constructed in such a way as to allow conductivity of electrostatic charges and shall be connected to the earthing system.

iii) Penetrations for cables and pipes shall be arranged.

iv) For allowing an elastic connection to abutting walls, a peripheral joint of 3 mm width shall be arranged and sealed with an appropriate neoprene sealant.

6.18 MISCELLANEOUS REQUIREMENTS

Doors and windows on external walls of buildings shall be provided with RCC sunshade over the openings With 300 mm, projection on either side of the opening. Projection on sunshade from the wall shall be minimum 450 nm over window openings and 750 mm over door openings.

Doors and windows on the external walls of buildings with metal cladding shall be fixed by creating recesses in the cladding system.

No cable trenches shall be provided in TG hall, Boiler/ESP area, fuel oil pump house, Ash pump houses etc.

All cables & pipes in outlying area shall run above ground over steel trestles or other supporting structures for easy inspection & maintenance except in transformer yard area and some other localized area where the same can run in RCC trenches. However, for facilities for which buried pipe & cables are permitted by Purchaser, the same can be provided. In case of trestles, minimum 7.0 m head clearance shall be provided for road crossings. In other areas, the clear height shall be 3.0m minimum.

All cable and pipe trenches shall be of RCC of minimum M25 grade. Trenches located outside buildings shall project at least 200mm above the finished formation level so that no storm water shall enter into trench. The bottom of the trench shall be sloped suitably for draining out the collected water into sump pit. The pre-cast covers shall be of minimum M25 grade and shall not weigh more than 65kg. Lifting hooks shall be provided in the pre-cast covers. Pre-cast covers shall have edge protection angles at top and bottom on all the four sides along with lugs.

Duct banks consisting of MS/PVC conduits for cables shall be provided with proper sealing arrangement consisting of fire retardant sealing compound.

All floor openings for cables below electrical panel shall be sealed with fire sealing compound after cables are laid.

Mild steel bars required for earthing / grounding mat shall also be supplied and installed.

All cable vaults shall be located above ground level i.e. cable vaults shall not be provided as basements in the buildings.

Connection work at terminal points is included in the scope of the Bidder.

Ground floor slab of all the buildings excluding building mentioned in Chapter 14 (Coal Handling Plant) shall be of minimum 150mm thick of M-20 grade laid over minimum 75mm thick PCC and 230mm soling of 63mm down graded aggregates (minimum) course unless specifically mentioned otherwise. The reinforcement shall consist of minimum 8mm diameter bars at 200 mm c/c of grade Fe 500D at top and bottom in both directions.

All openings in external walls provided for pipes, cables, duct etc. shall be effectively sealed to prevent water seepage, after the routing of the services are completed.

Natural lighting & Ventilation

The area of windows shall be a minimum 10 % of the floor area to ensure adequate natural lighting. Fans shall be provided in general office areas as per standard norms. Sewerage system shall be provided with adequate ventilation for the pipe work as well as manhole.

Furniture

All rooms shall be furnished for their intended use. The Contractor shall provide the Owner with a choice of furniture range.

6.19 STATUTORY REQUIREMENTS

All the applicable statutory rules pertaining to Factories act, Factory rules of State Government, Fire safety rules of Tariff Advisory committee, Water act of Pollution Control boards, Explosives act etc., and stipulations of other relevant statutory authorities shall be taken into consideration at the time of design and construction.

Provisions of safety, health and welfare according to Factories act shall be complied with at design stage. **These shall include provision of continuous walkway (minimum 750 mm wide) along crane-girder at crane girder level on both sides of the building, comfortable approach to EOT crane**. Cabin, railings, fire escape locker room for workmen, pantry, toilets, rest rooms etc.

Adequate no. of fire escapes shall be provided in a building. Fire proof doors, no. of staircase, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall. be made according to the recommendation of TAC.

For fire safety requirements of buildings Code IS: 1641 & IS: 1642 should be followed in addition to TAC requirements. **All masonry firewalls shall be minimum 345 thick and RCC firewall shall be minimum 200 mm thick.**

CHAPTER – 7

MATERIAL

7.1 STRUCTURAL STEEL

Steel will conform to Grade-A of IS: 2062 (latest) for rolled steel members or plates upto 20 mm thickness. For plates above 20 mm thickness and welded construction steel conforming to Grade-B (killed and normalized) of IS: 2062(latest) shall be used except for crane girders where Grade-C (IS: 2062) steel shall be used. Steel shall be procured from SAIL, RINL, TATA STEEL, JINDAL or any other approved main producers.

Chequered plate shall conform to IS: 3502 (latest) and minimum thickness of chequered plate for floorings, covers etc shall be 8 mm O/P.

Complete hopper including vertical and conical portion of bunker in mill building shall be provided with lining of atleast 6mm thick SS plate grade SS 316L .

The electrodes classification as per AWS shall be as follows:-

a) For welding of stainless steel to stainless steel: E308L

b) For welding of stainless steel to mild steel: E309

7.2 CEMENT

Ordinary Portland cement 43/53 grade conforming to IS: 8112 and, IS: 12269 shall be used for all structural work and special structure and for foundation. Portland pozzolana cement conforming to (IS: 1489, part-1) shall be used for plastering work, fill concrete and PCC. Sulphate resistant cement, conforming to IS-12330, shall be used in concrete mixes when concrete is exposed to aggressive soil/water conditions. Cement manufacturer shall be approved by the Owner.

7.3 REINFORCEMENT

The Reinforcement bars shall be as per the following codes: High Yield Strength Deformed bars of minimum grade Fe 500D conforming to IS: 1786 and Mild steel bars conforming to : Grade I of IS: 432 of either of “SAIL”, “TATA STEEL”, and “RINL” or other reputed main producer as approved by the purchaser. Welded wire fabric conforming to IS: 1566 Hard drawn steel wire shall conform to grade-1 of IS: 432(part-2).

Intermixing of different grades of rebars or rebars of different material composition in same structure shall not be allowed.

7.4 COARSE AGGREGATE

Sound and durable crushed stone aggregates shall be used. All aggregates shall be tested for alkali aggregate reaction. Materials, which contain high percentage of reactive silica, shall not be used. In exceptional cases of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundationsAggregate of sizes ranging between 4.75 mm & 150 mm shall be termed as Coarse Aggregate. Only Coarse Aggregate from approved quarries & conforming to IS: 383 shall be allowed to be used on the works.

7.5 **FINE AGGREGATE**

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS: 383 is termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification shall be allowed to be used on works.

In certain cases crushed stone sand may be added to natural sand in order to achieve the required grading with prior approval of the Owner.

Crushed stone sand alone may be used only with the prior approval of the Engineer for filling and PCC works only.

7.6 **WATER**

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts and other impurities. Normally potable water is found to be suitable. Generally, IS: 3550 shall be followed for routine tests. In case of doubt, the acceptance test for water shall be as per IS: 3025 and Table-I of IS: 456.

7.7 **ADMIXTURE**

Only admixtures of approved quality shall be used when directed or permitted by the Engineer in Charge. The admixture shall conform to IS: 9103.

CHAPTER – 8

LOADING

8.1 DEAD LOADS

Dead loads shall include the weight of structure complete with finishes, fixtures & partitions and shall be taken as per IS: 875 (Part-I)

8.2 IMPOSED LOADS

Imposed loads in different areas shall include live loads, erection, operation and maintenance loads. Equipment loads (which constitute all loads of equipment to be supported on the building frame) are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

For consideration of imposed loads on structures, IS:875 (Part-2) "Code of practice for design loads (other than earthquake) for buildings & structure" shall be followed. The following minimum imposed loads as indicated for some of the important areas shall however be considered for the design. If actual expected load is more than the specified minimum load, then actual load is to be considered

S No.	Location	Imposed Loads (T/Sq.m)
A)	Turbine Building	
	i) Ground floor (general)	3.00
	ii) Ground floor (Heavy equipment storage area)	5.00
	iii) Mezzanine Floor	1.50
	iv) Operating Floor a) Rotor Removal area Rotor removal area beams shall also be checked for ½ the rotor load at the center of beam	5.00
	b) Equipment Laydown area	3.00
	v) Gratings, chequered floors, walkways, platforms, stairs etc.	0.50
	vi) Roof (Where no equipment are located and non-accessible) Roof (where equipment are located and accessible)	0.15 0.50
B)	Deaerator and Heater Bay	
	i) HP / LP heater floor	2.0

S No.	Location	Imposed Loads (T/Sq.m)
	ii) Deaerator floor	1.5
	iii) Cable gallery	0.50 (In addition to this actual cable load shall be considered)
	iv) MCC & Control Building floors	1.00
	v) AHU room battery room, air washer room	1.5
C)	Mill & Bunker Bay	
	i) Ground Floor	2.5
	ii) Feeder Floor	2.00
	iii) Tripper Floor	2.00 Beams however shall be checked for feeder/tripper concentrated load
	iv) Roof	0.15 (where no equipment are located) 0.50 (where equipment are located)
D)	Dust Load for flat roof For inclined roof	0.1 0.05
E)	Operating floor of Underground Structures such as Channels, Sumps, Underground Pump House, Tanks, Trenches, Reservoirs, Cooling Water Ducts etc.	1.5
F)	In addition to earth pressure and ground water pressure, the surcharge load of 2T/sqm, shall also be considered for design of all underground structures.	
G)	Road Culverts / Bridges and its allied structures including RCC Pipe Crossings & Road Crossing of Trenches. Design for class 'AA' loading (wheeled & tracked both) and checked for class 'A' loading as per IRC Standard.	
H)	Covers for Channels / trenches	Trench cover at entry to building and road crossings shall be designed for live load of 10 M-ton at centre. Trench cover at other location shall be designed with a

S No.	Location	Imposed Loads (T/Sq.m)
		surcharge of 10.0 T/sqm or a concentrated load of 10 M-ton at center which is worst.
I)	Railway Supporting Structures, Rail Culverts	As per railway 'Bridge Rules'
J)	Boiler / ESP Support Structures	0.50
K)	General (Unless Specified Otherwise)	
	i) Stairs, Landings and Balconies	0.50
	ii) Toilets	0.20
	iii) Chequered plates, grating floors, etc.	0.50
	iv) RCC floors (General)	0.50
	v) a) Flat roofs (where no equipment are located)	0.15
	b) Flat Roofs (where equipment are located)	0.50
	vi) Inclined Roofs	As per IS:875 (Part-II)
	vii) Walkways (General).	0.50 T/sq.m or a concentrated load of 0.3 T/m which ever is greater
	viii) Walkways of conveyor galleries.	0.50
	ix) Floor of control room of switchyard control building	1.00
	x) Cable and pipe trestles	0.20 for walkway and in addition, friction loads as applicable.

Note:

1. Additional load for cable, piping / ducting, shall be considered as applicable.

2. Hung load shall be based on minimum loading equivalents of 1 kN/ m^2 for piping and 0.5 kN/m^2 for electrical ventilation and air conditioning.

3. Loading resulting from concentrations of facilities in specific areas shall be substituted where listed base loadings are excluded

4. Cantilever loads of not less than 2000 kg/metre at a distance of 1200 mm from the external face or the columns, on both sides of the ESP, for cable trays and walkways.

5. Cantilever loads of not less than 500 kg/metre at a distance of 1200 mm from the external face or the columns, on both sides of the boiler, for cable trays and walkways.

6. <u>All buildings of the project shall be designed considering solar panel</u>

load at Roof.

8.3 EQUIPMENT, PIPING AND ASSOCIATED LOADS

Equipment loads shall be considered over and above the imposed loads. Equipment loads shall be considered as given by equipment supplier.

8.4 CRANE LOADS

For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of frame according to the provisions of IS:875. The longitudinal crane surge shall be 5% of the static wheel load. Longitudinal surge and lateral surge shall not be considered to act simultaneously.

8.5 SEISMIC LOAD

- Seismic analysis shall be carried out as per the latest edition of IS:1893 (Part 1 & 4). Zone-IV shall be considered for design.
- The structures shall be classified into four categories as per table 5 of IS:1893 (Part4).
- Importance factor for each structure shall be as per Table 2 of IS:1893 (Part4) or mentioned elsewhere in specification , whichever is higher.
- Method of analysis for each structure shall be decided as per clause 10.3 IS:1893 (Part4), which depends on the seismic zone & category of the structure.
- Response Reduction factor shall be as per Table 3 of IS:1893 (Part4).

8.6 WIND LOAD

Basic wind speed at project site is 47m/sec. as per IS:875 Part-3

Probability factor,(k1 risk coefficient), terrain, height and structure size factor, k2 and topography factor, k3 shall be as per IS:875.

8.7 DAMPING IN STRUCTURES

The damping factor to be adopted shall not be more than as indicated below:

Type of Structure		Wind Load	Seismic Load
a)	Welded steel structure	1%	2%
b)	Bolted steel structure	2%	2%
c)	RCC structure	1.6%	5%

8.8 TEMPERATURE LOAD

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint shall be as per the provisions of IS:800 and IS:456 for steel and concrete structures respectively.

Systems and system component design criteria which require ambient temperature extremes shall use the range from 4°C to 46°C for dry-bulb temperatures.

8.9 The following densities shall be considered for design of coal bunkers:

(a) For volume calculations : 800 kg/cum
(b) For structural design : 1200 kg/cum

The coal bunker will be designed as per criteria outlined in IS:9178 (Part I&II)

CHAPTER – 9

STEEL STRUCTURE

GENERAL

Design of structural steel work shall include generally but not be limited to the steel constructions listed below:

Steel building structure and open structures: This shall include beams, columns, bracings, supporting structures for floors, roof slabs, cladding etc.
Crane, gantry girder, monorails etc.
Coal bunkers.
Coal conveyor galleries and trestles.
Large diameter oil tanks.
Large diameter pipe line for cooling water.
Single steel flue for R.C.C. Chimney.
Galvanised latticed structures for switchyard.
Pipe and cable racks.
Platforms and walkways.
Ladders, staircases, handrails etc.

9.1 FRAMING

All buildings/structures shall be either "rigid frame" or "simple space frame" 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.

The power house building design shall be a combination of rigid frame in transverse direction and simple frame in longitudinal direction.

If RCC floor / roof is assumed to act as diaphragm transmitting lateral loads to braced bays, it shall be provided with shear connectors. However, whenever large / more number of cut-outs are provided in the floor slab, horizontal floor bracings shall be provided below slab to transfer horizontal force to columns without considering diaphragm action from slab. 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 and horizontal bracing shall be provided as required in such cases.

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 minimize vibration, avoid resonance and maintain alignment and level.

Pipe rack shall consist of rigid main frame/braced frame in transverse direction spaced longitudinally as required. In longitudinal direction, pipe rack shall be divided into sections of suitable length with an anchor bay. The main transverse frames shall be connected with longitudinal beams, which will transmit horizontal forces to braced anchor bays. The pipe and cable rack bridge structure shall be adequately rigid to carry the forces from pipelines at anchor points without undue deflection so that pipelines are really anchored at the anchor points.

9.2 DESIGN CONCEPTS

All buildings / structures shall be framed structure. Basic consideration for structural framing shall be stability, rigidity, building usage, ease of fabrication / erection and overall economy. Additional bracings / moment connections shall be used to assure stability of structures. Structure shall be designed such that the surfaces of all parts shall be accessible for inspection, cleaning, painting and maintenance

Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc. Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loadings.

The different load combinations shall be taken as per IS:875 (Part-5) and other relevant IS Codes.

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

b. For the design of main plant structures during seismic condition, the deaerator feed water tank shall be considered full upto operating level. However, for other load combinations, deaerator feed water tank in flooded condition shall be considered.

c. In the analysis of main plant building & bunker building, <u>the stresses arising due to temperature must be considered.</u>

d. 'Lifted load' of crane shall not be considered during seismic condition.

e. In case two cranes are provided and tandem operation is not envisaged, the load shall be taken as one crane fully loaded and second crane without lifted load but standing idle adjacent to first crane.

f. In case two cranes are provided and tandem operation is envisaged for some bays, then the load shall be taken as both the cranes fully loaded and standing side for these bays. For other bays, load shall be taken as one crane fully loaded and second crane without lifted load but standing idle adjacent to first crane.

g. Permissible stresses for different load combinations shall be taken as per relevant IS codes.

h. Frictional force between the pipes and supporting structure in longitudinal direction need not be considered along with seismic or wind forces.

The design of steel structures shall be done by Limit state method. Design shall be as per provision of IS:800 (latest) and other relevant IS standards. For design of coal bins and hopper IS:9178 (Part I to III) shall be followed.

Roof decking sheets shall be designed as per IS:801 to carry the self load, dead load due to RCC slab and finishes and imposed load. The deflection of metal deck shall be limited as per BS:5950.

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

For design which requires the use of the minimum column load (such as, uplift on anchor bolts, column axial tension, etc.) The following criteria shall be used in determining minimum load: Use 90% of the column dead load, No live load is used, Uplift forces from vertical bracing are included where applicable and Wind uplift on the roof is included where applicable.

Base plates shall be placed on foundation pedestal with grouting. For large base plates necessary grout holes shall be provided. All anchor bolts for fastening steel columns on foundation shall be embedded in foundation during concreting itself. No anchor pockets in foundation shall be allowed. Design of base plates shall be based on design pressure on foundation which shall not exceed the following:

Pedestal in concrete grade M20	5.0 N / sq.mm
Pedestal in concrete grade M25	6.25 N / sq.mm
Pedestal in concrete grade M30	7.5 N / sq.mm

The total horizontal shear force at the base of column is transferred to the column pedestals through friction between the base plate and the grout. A coefficient of friction of 0.30 shall be used in conjunction with the minimum column load as defined above. If the horizontal shear force exceeds the frictional resistance force or if the column is subjected to a net uplift load, the total force shall then be transmitted through shear bars / shear keys welded to the base plate. Anchor bolts are not assumed to resist any horizontal shear force. Necessary recesses shall be kept in the foundation concrete for shear lugs.

Crane gantry girders shall be single web plate girders of welded construction with bearing and intermediate stiffeners. Crane girder shall be designed as simply supported and of single span length. Chequered plate shall be used for gantry girder walkway flooring. For lifting / monorails beams ISMB sections shall be preferred and the bottom flange of all beams shall be checked separately for distortion and reinforced suitably if required

9.3 PERMISSIBLE DEFLECTIONS

The permissible deflections of various steel members under normal loading 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.

9.3.1 **Vertical Deflection**

a) For beams supporting dynamic equipment : Span / 500
b) For beams supporting floors / masonry : Span / 325
c) For beams supporting pipes : Span / 400
d) For roofing and cladding components : Span / 325
e) For gratings and chequered plates : Span / 200 subject to a maximum of 6 mm

f) Coal/ Ash conveyor gallery bridges : Span / 450
g) For beams directly supporting drive machinery : Span / 500

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

c) The vertical deflection of metal deck sheet for floor / roof shall be limited to : Span / 250.

9.3.2 **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 / 325
d)	Crane gantry girder due to surge	:	Height/200
e)	Building main columns at crane rail level due to action of crane surge load only	:	Height / 2500 limited to maximum of 10 mm
f)	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.

9.4 **MINIMUM THICKNESS OF STRUCTURAL 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 shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgement in each instance.

a)	Trusses, purlins, girts and bracing	6mm
b)	Columns and beams	8mm
c)	Guessets	8mm
d)	Stiffeners	8mm
e)	Base plates	12mm & above
e)	Chequered plates	8 mm o/p & above
f)	Grating flats	5 mm

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

9.5 MINIMUM SIZES

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for platform of all structures shall not be less than 125 mm.

9.6 SLENDERNESS AND DEPTH RATIO

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

The following limiting ratios of depth to span shall 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 columns	1 / 30

9.7 JOINTS / CONNECTIONS IN STEEL STRUCTURES

Steel structures shall be detailed and connection and joints provided as per the provisions of IS:800, IS:9595, IS:1367, IS:9178 and IS:816 and as per following requirements:

9.7.1 a. Welding shall be used for shop fabrication and joints. For siteconnections,welding or high strength friction grip (HSFG) type bolts shall be used, except in few cases for shear connections of lighter members or removable beam connections where bolted (class 4.6) joints may be adopted e.g. purlins, side girts etc. Minimum two bolts of diameter not less than 16 mm per connection shall be used.

b. For high strength friction grip bolt connections IS:4000 shall be followed. High strength friction grip bolts shall be of property class 8.8 or 10.9 and shall conform to IS: 3757 and shall not be less than 20 mm in diameter unless designated otherwise

c. Connection of vertical bracings with connection members and diagonals of truss members shall be designed for full tensile capacity of the bracings unless actual loads are indicated on the drawings.

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

   i) For box section weld size shall be designed for 60% of full shear capacity or actual shear whichever is more. Where filet weld is not possible, full penetration but weld shall be provided.

   ii) For built-up I section or rolled section with cover plates, weld size shall be designed for 80% of full shear capacity or actual shear, (if indicated in drawings) whichever is more. However, weld size shall not be less 0.5 times the web thickness. Weld shall be double fillet.

   iii) All welds shall be continuous unless otherwise specifically approved. The minimum size of the fillet weld shall be 6 mm.

e. Shear connections shall be designed for 75% of section strength for rolled sections and 80% of section strength of built-up section or rolled section with cover plates. However, if actual shear load is more than above, the connection shall be designed for actual load.

f. Moment connection between beam and column shall be designed for 100% of moment capacity of the beam section. This can be achieved either by direct butt welding of the top flange of beam with column flange or by providing top moment plate with suitable notch for additional weld length.

g. All bolts and nuts shall have property class compatible to each other. For bolts carrying dynamic or fluctuating loads and those in direct tension shall be provided with an additional double coil helical spring washer conforming to IS:6755. The threaded portion of the bolt shall project through the nut at least by one thread.

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

i. All butt welds shall be full penetration butt welds.

j. For crane girders, welding between web and flange plates shall be carried out by submerged arc welding process. The connection between top flange and web of crane girder shall be full penetration butt weld. Bottom flange, connection with web can be fillet weld or butt weld as directed by Purchaser. Bearing edges of crane girders shall be machine finished.

k. Connection of base plate and associated stiffeners with the columns shall be designed considering the total load transferred through welds. However, minimum weld size (double fillet) shall not be less than 0.6

times the thickness of stiffeners. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection.

l. <u>Splicing shall be carried out with welding/ HSFG Connection (Grade 8.8 and 10.9 bolts)</u>

All work shall be full strength. Field splicing shall be done with web and flange cover plates for full strength. In exceptional cases, the field splicing shall be designed for 50% of load carried by the cover plates and remaining 50% load through full penetration butt weld. Shop splicing for all sections other than rolled shall be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections shall be carried out using web and flange cover plates.

9.7.2 All bolted connections shall have bolts of minimum 16 mm dia. The connections of stairs and handrailing shall be made with 20 mm diameter threaded fasteners conforming to IS:1363. Erection bolts shall be black bolts of minimum 12 mm dia.

9.7.3 Efficiency of site welds to be considered shall be as follows:

a) Butt weld above 25 m from ground : 50%
b) Others : 80%

9.8 REQUIREMENTS FOR SPECIFIC STRUCTURES

9.8.1 Large Diameter Oil Tanks

Design, fabrication and erection of the cylindrical welded storage tank shall follow the provisions of IS:803. The stresses in the tank shall be computed on the assumption that tank is filled with water. Tension in each course shall be computed at 30 cm above the centreline of lower horizontal joint of the course under consideration.

Wind and internal vacuum loads shall be considered together to check the stability of tank.

Joint efficiency factor shall be taken as 0.85 for butt joints to determine the minimum thickness of shell plates provided all the vertical and horizontal butt welds are spot radiographed. Where welds are not inspected by radiography joint efficiency factor of 0.7 shall be used. However it is recommended that all butt welded joints shall be radiographed.

Minimum thickness of shell plate shall be as given in clause 6.3.3.2 of IS:803 to which corrosion allowance shall be added. Maximum thickness of shell plate shall not exceed 40 mm. Width of shell plate shall not be less than 1500 mm.

Bottom plate uniformly resting on the substructure shall have a minimum thickness of 6 mm for tank upto 10 m in diameter and 8 mm for higher diameter. Bottom plate shall project at least 25 mm allround beyond the outer edge of weld attaching the bottom to the shell plate.

For large diameter oil tanks supported cone roof shall be provided. Arrangement of columns and rafters shall in general be as per fig 9 and 10 of

IS:803. Roof plates shall have a minimum thickness of 6 mm and shall not be attached to the supporting member. A curb angle shall be provided at the top of the shell in line with clause 6.3.6.2 of IS:803. Roof plates shall be attached to the curb angle with a continuous fillet weld on the top side only. Minimum slope of roof shall be 1 in 16.

Rafter clips for the outer row of rafters shall be welded to the shell. Columns shall not be rigidly attached to the bottom plates guide. Clips shall be welded to the tank bottom to prevent lateral movement.

Roof supporting columns shall be made from structural shapes or pipe or built up section. Suitable base frames or reinforcing pads shall be provided at the column base to distribute loads coming on the tank bottom.

Appurtenances and mountings covered under section 7 of IS:803 shall be provided in addition to any other appurtenance which the BIDDER considers essential for the safe and smooth operation of the fuel oil storage and oil handling system.

After erection and inspection of the tank, the tanks shall be tested as per clause 12 of IS:803. Leakage, if any noticed shall be repaired to the satisfaction of the OWNER and the tank retested to satisfy acceptance criteria.

9.8.2 Large Diameter Steel Pipes

Design, installation and testing of the pipe shall be, in general, conforming to latest edition of "Steel pipe - A guide for design and installation" – AWWA Manual M11 – published by American Water Works Association. Pipes shall be as per IS:3589, fabricated from steel plates conforming to IS:2062. Piping shall be designed for pump shut-off pressure or 1.5 times the maximum pump head whichever is higher. Thickness of the pipe shall also be adequate to withstand full vacuum in the pipe. Also, the pipes shall be hydro-tested at a pressure of 1.5 times the design pressure. Thickness of the pipes shall be calculated as per requirement of AWWA M11 and / or ASME B31.1. Underground large diameter piping shall be laid with minimum earth cushion of 1500 mm. A surcharge of 2 t/sq.m in addition to backfill shall also be considered. The pipes shall be given an internal coating with epoxy paint 250 micron. Where pipes are not encased wrapping as per IS:10221 shall be provided outside. Underground large diameter piping shall be given sand bedding conforming to requirements of IS:5822. The minimum thickness of sand bed under bottom of pipe shall be 100 mm. At locations of the change of flow direction thrust blocks shall be provided as per requirement of hydraulic transient analysis. Double kinetic type air-cum- vacuum valves shall be provided at locations as per requirement of hydraulic transient analysis. The complete piping system shall be line tested before commissioning of the system. All site joints shall be inspected by radiography

9.9 PAINTING

a. All steel structures shall receive two primer coats and two finish coats of painting. First coat of primer shall be given in shop after fabrication before dispatch to erection site after surface preparation as described below. The second coat of primer shall be applied after erection and final alignment of the erected structures. Two finish coats shall also be applied after erection.

b. Steel surface which is to paint, shall be cleaned of dust and grease and the heavier layers of rust shall be removed by chipping prior to actual surface preparation. The surface shall be cleaned to grade ST-2 as per SIS05-5900 or as per IS:1477(Part-1). Primer paint shall be redoxide zinc cromate confirming to IS:2074. Dry film thickness of each coat shall be 25 microns.

Finish paint shall be as follows:-

Structure	Prime coat (Micron)	Intermediate coat (Micron)	Top coat (Micron)	Total Dft (Micron)
Station building, Boiler structure, Mill & bunker bay structure, ESP structure, Misc Covered structure	Inorganic zinc silicate 1x75		HB epoxy polyamide (pigmented) 1x75	150
DM plant	Inorganic zinc silicate 1x75	HB MIO Epoxy 1x75	Aromatic poly-Urethane acid resistant 1x50	200
Coal handling and ash handling structures	Inorganic zinc silicate 1x75	HB MIO Epoxy 1x75	HB epoxy polyamide (pigmented) 1x75	225
Pipe and cable rack and misc open structure	Inorganic zinc silicate 1x75		Aliphatic poly-urethane (UV resistant) 1x50	125

All paints shall be of approved brand and shade as per the OWNER's requirement.

c. Joints to be site welded shall have no paint applied within 100 mm of welding zone.

Similarly where Friction grip fasteners are to be used no painting shall be provided. On completion of the joint the surfaces shall receive the paint as specified.

d. Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly.

Surfaces inaccessible after erection including top surfaces of floor beams supporting gratings or chequered plate shall receive one additional coat of finish paint over and above number of coats specified before erection. Portion of steel member embedded / to be encased in concrete shall not be painted.

Painting shall not be done in frosty or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted.

9.10 CODES AND STANDARDS

All steel materials shall comply with the following IS:-

i)	IS:801	-	Cold formed light gauge steel structural member.
ii)	IS:2062	-	Grade – A, Structural Steel for plate thickness upto 20mm
iii)	IS:2062	-	Grade – B (Killed), Structural Steel for plate thickness above 20mm
iv)	IS:2062	-	Grade – C, for crane gantry girder in turbine hall.
v)	IS:806	-	Steel tubes in general building construction.

b. Electrodes

The arc welding electrodes shall conform to the relevant IS; and shall be of heavily coated type having uniform thickness. 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. All electrodes shall comply with the following IS:

i)	IS: 814	-	Covered electrodes for metal arc welding structural steel
ii)	IS:815	-	Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.
iii)	IS:7280	-	Base wire electrode for submerged arc welding.

c. Bolts and nuts

All bolts and nuts shall conform to the requirements of IS:1367 - Technical Supply Conditions for Threaded Fasteners. Materials for bolts and nuts shall comply with the following IS codes. Mild steel for bolts and nuts tested to following IS shall have a tensile strength of not less than 44 Kg/mm2; and 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 :

i)	IS:1367	-	Technical supply conditions for threaded fasteners.
ii)	IS:1608	-	Method for tensile testing of steel other than sheet, strip, wire and tube.

iii) High tensile steel material shall have the mechanical properties as per IS:1367 or as approved by the Engineer.

d. Washers

Washers shall be made of steel conforming to the following IS:

i)	IS:1977	-	Structural steel (Ordinary Quality) St-39-0
ii)	IS:2062	-	Steel for general structural purpose

iii) IS:6623 - High Strength Structural Nuts
iv) IS:6649 - Hardened and tampered washers for high strength structural bolts & nuts.

9.11 FABRICATION OF STRUCTURAL STEEL WORK

9.11.1 The details of fabrication, shop testing and delivery to site of structural steel work including supply of all consumable stores, bolts, nuts, washers, electrodes and other materials as required including field connections are indicated below to be performed by the contractor:

a. Preparation & submission of complete detailed fabrication drawings and erection marking drawings as required including design calculations.

b. Furnish all materials, labour, tools & plant and all consumables required for fabrication and supply of all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections.

c. Furnish shop painting of all fabricated steelwork as specified.

d. Suitably mark, bundle and pack for transport all fabricated materials.

e. Prepare and furnish detailed bill of materials, dispatch lists (including bought out items) as required for fabrication of structural steelwork.

f. Load and transport all fabricated steelwork to site with field connection materials.

g. Maintain a fully equipped fabrication shop at site for modification and repairs as required.

No work under this specification will be provided by any agency other than the Contractor, unless specifically mentioned otherwise elsewhere in the contract.

9.11.2 Conformity with designs

The contractor shall design all connections, supply and fabricate all steelwork and furnish all connection materials in accordance with the approved drawings. The method of painting, marking, packing and delivery of all fabricated materials shall be as approved by the Engineer.

9.11.3 Materials to be used

Standard structural steel sections shall be used instead of fabricated steel sections as far as possible.

All steel materials required for the work shall be supplied by the contractor.

9.12 STORAGE OF MATERIALS

a. All materials shall be stored to prevent deterioration ensuring 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. The contractor shall maintain upto date account 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 shall be stacked separately with easily identifiable marks.

b. The steel used for fabrication shall be stored in separate stacks off the ground section-wise and lengthwise so that they can be easily inspected, measured and accounted for at any time. If required by the Engineer, the materials should be stored under cover and suitably painted for protection against weather.

c. 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].

d. Bolts, nuts, 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.

e. Paints shall be stored under cover in airtight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

9.13 INSPECTION OF FABRICATION WORK

As far as possible, all inspections by the Engineer shall be made at the contractor's fabrication shop. The contractor shall co-operate with the Engineer 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 & plant, 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 would be rejected at any time during the progress of the work.

The dimensions, forms, weights and tolerances of all rolled shapes, bolts, nuts, studs, washers etc. and other members used in the fabrication shall, wherever applicable, conform to the requirements of the latest relevant IS.

9.14 FABRICATION DRAWINGS

The sequence of submission of fabrication drawings for approval shall match with the approved fabrication and erection schedule. It should be ensured that the correctness of general arrangement for centerline dimensions and levels, section sizes, and adequacy of connections including splice joints as to the number of bolts, weld length, size of gusset/end plates are maintained. 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 spec.

The fabrication drawings shall include but not be limited to the following:

i) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

ii) Dimensional drawings of base plates, foundation bolt location etc.

iii) Details of all connections with supporting calculations.

iv) Any other drawings or calculations that may be required for the clarification of the works.

The fabrication drawings shall give all the necessary information for the fabrication, erection and painting of the steelwork in accordance with the provisions of this specification. Fabrication drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Fabrication drawings shall give complete information necessary for fabrication of various components of the steelwork, including the location, type, size and extent of welds. These shall also clearly distinguish between fabrication 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 fabrication drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence; and technique of welding shall be carefully controlled to minimize the locked -up stresses and distortion. Welding symbols used shall be in accordance with the requirements of IS:813; and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

9.15 WORKMANSHIP

a. All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of IS:800 and other relevant Indian standards or equivalent.

b. 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 IS:1852. If straightening is necessary, it shall 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.

c. Cutting shall be effected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch is permitted for mild steel only. Gas cutting of high tensile steel is 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 shall be permitted if special care is taken and done under expert hand.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, subjected to substantial stress or which 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.

d. Finishing of sheared or cropped edges of plates or shapes of edges gas-cut with 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.

e. 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.

f. Bolted construction:

i) 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 shall 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 black bolts shall be not more than 1.5 mm or 2 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 to IS:919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thicknesses 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.

ii) 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 to 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 connection as may be specified.

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 indicated on the drawings.

g. Welded Construction

i) Welding shall be in accordance with relevant IS. Welding shall be done by experienced and good welders qualified by tests in accordance with IS:817. Surfaces 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.

ii) 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.

iii) 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 shall be made by shop splicing not more than 3 sub-sections, each made in accordance with this paragraph. Welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant IS.

iv) 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 joint in a manner ensuring soundness. Where possible, this should be done by use of extension bars or run-off plates which need not be removed upon weld completion. 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 conform to the relevant IS.

v) If welding is to be undertaken at low temperature, adequate precautions as recommended in relevant IS shall be taken. 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 20oC, all requirements regarding preheating of the parent material shall be in accordance with the relevant IS.

vi) Where required, intermediate layers of multiple-layer welds shall be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld is cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld & base metal from over peening.

vii) The equipment shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of type and capacity as recommended by the electrode manufacturer.

viii) Column splices and butt joints of compression members 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 mm.

ix) Bases and caps fabricated out of steel plates, 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. The ends of lacing bars shall be neat and free from burrs. 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. Provision shall be made for all necessary steel bearing plates to take up reaction of beams & columns and the required stiffeners & gussets whether or not specified. Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

x) All shop connections shall be welded as specified. Certain shop connections, may be changed to field connections if desired by the Engineer for convenience of erection; and the contractor shall make the desired changes. The steelwork shall be temporarily shop-erected complete so that accuracy of fit may be checked before dispatch. The parts shall be shop-erected with a sufficient number of parallel drifts to bring and keep the parts in place. In case of parts drilled or punched using steel jigs to make all similar parts interchangeable, the steelwork shall be shop erected facilitating the check of interchangeability.

9.16 TESTING, ACCEPTANCE CRITERIA AND DELIVERY

a. The contractor shall carry out testing as per IS. The contractor shall get the specimen tested in a laboratory approved by the Engineer and test results shall be submitted to the Engineer in triplicate within 3 days after completion of the test. All electrodes shall be procured with test certificates. The correct grade and size of electrodes not deteriorated in storage shall only be used. The testing of welding shall be performed as under with quantum of minimum non-destructive tests to be conducted during fabrication and after erection as below:

VISUAL EXAMINATION

All welds shall be 100% visually inspected to check the following:

Presence of undercuts
Surface cracks in both welds and base metals.
Unfilled craters
Improper weld profile and size
Excessive reinforcement in weld
Surface porosity

Before inspection, the surface of weld metal shall be cleaned of all slag, spatter matter, scales etc. by using wire brush or chisel.

DYE PENETRATION TEST (DPT)

This test shall be carried out for all important fillet welds and groove welds to check the following:
Surface cracks
Surface porosities

Dye Penetration Test shall be carried out in accordance with IS: 3658 or equivalent American National Standard ASTME165.

5% of the total length, dye-penetration test shall be carried out to the root and final run for fillet welds.

10% of the total length, dye-penetration test shall be carried out to the root run after back gouging for butt welds.

ULTRASONIC TESTING

All butt weld shall be tested for 100% length by ultrasonic test to detect the following:
Cracks
Lack of fusion
Slag inclusions
Gas porosity

Ultrasonic testing shall be carried out in accordance with IS: 3664, IS: 4904 or equivalent American National Standard ANSI / AWS D1-92 Chapter 6: Part C.

Before Ultrasonic test is carried out, any surface irregularity like undercuts, sharp ridges etc. shall be rectified. Material surface to be used for scanning by probes must allow free movement of probes. For this purpose, surface shall be prepared to make it suitable for carrying out ultrasonic examination.
All butt-welds in beams, girders & columns will be of full penetration. Butt welds shall be radiographically or ultrasonically tested as per IS: 822 and standard practice.

Plates above 25 mm thickness shall be subject to ultrasonic test as per ASTM-A435 or equivalent to check the presence of lamination

<u>RADIOGRAPHIC TESTING(X – RAY AND GAMMA – RAY EXAMINATION)</u>

Generally, splicing shall not be provided in tension flange of bunker girder<u>. For structures supporting bunkers and deaerator, 100% length of all butt welds shall be tested. For other structures, this test shall be limited to 2% of length of welds of each element of butt joints for welds made by manual or semi-automatic welding and 1% of length of weld if made by automatic welding machines.</u> The location and extent of weld to be tested by this method shall be decided by OWNER to detect the following defects:

gas porosity
slag inclusions
lack of penetration
lack of fusion
cracks

When radiograph is not possible due to inaccessibility to the satisfaction of ENGINEER In-Charge, ultrasonic test shall be carried out after grinding the surface.

Radiographic testing shall be conducted in accordance with IS 1182, IS 2595, IS 3657 or equivalent American National Standard ANSI / AWSD1.1- 92.
Any surface irregularity like undercuts, craters, pits, etc. shall be removed before conducting radiographic test. The length of weld to be tested shall not be more than 0.75 x focal distance. The width of the radiographic film shall be width of the welded joint plus 20 mm on either side of the weld.

CONTRACTOR shall provide testing equipment for conducting non-destructive tests for confirming the integrity of welding wherever necessary as directed by the OWNER..

In cases, the test results shows deficiency, the Engineer shall have option to reject or instruct any remedial measures to be carried out by the contractor.

b. All bolts, nuts and washers shall conform to the relevant IS. If desired by the Engineer, representative samples of these materials should be tested in an approved laboratory and in accordance with the procedures described in relevant IS. All paints and primers shall be of standard quality and shall conform to the provisions of the relevant IS. The tolerances on the dimensions of individual rolled steel components shall be as per IS:1852. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures subjected to dynamic loading (like wind, seismic etc.) and thin walled construction (like box girders) shall be as per IS:7215.

c. Should any structure or part of a structure be found not to complying to the provisions of the 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.

When all tests to be performed in the contractor's shop have been successfully carried out, the steelwork will be accepted forthwith; upon receipt of which, the items shall be shop painted, packed and dispatched. No item should 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 Purchaser to accept the work, should it, on further tests before or after erection, be found not in compliance with spec.

d. The contractor should deliver the fabricated structural steel materials to site with all necessary field connection materials in a sequence permitting an efficient and economical performance of the erection work. The Purchaser may prescribe or control the sequence of delivery of materials, at his own discretion. 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.

9.17 RECTIFICATION OF DEFECTS IN WELDS

Limits of Acceptability of welding defects shall be as follows.

Visual inspection and Dye Penetration Test

The limits of acceptability of defects detected during visual inspection and Dye Penetration Test shall be in accordance with clauses 8.15.1 and clauses 9.25.3 of American National Standard ANSI / AWS D1.1-92 respectively, for statically and dynamically loaded structures.

Ultrasonic Testing

The limits of acceptability of defects detected during ultrasonic testing shall be in accordance with clause 8.15.4 and clause 9.25.3 of American National Standard ANSI / AWS D1-92 respectively, for statically and dynamically loaded structures.

Radiographic Testing:

The limits of acceptability of defects detected during Radiographic testing shall be in accordance with clause 8.15.3 and 9.25.2 of American National Standard ANSI / AWS D1.1-92 respectively for statically and dynamically loaded structures.

In case of detection of defects in welds, the rectification of the same shall be done as follows:

i) All craters in the weld and breaks in the weld run shall be thoroughly filled with weld.

ii) Undercuts, beyond acceptable limits, shall be repaired with dressing so as to provide smooth transition of weld to parent metal.

Welds with cracks and also welds with incomplete penetration, porosity, slag inclusion etc., exceeding permissible limits shall be rectified by removing the length of weld at the location of such defects plus 10 mm from both ends of defective weld and shall be re-welded. Defective weld shall be removed by chipping hammer gouging torch wheel. Care shall be taken not to damage the adjacent material.

9.18 ERECTION OF STRUCTURAL STEEL WORK

9.18.1 The works related to the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials arriving at site, installing the same in position, painting and grouting the stanchion bases all complete are detailed below:

a. Providing all construction & transport equipment, tools, tackles, consumables, materials, labour and supervision as 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.

c. Transportation of all fabricated structural steel materials from site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation in proper location as per approved erection drawings. If necessary suitable temporary approach roads should be built for transportation.

d. Checking centerlines, 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 as per drawings.

f. Painting of the erected steel structures.

g. 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.

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 drilled in incorrect location during fabrication.

9.18.2 The work shall conform to the latest revisions of the following IS Codes:

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-12840	: Tolerance for erection of Steel Structures

9.18.3 Conformity with designs:

The contractor should erect the fabricated steel structures, align all the members, complete all field connections as per approved drawings. All works shall conform to the provisions of the relevant IS. The testing and acceptance of the erected structures shall be in accordance with the provisions of this specification.

9.18.4 a. The contractor should take delivery of all the materials at site. He shall unload the materials and perform all formalities such as checking of materials and attend to insurance matters as specified above.

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. All field connection materials such as bolts, nuts, washers and electrodes, other consumables such as oxygen and acetylene gas, paints, fuels, lubricants, oil, grease and any other material as required for the execution of the works shall be supplied by the contractor for erection work.

b. All materials shall be stored preventing deterioration and ensuring 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. The contractor should establish a suitable yard at site for storing the fabricated steel structures and other materials. The yard shall have proper facilities such as drainage, lighting, suitable access for large cranes, trailers and other heavy equipment. 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. 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.

c. The contractor shall establish and maintain quality control procedures for different items of work and materials; and shall submit the records of the same to the Engineer. The quality control operation shall include but not be limited to the following:

i) Erection : Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

ii) Painting : Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

9.19 WORKMANSHIP

a. The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition. The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange in most economical method; and sequence available to him consistent with the drawings.

b. Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install, 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 during the course of the erection of the steel framing, arrangement for installation by the erector shall be made.

The responsibility of the contractor in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, leveled, 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 erection

c. Positioning and leveling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be as per approved drawings. Anchor bolts and other anchor steel shall be embedded. 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, the contractor shall set proper screed bars to maintain proper level. Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable. No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

d. All relevant portions in respect of bolted construction for fabrication of structural steelwork shall also be applicable for field bolting as below:

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 light 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. High tensile bolts shall be tightened to provide the required minimum bolt tension by any of the following methods:-

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 as below 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.

Bolts shall 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 shall be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

Torque Wrench tightening: When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques as below. 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.

Nominal bolt diameter (mm)	Torque to be applied for bolt class 8.8 of IS:1367 (Kgm)
20	59.94
22	81.63
24	103.73

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 shall 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 as per IS.

e. Field Welding: All field assembly and welding shall be carried out as specified for fabrication work, 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.

f. Holes, cutting and fitting: No cutting of sections, flanges, webs, cleats, bolts, welds etc. shall be done. 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. 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.

9.20 DRIFTING

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock shall be considered as permissible. For this, light drifting shall 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 shop work error 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.

9.21 LOAD TEST AND ACCEPTANCE CRITERIA

a.) Loading tests shall be carried out on erected structures 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 be dismantled and replaced with suitable member. On the basis of the tests, the Engineer will decide and his decision will be final. 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

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 below:-

i) 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.

ii) 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.

b.) Structure of same design:

Where several identical same design structures exists as a prototype, one structure shall be fully tested, 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.

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 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.

c.) Repair for subsequent test and use after strength tests: The structure passed the "Strength Test" as above 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 above.

9.22 TOLERANCES

Considering expected variation in the finished dimensions of structural steel frames, these shall be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabrication tolerances for the finished parts; and the rolling tolerances for the profile dimensions permitted under the specification for fabrication of structural steelwork shall be as indicated below:

	Component	Description	Variation Allowed
a	For Buildings Containing Cranes		
	i) Main Colomn	a) Shifting of column axis at foundation level withrespect to building line	
		i) In longitudinal direction	(+/-) 3.0mm
		ii) In lateral direction	(+/-) 3.0mm
		b) Deviation of both major column axis from vertical between foundation and other member connection levels :	
		i) For a column upto including 10M	(+/-) 3.5 mm and from true height vertical
		ii) For a column greater than 10M but less than 40M height	(+/-) 3.5 mm from true vertical for length measured between conne-ction 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 mm

	Component	Description	Variation Allowed
		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
	ii) 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 of supports.	1/250 of depth of truss or 20 mm whichever is the least.
	iii) Cranes Girders & Tracks	a) Difference in levels of crane rail measured between adjacent columns.	2.0 mm
		b) Deviation to crane rail gauge	(+/-) 3 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 ofweb.	(+/-) 3.5 mm
	iv) Setting of expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C. The coefficient of expansion or contraction shall be taken as 0.000012 per Deg.C per unit length.	
b	For Buildings without Cranes		
	The maximum tolerances for line and level of the steel work shall be ±3mm on any part of the structure. The structure shall not be out of plumb more than 3.5 mm on each 10 m section of height and not more than 7 mm per 30 m section. These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.		

9.23 QUALITY CONTROL PROCEDUREp

The contractor shall establish & maintain quality control procedure for different items of works and material to ensure that all works are performed as per specification.

Contractor shall got approved field quality plan for all the works to be executed

Quality plan shall be prepared based on guide lines furnished in Volume-II of the specification.

CHAPTER – 10

REINFORCED CONCRETE STRUCTURES AND FOUNDATIONS

10.1 GENERAL

All structures, building foundation, machines / equipment foundation, water retaining structure, trenches, pits, etc., shall be designed as per relevant IS codes in general. Construction in general shall follow provisions of IS: 456 and IS: 3370 for normal and water retaining structures respectively.

10.2 DESIGN METHODOLOGY

a) All design of RCC structures shall be carried out by limit state method as per IS: 456-2000. Working stress method shall be adopted for the design wherever specifically mentioned in this specification.

b) For all concrete structures, ductile detailing has to be done as per IS: 13920 and IS: 4326.

c) For reinforcement detailing, IS: 5525 and SP34 shall be followed.

d) RCC Silo shall be designed as per IS:4995(Part1&2)

e) Two layers of reinforcement (on both inner and outer faces) shall be provided for RCC wall sections having thickness 150mm or more.

10.3 FOUNDATION AND UNDERGROUND STRUCTURES

a) Foundation system to be adopted for structures shall be based on loading arrangement, load intensity and soil strata.

b) All RCC liquid retaining structures shall be designed as uncracked section for water face and cracked section with crack width limited to 0.1 mm for earth face in accordance with IS:3370 (Part 1 to 4) by working stress method, using limited steel stress. For all other underground structures such as conveying structures / slurry pump house/ pump houses / underground structures such as tunnels, reclaim hopper pit, not in contact with liquid on inside face may be designed as cracked sections with crack width limited to 0.1mm for both faces.

c) Only CW Forebay & CW Channel may be designed for crackwidth as 0.2mm for earth face in accordance with IS:3370 (Part 1 to 4) by working stress method, using limited steel stress. However water face to be designed as uncracked section.

d) All liquid retaining / carrying structures shall be tested for water tightness as per the provisions of IS: 3370 and IS: 6494 and in case of leakage, the same shall be rectified by chemical injection grouting through nozzles.

e) Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest. Co-efficient of passive earth pressure shall be used only in design of shear keys for stability against sliding.

f) In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. No pressure releaving devices shall be permitted in underground structures except forebay & CW Channel.

g) For design of all underground structures, including CW ducts, pump house and forebay etc. ground water table shall be assumed at the finished ground level unless specified otherwise. In addition to ground water pressure, minimum surcharge load of 2 T/M^2 shall also be considered for design of all underground structures.

h) All building sub-structures including pump houses shall be checked for sliding, uplift and overturning stability during both construction and operating conditions for various combinations of loads. Factor of safety for these cases shall be as per IS: 456 and other relevant IS codes. However, following minimum factor of safety shall be followed.

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

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

iii) Factor of safety against uplift due to hydrostatic forces shall be 1.2 considering empty condition inside and ignoring the superimposed loading. For purpose of calculating downward load due to overburden, only the mass located vertically above the projected area of base slab shall be taken into account.

In cases where dead load provides the restoring forces, only 0.9 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

10.4 GROUTING

i) Non-shrink flow able grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticizer admixture shall be added in the grout. For grouting of base of machine foundation high strength flow able ready mixed non-shrink grout shall be used.

ii) Type and grade of grouting for structural columns and equipment bases shall be indicated. Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M30.

iii) Nominal thickness of grouting shall be at least 50 mm for building columns and pedestals of major equipment. For secondary posts, stair and ladder base, etc. grouting shall not be less than 25 mm thick.

10.5 EDGE DISTANCE FOR BOLTS

Minimum distance from the center line of foundation / anchor bolt to edge of pedestal shall be the maximum of the following:

i) Clear distance from the edge of base plate / base frames to the outer edge of the pedestal shall be minimum 50 mm.

ii) Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm.

iii) Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm.

10.6 LOADING CONDITIONS FOR UNDERGROUND STRUCTURES

Following loading conditions shall be considered in addition to the loading from super structure for the design of substructure of pump house, channels, sumps, tanks, trenches and other underground structures containing liquid.

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

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

c. Design shall also be checked against buoyancy due to the ground water during construction as well as after construction stages. Minimum factor of safety against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loadings. Provision of pressure relief valves / flap valves, etc. may be considered only in forebay of CW Pump House & CW Channel to counter the buoyancy. When pressure relief valves are used, 60% of the hydrostatic pressure shall be considered for design of the base slab.

d. Base slab of the pump houses shall also be designed for the condition of different combination of pump sump being empty during maintenance stages with maximum ground water level.

e. Intermediate dividing pier of pump sumps and partition wall (if applicable) in channel shall be designed considering water on one side only and other side being empty for maintenance.

f. All pump houses and other substructures (wherever applicable) shall be checked for stability against sliding and overturning during construction as well as operating conditions for various combinations of loads.

10.7 MACHINE FOUNDATIONS

Turbo- Generator (TG) foundation:

TG foundation shall be supported on vibration isolation system.The vibration isolation system shall consist of steel helical spring units and viscous dampers supporting the RCC deck which would support the machine. The spring units shall conform to DIN 2089 and DIN 2096.

GERB or equivalent manufacturer's vibration isolation system shall be supplied for supporting TG foundation.

Isolation efficiency of at least 90% shall be provided for the Turbo generator.

TDBFP & MDBFP foundations:

Alternative-1

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

Alternative-2

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

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

BFPs in ground floor

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

PA/ FD/ID Fan foundations:

Alternative-1

These fan foundations shall consist of RCC top deck supported on steel helical springs & viscous dampers. The springs & viscous dampers shall be in turn supported on RCC sub-structure which shall be supported below Ground level.

Alternative-2

These fan foundations shall consist of RCC top deck supported on RCC sub-structure which shall be supported below Ground level either with open or pile foundation.

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

Coal Mill foundation:

Alternative-1

These foundations shall consist of RCC top deck supported on steel helical springs & viscous dampers. The springs & viscous dampers shall be in turn supported on RCC sub-structure which shall be supported below Ground level.

Alternative-2

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

General requirement for machine foundations:

- The vibration isolation system (where ever applicable) supplied shall be of proven make and shall be in successful operation supporting machines like steam turbogenerators,
- Springs and dampers of the vibration isolation system shall be located minimum 300 mm above the finished floor level for ID/PA/FD fans. Basements/pits/trenches shall not be provided for these machine foundations.
- Wherever alternative-2 is adopted by the bidder for BFPs or FAN foundations, suitable provisions to be ensured by the bidder in their General Arrangement and design to prevent transmission of vibration from these machine foundations to other nearby structures / foundations.
- The bidder or his consultant should have adequate prior experience in design of machine foundations for the respective alternative to be adopted by the bidder and the machines should be in successful operation for at least one year prior to the date of submission of bid.

10.7.1 **a) Design of Foundation for TG, TDBFP, MDBFP & Fan foundations**

(i) The Scope of Work for Bidder for the design shall consist of the following:

- Finalization of the general arrangement layout and levels of the foundation for TG, TDBFP, MDBFP & FAN foundations based on the equipment layout keeping in view the layout constraint and limitations of available space.

- Submission of design criteria and loading data of the equipment foundations.

- Analysis of the top deck, design and detailing of the reinforcement and finalization of the spring arrangement.

- Submission of all design calculation, all loading drawings, general arrangement drawings, embedment drawings, spring arrangement drawings and reinforcement drawings for the foundations under the scope for the approval of the Owner. 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.

- Submission of construction methodology / casting sequence and special requirements (if any) for the top of deck.
  Arrangement of foundations for various machine foundations like TG, TDBFP & MDBFP & FAN and Coal Mills shall be as specified elsewhere in this specification.

(ii) Analysis for the foundation

For the foundations of the all equipments, details static and dynamic analysis shall be done. The static analysis shall include all operating condition, load cases and abnormal loads like short circuit, loss of blades & unbalance and seismic forces as per IS:1893.

The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. A minimum fatigue factor of 2.0 shall be considered for dynamic forces. The vibration amplitudes shall be calculated at the machine bearing locations and at any other points of interest by a forced response analysis. The unbalance forces used for this analysis shall correspond to the balance quality grade of the machine as per VDI 2060 or the unbalance forces as provided by the machine manufacturer whichever is higher. It shall be ensured that the calculated amplitudes do not exceed the limits specified by the machine manufacturer and relevant Standards such as VDI 2056.

Bidder to consider the acceleration at the top of the deck for the design of supporting / fixing arrangement of machine.

(iii) Design criteria for steel helical springs and viscous dampers

The isolation efficiency for steel helical springs and viscous dampers shall be at least 90%. The ratio of actual spring supported weight to the nominal spring capacity shall not exceed 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

(iv) Grade of Concrete and reinforcement

Grade of concrete for Top deck shall be minimum M35 conforming to IS: 456-2000. The grade of reinforcement for Top deck shall be Fe500D (TMT) conforming to IS: 1786.

(iv) Reinforcement Design

Working stress method as per IS: 456-2000 shall be used for reinforcement design. The design shall be done for the worst load combination. Minimum reinforcement shall be provided as per IS: 456-2000 and IS: 2974 (Part-III), if the calculated reinforcement is less than the minimum.

Block Foundations:

a) Block foundation resting on soil shall be analyzed using elastic half space theory/Barkan's method. In case the foundation is supported over piles, Novak's approximation shall be used for determining the spring constant and damping ratio of pile groups. The mass of the RCC block shall be at least three times the mass of machine. Free vibration analysis of the foundation shall be carried out to evaluate the natural frequencies. The fundamental natural frequency shall be kept at least 20% away from the operating frequency (speed). Forced vibration analysis shall be carried out if the dynamic forces are made available by the machine supplier in which case the amplitude limits stipulated by the machine supplier and VDI 2056, whichever is lower, shall be satisfied. Reinforcement design shall be done by working stress method as per IS: 456-2000 and IS: 2974 (Part-IV).

b) For the foundations supporting minor rotating equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor equipment is to be supported on building structure, floors, etc., suitable vibration isolation shall be provided by means of springs, neoprene pads, etc., and such vibration isolation system shall be designed suitably.

Steel Helical Springs and Viscous Dampers

General Requirement:

This part of the specification covers the requirement for the manufacturing, testing, supply, and transport to site, pre-stressing erection, supervision of erection by the vendor, release of pre-stress, alignment, commissioning, etc. of Steel helical springs and viscous dampers.

The Steel helical springs and viscous dampers supplied should be of proven make.

Codes and Standards:

Some of the relevant applicable Indian standards and codes, etc, applicable to this section of the specification are listed below:

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

Design & Supply of Material

i) Supply

Steel helical springs and viscous dampers and associated auxiliaries shall consist of:

(a) 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.

(b) Frames for pre-stressing of spring elements.

(c) Suitable hydraulic jack system including electric pumps, high pressure tubes etc. required for the erection, alignment etc., of the spring units. One set of extra hydraulic jacks, and hand operated pumps shall also be provided.

(d) Any other items which may be required for the pre-stressing, erection, release of pre-stress, alignment, and commissioning of the Steel helical springs and viscous dampers.

ii) Design

The spring units should have stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 50% of vertical stiffness. The stiffness should be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is not more than 3 Hz. The damper units or spring-cum-damper units should be of viscous type offering velocity proportional damping. The damper units should be suitable for temperatures ranging from 0 to 50°C. The damping resistance of individual damper units should be such that the designed damping can be provided using reasonable number of Units.

The Steel helical springs and viscous dampers shall be designed for a minimum operating life of 30 years.

Manufacturing & Testing

Complete manufacturing and testing of the Steel helical springs and viscous dampers shall be done at the manufacturing shop of the approved sub vendor / supplier. For this purpose the contractor / sub vendor shall submit the detailed quality plan for approval of engineer and take up the manufacturing / testing after approval of such quality plan. The quality plan shall include

(a) Manufacturing schedule and quality check exercised during manufacturing.

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

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

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

(e) Manuals for erection, commissioning, testing and maintenance of the Steel helical springs and viscous dampers.

(f) A checklist for confirming the readiness of the civil fronts for erection of Steel helical springs and viscous dampers.

(g) Checklist for equipment required at each stage of erection.

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

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

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

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

Transportation

Steel helical springs and viscous dampers shall be suitably protected, coated, covered, boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection.

Erection and Commissioning

Complete erection and commissioning of the Steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre-stress in spring elements, making final adjustments and alignments etc. shall be carried out by a specialist supervisor of vendor.

The contractor shall guarantee the performance of the Steel helical springs and viscous dampers for 24 months from the date of commissioning of each machine which shall be termed as Guarantee Period".

Supervision

The supervision of installation of Steel helical springs and viscous dampers including pre-stressing, placing, releasing and alignment of spring units shall be done by a specialist supervisor of sub vendor / supplier, trained for this purpose.

Realignment of Spring System

If any realignment of the Steel helical springs and viscous dampers is required to be done for aligning the shaft or for any other reasons during the first one year of operation from the date of commissioning of the machine, the same shall be done by the contractor.

Acceptance Criteria

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

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

Tolerances are within the specified limit.

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

Bought out material is from the approved manufacturer / vendor.

Bought out material is matching with the approved sample.

10.8 INCREASE IN STRESSES

10.8.1 Where stresses due to wind (or seismic) and temperature are combined with those due to other loads, the allowable stresses in concrete and reinforcement steel shall be increased by 33.33% in case of working stress design.

10.8.2 Bearing capacity of the soil / pile capacity shall be allowed to increase by 25% under seismic / wind load condition except for chimney & NDCT where increase in bearing capacity/pile capacity is not considered.

10.9 MINIMUM THICKNESS OF STRUCTURAL ELEMENTS

The following minimum thickness shall be followed:

Flat roof slab	:	125 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 /	:	125 mm

Launder walls and base slab		
All footings (including raft foundations)	:	300 mm
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

10.10 From fire resistance point of view minimum thickness of reinforced concrete members shall be as per fig. 1 or table 16a of IS:456.

10.11 **MINIMUM HEIGHT FOR PEDESTALS/ENCASEMENT OF STEEL COLUMNS/WALL BEAMS**

10.11.1 **Top of RCC Pedestals should be kept above FFL as stated below.**

Top of pedestal shall normally be kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) unless specified otherwise. 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.

<u>All wall beams shall be provided with gunniting of 50 mm thick all-round with nominal reinforcement and chicken mesh.</u>

10.11.2 **Pedestals to steel columns for equipment structure**

Top of RCC pedestals shall be kept above FFL as stated below.

a.	Equipment in open area	:	As required (300 mm min.)
b.	Equipment in covered area	:	As required (150 mm min.)
c.	Structures and equipment	:	As per vendor's data subject to supplied by vendor minimum as specified above.

10.12 **The number of construction joints in the columns of steam turbine foundation shall be restricted.**

Construction joints at the following three locations shall be provided:

a) At the meeting points of the columns and the raft.

b) At the meeting points of the column and the top deck.

Additional reinforcement and shear keys shall be provided at the construction joints.

The base raft for steam turbine and GT foundation and table top for steam turbine shall be cast in single pour.

10.13 CONCRETE MIX

The following minimum grades of concrete as per IS: 456 shall generally be used for the type of structures noted against each grade.

a) Grade M15 : Fill concrete.

b) Mix(1:4:8): Foundation below brick wall, blinding layer below foundations, trenches and underground structures, minimum thickness of the layer shall be 75 mm.

c) Grade M20 : Base plate encasement, pavement around building including plinth protection work, encasement of structural steel work, grade slab & grade beams etc.

d) Grade M25 : All RCC members, e.g. foundation and superstructure, pedestals, roof slabs, cable and pipe trenches, water retaining structures, cooling water channel, CWPH forebay, raft & sump etc.

e) Grade M30 : TG foundation and chimney raft, Shell & Superstructure, NDCT except basin.

f) Grade M35 : TG top deck & NDCT basin etc.

For superstructure of RCC chimney and Natural draft cooling towers richer mix may be used as per design requirement. However, requirement of Table-4 & 5 of IS: 456 shall be satisfied as per the exposure condition. As per IS: 456, exposure condition will be **"severe"** for all structures under the civil scope of work.

10.14 ALLOWABLE SETTLEMENT

The total permissible settlement and differential settlement of the foundations will be governed by IS: 1904, IS: 13063, IS: 3370 and from functional requirements whichever is more stringent.

All foundations shall be so designed that the settlements are within permissible limits as per relevant Indian Standard or from consideration of safe equipment / machine operation whichever is critical. In case of open foundations without piles, Ground improvement methods opted by contractor, like sand drains / stone columns etc. to reduce settlement and increase the rate of settlement, detail methodology of such installation supported by calculation based on relevant field data shall be furnished for approval of Owner / Consultants before execution. In the event, the contractor adopts any patented method of ground improvement or retain any specialized agency for such purpose, the same can be done subject to prior approval of owner.
<u>Effects of uplift and reduction in bearing capacity due to underground water table shall also be considerd.</u>

Boiler and ESP support structures shall be checked for differential settlement of foundations which shall be restricted to 1 in 1000 of span or 8 mm whichever is less.

10.15 AFTER AWARD OF WORK ACTIVITIES

a) This part covers the requirements for general use of Plain and Reinforced Cement Concrete work in structures at all locations, cast-in-situ or precast , including all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work. The special requirements of structures covered in latest IS: 456 should also be complied with.

b) The works to be provided by Contractor:

i) Furnish all labour, supervision services including facilities as required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plant, transportation etc. required for the work.

ii) Prepare progressively detailed drawings and bar bending schedules for reinforcement bars showing the positions and details of spacers, supports, chairs, hangers etc.

iii) Submit shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedment, hangers, openings, frames etc.

iv) Submit detailed drawings of supports, templates, hangers etc. required for installation of various embedment like inserts, anchor bolts, pipe sleeves, joint seals, hangers, openings, frames etc.

v) Submit detailed schemes of all operations required for executing the work e.g. material handling, concrete mixing, placement of concrete, compaction, curing, services, approaches etc.

vi) Design and submit concrete mix designs required to be adopted on the job.

vii) Provide all incidental items necessary for successful completion of the work in accordance with the drawings, specifications and schedule of Items.

ix) Supply of specialized materials as directed by the Engineer with a guarantee in approved performa for satisfactory performance.

x) Furnish samples and submit for approval the results of various properties of the following materials:

a. The various ingredients of concrete including concrete.

b. Embedments.

c. Joint seals.

The following information and data including samples where necessary shall be submitted by the bidder progressively during the execution of contract.

a) Programme of execution and Requirement of Materials

Within 15 days of the award of contract, the Contractor will submit a Master Programmed 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.

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 emergency of the work.

b) Samples

Materials supplied by the Contractor have to be tested for physical, chemical and other properties in the reputed labs at their cost. If found unsuitable, the same shall be removed from the site. Samples of the following materials & any other materials proposed to be used, shall be submitted as directed by the Engineer in Charge, in sufficient quantities free of cost for approval. Approved samples will be preserved by the Engineer in Charge for future reference. The approval of the Engineer in Charge shall not, in any way, relieve the Contractor of his responsibility of supplying materials of specified qualities:-

i) Coarse and fine aggregates.

ii) Cement

iii) Reinforcement

iv) Admixtures

v) Plywood for formwork

vi) Embedded & anchorage materials as may be desired by the Engineer in Charge.

vii) Joint sealing strips and other waterproofing materials.

viii) Joint filling compounds

ix) Foundation quality Rubber Pads.

c) Design Mix

Design mix as per the specification giving proportions of the ingredients, sources of aggregates & cement, along with test results of trial mixes as per relevant I.S. is to be submitted to the Engineer in Charge for his approval before it can be used on the works.

a. Detailed drawings & designs of formworks to be used.

b. Detailed drawings for templates & temporary supports for embedments.

c. Test reports for cement, reinforcement steel and formwork including inspection reports.

d. Any other data as per specification.

d) Conformity with Design

The contractor should prepare check lists in approved performa which will be known as "Pour Cards" listing out all items of work involved. The contractor should inform the Engineer, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help & assistance to the Engineer for checking required in the pour. On satisfying himself that all details are in accordance to the drawings & specifications, the Engineer will give written permission 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 should be written on accompanying sheets attached to the Pour Cards. These sheets, termed as "Progress Cards" shall be prepared by the contractor on approved performa. The Pour Cards along with accompaniments shall be handed over to the Engineer before starting placement of concrete. One of 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 shall be to Engineer's approval.

10.16 STORAGE OF MATERIALS

a. 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 it's otherwise considered defective by the Engineer, shall not be used for concrete and shall be removed from site immediately. 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.

b. Cement shall be stored off the ground in dry, leak proof, well-ventilated ware-house at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter. Sufficient space of storage with open passages should be arranged between stacks. Cement shall be stored in easily countable stacks with consignment identification marks arranged in the order of their receipts at site. Sub standards or partly set cement shall not be used; and shall be removed from the site, as soon as it is detected.

c. Aggregates shall be stored on planks or on 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 stockpiles stacks and sufficient care shall be taken to prevent the material at the edges of the stockpiles from getting intermixed. Stacks of fine & coarse aggregate shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths.

d. Reinforcing shall be stored consignment –wise and size wise off the ground & under cover. It shall be protected from rusting, oil, grease and distortions. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

10.17 CONCRETE MIX REQUIREMENTS

Concrete mix requirements shall be in accordance with IS: 456 and as supplemented and modified herein or by other best possible standards.

a. Washing & Screening of coarse and fine aggregates shall be carried out to remove fines, dirt and other deleterious material.

b. Admixture: All concrete shall be designed for normal rate of setting and hardening at normal temperature and humidity under different climatic conditions. Admixtures shall be used in accordance with IS: 456 to modify the rate of hardening, to improve workability or an and aid to control quality. The Engineer reserves the right to order for laboratory test or use test data or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer’s directions and/or as desired by the Engineer.

c. Concrete grades to be used in different parts of work shall be as shown on the drawings or as per the Engineer’s instructions. In case of liquid retaining structures, IS: 3370 shall be followed.

d. Proportioning of ingredients of concrete shall be made either with preliminary test by designing the concrete mix [“Design Mix Concrete“] or without preliminary test adopting nominal concrete mix. Design mix concrete shall be used on all concrete works while nominal mix concrete, as per IS: 456, may be used as shown on drawings and approved by the Engineer. In all cases, the proportioning of ingredients and works control shall be in accordance with IS: 456 and its adequacy after obtaining Engineer’s approval.

e. Mix Design Concrete

Concrete mixes shall be designed by the contractor to achieve the strength, durability and workability economically with various ingredients. In general the design will keep in view the following considerations:

i) Consistent with the various other requirements of the mix, the quantity of water should be kept at the lowest possible level.

ii) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

iii) 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.

iv) Chemical admixtures may be used to modify the rate of hardening and improve workability.

v) 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.

vi) Concrete Mix Design and Strength requirements

Concrete mix design shall be as per IS: 10262 and SP: 23. 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.

f. Minimum cement content

The minimum cement content for each grade of concrete shall be as per Table 1.

TAB L E - I MINIMUM CEMENT CONTENT & MAX. W / C RATIO SPECIFIED FOR DIFFERENT GRADES OF CONCRETE

S. No.	**Conc Grade**	**Min cement content (kg/cum)**	**Water, Cement ratio**	**Slump (mm)**
1	M 10	-	-	-
2	M 15	250	0.5	-
3	M 20	320	0.55	As/IS 456
4	M 25	365	0.50	Do
5	M 30	365 - 400	0.45	Do
6	M 35	425	0.45	Do
7	M 40	425	0.40	Do

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.

g) Water-Cement Ratio

The choice of water-cement ratio in designing a concrete mix will depend on

i) The requirement of strength.
ii) The requirement of durability.

j) Strength Requirements of Concrete Mix

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.

k) Durability

Tables 4 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.

In general the water cement ratio between 0.4 and 0.45 will be desirable to satisfy the durability requirement and from the consideration of Impermeability of concrete. The contractor may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer / super-plasticizer.

l. 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 embedment's 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 limits of consistency for various types of structures as per Table – I

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 7 of IS: 456 shall be carried out.

m. Size of Coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Engineer:

Reinforced concrete except foundation - 20 mm

Ordinary Plain concrete and RCC foundations - 40 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the specified proportions, strength and consistency that will work readily into position without segregation.

Coarse aggregate will normally be separated into the following sizes and stacked separately in properly designed stockpiles 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 into20 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

n. Mixing of Concrete

Controlled concrete only in batching plant shall be used for all major and minor works including power house column foundation, TG, boiler foundation, ID, FD, PA, BFP foundations, chimney, cooling tower & other important structure.

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 Purchaser to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as per IS: 4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS: 1791 should be allowed to be employed. Batching Plant where used shall conform to IS: 4925.

Hand mixing if permitted 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 Purchaser.

Crushed ice shall be used in concrete mixing water so as to maintain temperature in the concrete in the top decks of the machine foundations. Arrangements for standby weight batching plant and equipment shall also be made available by the contractor for continuous pour of concrete.

o. 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, concrete shall by placed and compacted in the final position before the initial setting of the cement starts. Concrete should be conveyed in such a way preventing segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design should be used. If, inspite of all precautions, segregation does occur during transport, the concrete shall be properly remixed before placement. During very hot weather, concrete shall be transported in deep container to reduce the rate of loss of water by evaporation or loss of heat. If necessary, the container should be covered. Conveying equipment for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

p. Placing and Compacting of Concrete

i) Relevant I.S. Code should be followed for the procedure of surface preparation,placement, consolidation, curing, finishes, repairs and maintenance of concrete. Concrete shall be placed against the surfaces of formwork or construction joint in concrete or masonry. The surface against which concrete is placed shall be cleaned thoroughly. 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. shall be removed by air water jetting or water at high pressure.

Concrete shall be placed in the formwork by approved means, and shall not be dropped from a height or handled in a manner which may cause segregation.

ii) Construction joint shall be kept moist for at least 72 hours prior to placement.

Concrete shall be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution shall be adopted. Formwork shall be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

iii) 12 mm thick mortar with less w/c ratio as that of the concrete being placed and cement slurry shall be spread thoroughly on the construction joint just prior to placement of concrete. The concrete shall be spread, and thoroughly compacted 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. In thin members with heavy congestion of reinforcement of other embedments, where effective use of internal vibrator is, doubtful, in addition to immersion vibrators, the contractor should employ form vibrators conforming to IS: 4656. For slabs and other similar structures, the contractor should employ screed vibrator as per IS: 2506. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or distorted during placing and consolidation of concrete.

iv) The rate of placement of concrete shall be such that no cold joint is formed; and fresh concrete is placed always against green, plastic and workable concrete. No concrete shall be placed in open during rains. During rainy season, no placement in the open should be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at 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.

v) Slabs, beams and similar members shall be poured in one operation. Moulding, throating, drip course, etc., shall be poured as per the drawings. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as per drawings. 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.

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 disturbed.

10.18 **a) CONSTRUCTION JOINTS**

Concrete structure shall be completed 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 shall be formed as per drawings. Vertical construction joints shall 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. For water retaining structures and leak proof buildings suitable and approved water stops shall be installed at the construction joints as per clause 12.4 of IS:456. Where the location of the joints are not specified, it shall be in accordance with the following:-

i) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.

ii) Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) A joint in a suspended floor slab shall be vertical and at the middle of the span and at right angles to the principal reinforcement.

iv) Feather-edges in concrete shall be avoided while forming a joint.

v) A construction joint should preferably be placed in a low stress zone and at right angles to the direction of the principal stress.

b. 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:-

i) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete should 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.

ii) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface shall 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, shall be placed on the cold joint, fresh concrete shall be placed on the mortar layer and the joint shall be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

iii) In case the concrete at the joint has become so stiff that it cannot be remolded and mortar or slurry does not rise inspite of extensive vibration, the joint shall be left to harden for atleast 12 to 24 hrs. It shall then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as indicated above.

c. Expansion and Isolation Joints

i) Expansion and isolation joints in concrete structures shall be provided at specific places as shown on the drawings with materials and types of joints as specified. In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids as specified on the drawings. All materials should be procured from reliable manufacturers to the approval of the Engineer. Test certificates for the materials should be furnished. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval from concerned engineer of the method of forming the joints should be obtained.

ii) Duraboard HD or its equivalent of approved manufacturer shall be used as filler 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 recommended by the manufacturer.

Commercial quality of expanded polystyrene products commonly used for thermal insulation can also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material should procured from reliable manufacturers as approved by the Engineer. The method of installation shall be similar to that recommended by the manufacturer for fixing on walls. A coat of bitumen paint shall be applied on the board against which concrete is placed.

iii) Joint sealing strips shall 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. General strips shall be of PVC or otherwise as specified. Sealing strips shall not have any longitudinal joint; and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material shall 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. The contractor should supply all labour and materials for installation including the material and tools required for jointing, testing, protection, etc. The joints in rubber seals shall be vulcanized as needed.

iv) The minimum thickness of P.V.C. sealing strips shall be 3 mm and the minimum width 100mm. The actual size and shape shall be as shown in drawings. The material should be of good quality Polyvinyl Chloride highly resistant to tarring, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties shall generally be as follows:

i)	Specific Gravity	:	1.3 to 1.35
ii)	Shore Hardness	:	60A to 80A
iii)	Tensile Strength	:	10 to 15 N/Sq.mm

iv) Maximum Safe Continuous Temperature : 70 Deg.C

v) Ultimate Elongation : Not less than 275%

v) Bitumen Compound: When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound Manufacturer's recommendation. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS: 1834.

vi) Isolation Joints: Strong and tough alkathene sheet or equivalent, about 1 mm in thickness 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.

vii) 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. The rubber shall have a unit weight of 1500 kg/cum, 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.

viii) <u>All foundation structures in contact with soil shall be coated with two coats of Bituminous coating.</u>

10.19 REPAIRS, FINISHES AND TREATMENT OF CONCRETE SURFACES

a. Adequate and sound concrete surfaces, whether formed or unformed, should be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing and consolidation by experienced workmen.

b. Unsound concrete resulting from improper mix design, incompetent methods, equipment and form work, poor workmanship and protection shall not be accepted and shall be dismantled, removed and replaced by sound concrete at the contractor's cost. All concrete work shall be inspected by the contractor immediately after the forms are removed and he should promptly report of occurrence of any defects to the Engineer. All repair works should be carried out as per the instructions and in the presence of the Engineer. Generally, repair work shall consist of any or all of the following operations:

i) Sack rubbing with mortar and stoning with carborundum stone.
ii) Cutting away the defective concrete to the required depth and shape.
iii) Cleaning of reinforcement and embedments.
iv) Roughening by sand blasting or chipping.
v) Installing additional reinforcement/ welded mesh fabric.
vi) Dry packing with stiff mortar.
vii) Plastering, guniting, hotcreting etc.

viii) Placing and compacting concrete in the void left by cutting out defective concrete.

ix) Grouting with cement sand slurry of 1:1 mix.

c. Finishing Unformed Surface

The requirement of finishes of formed surfaces are specified hereunder separately. The contractor should include for concrete, the provision of normal finishes in unformed surfaces which can be achieved by screeding, floating, trowelling etc. A few typical and common cases of treatment of concrete surface are cited below:

i) Floor: For non-integral floor finish, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and finished with a wooden float fairly smooth removing all laitance. No over trowelling, to obtain a very smooth surface, shall be done as it will prevent adequate bond with the subsequent finish. The surface shall be scored and marked to provide better bond.

For monolithic finish, 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 should then started after the moisture film & shine 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 should 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 should 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 floor should be marked in a regular geometric pattern after initial trowelling.

ii) Beams, Columns & Walls: If on any other concrete structure, it is intended to apply plaster or such concrete surfaces against which brick- work 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.

d. Protection and Curing of concrete: Newly placed concrete shall be protected 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. Steps shall be taken to protect immature concrete from damage by debris, excessive loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete. As soon as the concrete has hardened sufficiently, it shall be covered either with sand, hessian, canvas or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water shall be allowed if the Engineer is satisfied with the adequacy of the arrangements made by the contractor.

The contractor shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. In case any lapse on the part of the contractor is noticed, the Engineer will inform the contractor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the contractor within 3 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.

10.20 REINFORCEMENT

The reinforcement used shall be cold worked steel high strength deformed bars of grade Fe 500D conforming to IS: 1786 – latest.

a.) All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

b.) Bar Bending Schedules

The contractor shall submit to the Engineer bar bending schedules with working drawings showing clearly the arrangements proposed by the contractor. Upon receipt of the Engineer's final approval of the bar bending schedule and drawings, the contractor shall submit the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. Approval of such detailed drawings shall not relieve the contractor of his responsibility for correctness nor of any of his obligations to meet the other requirements of the contractor.

c.) Bending

Reinforcing steel shall be bent in accordance with the procedure specified in IS: 2502. Bends and shapes shall comply strictly with the dimensions corresponding to the approved bar bending schedules which 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. Re- bending can be done only if approved by the Engineer. Reinforcing bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent.

d.) Placing in position
All reinforcements shall be accurately fixed and maintained in position as shown on the drawings. Bars at crossing points, shall be securely tied togetherby # 20G annealed soft iron PVC coated wire or by tack welding in case of bar larger than 25 mm dia. 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 with FBEC 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.

e.) Welding

Normal bond laps in reinforcement should be placed by lap or butt welding reinforcement bars. The work should be done with suitable safe guards as per IS for welding of mild steel bars used in reinforced concrete construction as per IS: 2751 and IS: 456. Welded mesh fabrics to IS: 566 shall also be as per drawings.

f.) 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 as per IS: 456. 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. Arrangements for placing concrete shall be such that reinforcement in position do not have to bear extra load and get disturbed.

The cover for concrete over the reinforcements shall be as shown on the approved drawings. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1part cement to 2 parts sand by volume and cured in a pond for at least 14 days. The type, shape, size and location of the concrete blocks shall be as approved by the Engineer.

g.) Cold Weather Concreting

When conditions are such that the ambient temperature may be expected to be 4.5 Deg.C or below during the placing and curing period, the work shall conform to the requirements of clause 13 of IS: 456 and IS: 7861.

h.) Hot Weather Concreting

When depositing concrete in very hot weather, the contractor shall take all precautions as per IS: 7861 and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 38oC while placing.

10.21 FORM WORK

a. The contractor shall prepare, before commencement of actual work, designs and working drawings for formwork and centering. The formwork shall conform to the shape, grade, lines, levels and dimensions as shown on the drawings. Materials used for the formwork inclusive of the supports and 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.

b. The centering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rakes shall 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. 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 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. Bolts passing completely through liquid retaining walls/ slabs for the purpose of securing and aligning the formwork shall not be used.

c. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Engineer immediately and rectified as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion-resistant devices. Rigid care shall be exercised in ensuring that all column forms are 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 meters span. Bevelled forms 25 mm x 25 mm shall be fixed in the form-work at all corners to provide chambering of the finished concrete edges. 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 as necessary. 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.

d. 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 or other compound before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork.

e. 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.

f. Inspection of Forms

Casting of concrete shall start only after the formwork inspection and approval by the Engineer. The concreting shall start as early as possible within 3 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.

g. 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 the date on which concrete is placed in each part of the work; and the date on which the formwork is removed there from. 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. Forms for various types of structural components shall not be removed before the minimum periods as detailed below:-

Schedule of Removal of Form Work

Part of Structure	**Ordinary Portland Cement Concrete**				**Rapid Hardening Portland Cement Concrete**			
	Temperature (°C)				**Temperature (°C)**			
	Above 40	**40 to 20**	**20 to 5**	**Below 5**	**Above 40**	**40 to 20**	**20 to 5**	**Below 5**
	Days	**Days**	**Days**	**Days**	**Days**	**Days**	**Days**	**Days**
Columns &	2	1	1	Do not remove	1	1	1	Do not remove

Walls				forms until site cured test specimen develop atleast 50% of the specified 28 days strength				forms until site cured test specimen develop atleast 50% of the specified 28 days strength
Beam sides	3	2	3		2	1	1	
Slabs, 125 mm	10	7	8		7	4	5	
Slabs over 125 mm thick and soffit of minor beams	18	14	16		12	8	9	
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 40oC can be reduced to those of the temperature range of 20oC to 40oC.

Joints in beams shall be located at the middle of span. 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.

h. 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 :-

i) Sectional dimension - +/- 5 mm

ii) Plumb - 1 in 1000 of height

iii) Levels - +/- 3 mm before any deflection has taken place

The above tolerance shall be 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. Any error, within the above tolerance limits 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.

i. Re-use of Forms

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired and inside surface treated as specified hereinbefore. Formwork shall not be used / re-used if declared unfit or unserviceable by the Engineer.

j. Generally, the “ordinary” class formwork 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. Plywood formwork 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 utilization of used plywood for the "ordinary" class, if it is still in good condition. Ornamental formwork shall be used where ornamental and curved surfaces are required and shall be made of selected best quality well seasoned timber or plywood, which can be shaped correctly. The contractor shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings.

10.22 ANCHOR BOLTS, ANCHORS, SLEEVES, INSERTS, HANGERS/ CONDUITS/PIPE AND OTHER MISC. EMBEDDED FIXTURES

The contractor shall build into concrete work all the items as noted below; and shall embed them partly or fully as directed and secure the same as may be required. The materials shall be as specified and be of best quality available according to relevant IS and of approved manufacture to the satisfaction of the Engineer. Exposed surfaces of embedded materials shall be painted with one coat of approved anti-corrosive paint and/or bituminous paint. If welding is to be done subsequently on the exposed surfaces 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 required items to be embedded shall be as follows:

i) Inserts, hangers, anchors, frames around openings, manhole covers, Frames, floor clips, sleeves conduits and pipes.

ii) Anchor bolts and plates for machinery, equipment and for structural steel work.

iii) Dowel bars, etc. for concrete work

iv) Lugs or plugs for door and window frames occurring in concrete work.

v) Flashing and jointing in concrete work.

vi) Any misc. embedments and fixture as may be required.

vii) Convextra-GP2, Sikka grout or equivalent grouting material shall be used as per manufacturer's specification.

Correct location and alignment, as per drawings/instructions of all these embedded items shall be entirely the responsibility of the contractor.

10.23 PRECAST CONCRETE

The precast concrete shall be similar as for the cast-in-place concrete described herein. All precast work shall be carried out in a yard which shall be dry, properly levelled and having a hard and even surface. It shall be paved with concrete or masonry as needed; and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S.

sheeting. Casing shall be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 days of curing and can be removed for erection after 28 days of curing. The moulds shall be of steel or of timber lined with G.I. sheet metal.

Lifting hooks as necessary shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection. Precast concrete units, when ready, shall be transported to site by suitable means. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Engineer. The contractor shall render all help with instruments, materials and men to the Engineer for checking the proper erection of the precast units.

10.24 SAMPLING AND TESTING

The contractor shall carry out all sampling and testing as per IS for the following items:

a. Cement

Representative samples shall be taken from each consignment of cement received from the manufacturer / supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths as per IS:269. Soundness Tests shall also be carried out as required. No cement from a particular consignment / batch shall be used on the works unless satisfactory 3 days and 7 days test results for compressive strength are known. These tests shall be of great importance as their results shall have bearing on the acceptance of concrete or otherwise.

b. Aggregates

The contractor shall carry out any or all the tests of aggregates as required as per IS: 2386 Parts-I to VIII. The acceptance criteria of the samples tested shall be as per the relevant IS.

c. Water

Water for concrete works shall be tested as per IS: 3550 by the contractor at regular intervals and whenever directed by the Engineer. The final acceptance criteria in case of doubt shall be as per IS: 3025 & IS: 456.

d. Admixture

Air Entraining Agents (AEA): Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cylinder cube crushing strength vis-à-vis quantity of A.E.A. used for all types of concrete shall be established by the contractor by carrying out sufficiently large number of tests. After than, at regular intervals and whenever directed by the Engineer, the contractor should check up, the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results. Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the contractor.

e Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be as per IS: 516 and IS: 1199 with the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed apart from other tests as per 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 and as per clause 7.3.7(f) above shall be carried out by the contractor every 2 hours. 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 shall be done as per specification by the contractor. In the course of dismantling, if any damage is done to the embedded items or adjacent structures, the same shall be made good by the contractor to the satisfaction of the Engineer.

f. Concrete for Equipment or Steel Structures Foundations

Concrete for equipment foundation, whether principal or auxiliary, shall be poured continuously so that the structure becomes monolithic, particular care being exercised to see that the base slabs, if any, are of compact impervious construction. Tunnels, passages apertures and so forth shall be provided in accordance with the drawings for the installation of mechanical and electrical equipment, pipes or cables. The top elevation of the equipment foundations or parts shall be accurately cast to 20/50 mm (or more as may be specified on the drawings) above the level required for grouting and it shall be pneumatically chiseled of and well roughened just prior to the erection of the equipment concerned. All embedded anchor bolts or bolt sleeves shall be accurately and firmly set with the aid of approved templates, steel supports and / or other accessories. For holding the embedded bolts or sleeves in the correct position during concreting, template shall have to be of steel of suitable section approved by the Engineer in Charge. Two (2) sets of templates shall have to be provided, one to hold the bottom and the other the top of the bolts or sleeves. The bottom template shall be securely and rigidly fixed by providing anchorage arrangement and by welding to the lowest part of the steel reinforcement and other structural supports. The top templates shall be securely fixed by tying with guy wires and turn buckle arrangement to firm and rigid adjoining structures and stagings.

Bolt pockets, where required, shall be cast with wooden taper wedges. These shall be withdrawn at an appropriate time when the concrete has set, the pockets cleaned roughened and then covered or blocked thoroughly to prevent debris getting into these. The exposed portions of bolts and embedded parts shall be kept well greased and adequately protected from damage throughout construction. Any damages found shall have to be corrected at the contractor cost. The

Purchaser shall have the right to use the foundations, pads, piers, slabs, floors and all concrete work as needed for other works or equipment erected prior to its "Taking over"

10.25 SPECIAL CONDITIONS FOR CONSTRUCTION OF TG FOUNDATION

a) Scope

i) The work to be performed under this contract consists of providing all materials except those supplied by the Purchaser, shuttering, staging, inserts, construction equipment, labour and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of the work, all in the strict accordance with the drawings, schedules and specifications and including revisions and amendments thereto and such detailed drawings as may be provided by the Consultant, during the execution of the work.

ii) It is not the intent to specify completely herein all the details of designs and construction of the structure. However, the structure shall conform in all respects to high standards of Engineering, design and workmanship and be capable of performing in continuous commercial operation upto contractors guarantee in the manner acceptable to the Purchaser / Consultant who will interpret the meaning of drawings and specifications and shall have the power to reject any work or materials which in his judgment are not in full accordance therewith.

b) Form Work

i) All forms shall be abundantly wetted on both sides before concrete in poured. The date of removing forms for each individual stage of construction shall be fixed by the Purchaser / Consultant.

ii) The minimum period for striking of formwork shall be as follows:-
- Vertical sides of beams and pedestals - 7 days
- Bottom of beams / slabs - 28 days

However, the vertical faces shall be loosened after 24 hours of completion of concreting the supports.

iii) Concrete surface shall not normally be patched or otherwise treated after the removal of forms. Where the surfaces exposed on stripping is not of a satisfactory nature, owing to the contractors failure to take necessary precaution before, during or after the concrete placing, such surfaces shall be worked and finished in accordance with the instructions of the Purchaser / Consultant at the cost of the contractor. The pores shall be filled in with a neat solution of cement and water applied by brush and when dry the surface shall be rubbed down with carborundum stone. The cost of the above treatment shall be deemed to be included in the unit rate entered by Contractor. The top surface of the T.G. deck shall be float-finished, unless otherwise specified to the required levels. There must be no surface grouting are treating which might draw the "fines" to the top. All shuttered surfaces shall be left as they strip without removing boards or panel markings.

Any serious honey combing will render the concrete work liable to rejection and cutting out and re-concreting wholly or partly as the Engineer in Charge directs. All costs involved in repairing defect shall be borne by the Contractor.

iv) The arrangement and method for movement of workers during TG construction to various levels of the TG foundations shall be submitted well in the advance to the Engineer- in – Charge for his approval for taking up the work.

v) In addition to the above paras the contractor shall also satisfy all other requirements for formwork mentioned in elsewhere in the specification.

c. Staging

i) The entire staging for supporting the formwork, walkways and platforms for placing concreting equipments such as vibrators, etc., shall be of structural steel. The staging shall be designed for the worst combination of loading as specified hereinafter.

ii) The Contractor shall submit 2 copies of design calculations and drawing to prove adequacy of the staging for approval of the consultant. On receipt of final approval, the contractor shall supply 20 copies of approved drawings for distribution.

iii) The staging shall be so designed that no load from platforms are passed on to the formwork at the top.

iv) All platforms, walkways etc. shall be clear of the formwork and at least 200 mm above it. The width of platforms and walkways shall be at least 1.2 metres for easy movement of labour both ways.

v) The platforms shall be of planks or bamboo mats (clamped with steel strips suitably stiffened to avoid springing).

vi) The form work and staging shall be designed for a live load of 1000 Kg/m2.

vii) Unit weight of green concrete shall be considered as 2500kg/m3 for design of form work and staging.

viii) The staging shall be braced in both the directions.

ix) The staging shall be supported on rigid surfaces at ground level.

x) The staging shall be sufficiently rigid to prevent any distortion in the form work.

d. Special Precautions

i) The contractor shall take all precautions to ensure concreting of TG Raft, columns and TG Deck in one pour each. Concreting shall be continuous and no break in concreting shall be permitted.

ii) The Contractor shall prepare a scheme for concreting giving details of number of mixers, labour, vibrators, pouring schedule and obtain prior approval of the same from the Engineer-in-Charge before starting of concreting.

iii) <u>The Contractor shall ensure that at no time the temperature of the green concrete exceeds 38 degree C by taking proper precautions. If required, ice shall be added to control the temperature at no additional cost to the Purchaser.</u>

iv) Approved "Retarders" shall be used by the contractor in the proportions specified by the manufacturer for total concreting work of the TG foundation. The cost of the admixture shall be included in unit rates quoted by the Bidders.

e. Test for Soundness of Concrete

ULTRASONIC TESTING
Ultrasonic pulse velocity test shall be carried out for the top deck of all machine foundations and TG substructure to ascertain the homogeneity and integrity of concrete. UPV test shall also be carried out for Chimney and NDCT on the bottom portion to a height of 30metre from top of foundation and shall be conducted immediately after the construction up to 30m. In addition, additional cubes (at the rate of one cube per 150 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values. Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the CONTRACTOR shall rectify the defects suitably using cement / epoxy grout etc

Quality Control Procedure.

The contractor shall establish & maintain quality control procedure for different items of works and material to ensure that all works are performed as per specification.

Contractor shall got approved field quality plan for all the works to be executed

Quality plan shall be prepared based on guide lines furnished in Volume-II of the specification.

CHAPTER – 11

DESCRIPTION OF BUILDINGS, STRUCTURES AND OTHER FACILITIES

11.1 TEMPORARY STRUCTURES FOR EXECUTION

11.1.1 Construction water:

The Contractor will make his own arrangement (pumping etc.) for withdrawing water for construction purpose and further distribution to work site including all connected works without any cost implication to the owner. Location of water tapping shall be got approved from the owner / consultant before execution.

11.1.2 Temporary site building

The CONTRACTOR shall provide for at his cost the following building facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities. All these building shall have brick cladding, Steel / AC sheet roofing over steel roof truss with cement concrete flooring and false ceiling with A/C as required.

11.1.3 Site office

Contractor shall provide about 500 sqm of office area with A/C and false ceiling for the use of Owner / Owner's representative in addition to the Contractor's requirement. Additionally an A/C Conference room to accommodate about 70 people shall also be provided in the site office complex for the Owner's use. In addition to these, basic facilities like toilet for gents and ladies, potable water tanks, soak pit and septic tank for sewage disposal shall also be provided. Covered parking area for parking 10 cars shall also be provided for Owner's use.

11.1.4 Stores

A covered store shall be provided with brick cladding and G.I/colour coated sheeting to store at least one month requirement of cement. Cement in bags shall be stored on a raised floor well away from outer walls and insulated from the floor to avoid moisture. Not more than 15 bags shall be stacked in any tier. Each consignment of cement shall be stored separately and consumed in its order of receipt.

Covered storage area may also be provided to store other construction material which will be affected on exposure to wind, sun and rain.

Reinforcement shall be stacked on top of timber sleepers to avoid contact with ground / water.

Storage yard paved or unpaved shall be provided with in the stores complex for storage of other material. Proper fencing and security arrangement shall be provided for the stores complex.

Land to develop store shall be arranged by contractor at his own cost outside plant boundary

11.1.5 **Temporary Workshop and Garage**

The CONTRACTOR shall provide for a temporary workshop and garage to attend to routine maintenance and repair of the construction equipments as well as his fleet of vehicles used for construction activities. Land to develop Temporary Workshop and Garage shall be arranged by contractor at his own cost outside plant boundary

11.1.6 **Fabrication yard**

Depending on the extent of fabrication envisaged at site, the CONTRACTOR shall establish a full-fledged structural fabrication yard with adequate handling facility during and after the fabrication. A fully equipped testing laboratory providing radiography, ultrasonic, dye penetration, magnetic particle test facilities shall be ensured adjacent to the fabrication yard to enforce strict quality control. Portion of the yard shall have covered shed with H.O.T / E.O.T cranes so that fabrication work can proceed even during inclement weather. Land to develop Fabrication yard shall be arranged by contractor at his own cost outside plant boundary.

11.1.7 **Quality control laboratory**

A fully equipped quality control laboratory shall be established at site with qualified personnel to conduct acceptance test on all construction material, weldments, concrete cubes, soil & rock samples etc.

This laboratory shall be housed in a covered building with A/C facility as required by the testing facility. All testing equipment shall be periodically calibrated to the satisfaction of the OWNER. All testing shall be carried out in presence of OWNER. Finally the laboratory shall be handed over to OWNER in good condition after completion of project.

If OWNER desires to carry out conducting any test for verification of test results the same has to be arranged by the CONTRACTOR. Conducting any test as per the directive of OWNER arising out due to faulty construction/non conforming to quality shall be CONTRACTOR'S responsibility at his own cost.

11.1.8 **Fuel storage area**

CONTRACTOR shall obtain necessary permission from competent authorities and establish and operate a POL outlet with proper storage, dispensing and adequate fire fighting facility. Such outlets for petroleum product are required only if no regular petrol bunk is available in the near vicinity.

11.1.9 **Staff Welfare facility**

CONTRACTOR shall provide adequate facility for his staff inside the plant boundary such as Toilets for both gents and ladies, Canteens, drinking water facility, rest places, creches etc.

Necessary approach roads to the construction facility complex and internal roads within the complex as well as proper drainage of the area shall be the CONTRACTOR's responsibility.
CONTRACTOR shall also provide for proper disposal of sewage and other wastewater to meet with the requirement of Pollution Board.

Construction and maintenance of the staff and labour colony to satisfy all statutory requirement is the sole responsibility of CONTRACTOR. Land required to construct staff & labour colony shall be arranged by the contractor at his own cost outside plant boundary.

Contractor to establish a Fly Ash Brick Plant at site to fulfil the requirement of Fly Ash Bricks for the project.

11.1.10 **Construction Power**

Contractor has to arrange construction power from UHBVN/HVPN as per their rules and regulations at his own cost. Necessary distribution of the power line to the various locations as required shall be executed by the CONTRACTOR at his cost. BIDDER has to make provision of D.G. sets as standby power source. This is especially essential in the case of structures involving deep dewatering as well as where uninterrupted concreting has to be resorted to. The BIDDER along with his Bid shall indicate his average and peak power demand.

11.2 **TURBINE GENERATOR BUILDING**

Turbine building (TG bay and heater bay) framing shall be of structural steel with moment connected framing in the transverse direction and bracing in the longitudinal direction.

Service and maintenance bays shall not have any intermediate floors, however a 1500 mm wide observation gallery with handrails shall be given along the wall at the operating floor level to observe the TG erection operation. Intermediate floors shall preferably be provided at 8.50 m and operating floor at 17.0m. Floor at 8.50m and operating level shall be RCC floors over steel framing, where as the floor at any other level if required may have chequered plate / gratings supported on structural steel frame work.

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 ladder at two ends. Bottom level of roof framing shall be decided by the crane clearance requirement duly taking into account clearance required for mounting light fixtures. Roofing shall consist of in-situ RCC slab of minimum 150 mm thickness laid to a slope of 1 in 100, constructed over permanently colour coated galvanized MS troughed metal sheet of approved profile supported on steel purlins and trusses. TG bay roof shall be provided with exhaust system.

Permanent colour coated sandwiched insulated metal cladding system from 3m (approx) above ground floor up to roof shall be provided on gable end and A row. Brickwork shall generally be provided from ground floor to 3m (approx) height. On other rows brickwork shall be provided upto roof level. Wall in front of transformers shall be of adequate thickness to satisfy "fire rating" as per TAC regulations. On the heater bay side the brick wall shall be provided upto 1m above deaerator floor level. Cladding beyond the above level shall of permanent colour coated sandwiched insulated metal cladding system.

Windows shall be side-hung steel glazed using 6mm thick wired glass generally. However in areas where cladding is of sheeting fixed glazing in anodized aluminum framework and in accessible areas sliding windows in anodized aluminum framework using 6mm thick wired glass shall be provided. All the doors on external walls shall be of double plate flush steel doors. For equipment entry into the service bay specially designed steel sliding cum / folding / rolling shutters shall be provided with appropriate operating mechanism. Rolling shutter shall also be provided in front of condenser to facilitate tube removal.

Staircase protected on all sides with fireproof enclosure shall be provided to satisfy TAC regulations. All the doors leading to the inside of the power house from staircase shall be automatically closing fire proof door satisfying TAC regulations. Access cage ladders shall be given to TG building roof.

A roof shall be provided with roof water proofing treatment using high solid content liquid applied elastomeric water proofing membrane with separate wearing course as per ASTM-C-836 & 898. Thickness of the membrane shall be 1.5mm (min.). This treatment shall include application of polymerized mastic over the roof to achieve smooth surface and primer coat. Wearing course on the top of membrane shall consist of 25 mm thick PCC (1:2:4) cast in panels of maximum 1.2x1.2m size and reinforced with 0.56mm dia galvanized chicken wire mesh and sealing of joints using sealing compound/ elastomeric water proofing membrane. However, chequered concrete tile flooring 22mm (min.) thick of approved colour and shade conforming to IS:13801 shall be provided for path way of 1m width for access of personnel and handling of equipment and for the entire area of the roof where equipment like A/C ventilation plant, cooling towers, etc. are provided in place of PCC wearing course. Equipment shall be installed on raised pedestal of minimum 30 cm height from the finished roof to facilitate maintenance of roof treatment in future. MS rain water pipe of min. 150 dia OD conforming to IS: 1239 shall be provided to drain off the rainwater from roof. They shall be suitably concealed from the façade.

All the suspended floors in Main Plant Building are elsewhere in the BOP Area (having steel structure construction) should be supported on colour coated trough shaped permanent decking on beams.

All the intermediate floors shall be provided with proper drainage. Catch pit with CI grills shall be provided near the internal column in a regular pattern and the floor shall be sloped towards the catch pit by varying the thickness of the bedding concrete for the floor finish. Catch pits shall be at the same co-ordinate for all floor levels. 100 NB galvanized MS pipes conforming to IS: 1239 shall be provided to carry the drainage down. The pipes shall be clamped on to the intermediate column. Sumps shall be provided in ground floor to receive the water. Proper drainage arrangement shall be provided in the ground floor by means of RCC gravity channels with MS grills on top. The drainage shall be led to sumps from where the water shall be pumped to plant drainage, concrete kerb shall be provided to isolate the area and water shall be led through sump and channels to the floor drainage system. Oil water separator should be

provided as required to isolate oil from the drainage water where the water is mixed with oil.
In operating floor the design live load shall be painted on the floors prominently showing the extent of the area where such loading is permitted.

Wherever openings are provided in the floor for handling of equipment using EOT cranes such openings shall be covered with gratings provided over removable steel beams.

Expansion joint shall be provided in the building to satisfy the requirements of IS: 800 and IS: 3414.

Suitable provision for future expansion shall be made by BIDDER while designing / executing the foundation system for last grid of main plant building.

In any case auxiliary columns shall not be supported on TG foundation. Preferably auxiliary columns shall be fabricated box section.

A minimum headroom of 2200 mm below beam bottom shall be given in the cable vaults. In control room false ceiling level shall be kept 3500 mm above floor level

Portion of the structural steel column projecting into the room shall be encased with brick masonry to shield it from fire hazards.

Cable vault in ground and second floor shall be provided with minimum 2 doors per unit. The doors shall be flush steel doors. No windows shall be provided on the turbine bay side

Switchgear room shall be provided with minimum two steel doors to satisfy statutory requirement. In addition a two leaf sliding doors of slush welded steel construction shall be provided to move the switchgears into the room making use of equipment lifting hatch provided in turbine building.

Main entrance to control room shall be provided with air locked lobby with automatic closing sliding glass doors. Lobby shall be formed of anodized aluminum framing with toughened sheet glass 6 mm thick. Partition between control room and adjoining rooms shall be of glazed aluminum partition with 300 mm high brick wall at bottom for toe protection. All the doors shall be single leaf glazed aluminum doors for all cabins. For movements of panels suitably sized double leaf aluminum glazed doors shall be provided. Control room wall upto the false ceiling level shall be of aluminum glazed partition on either side of air lock. In other area cladding shall be of brick wall. UPS room shall be provided with brick cladding all-round to reduce sound nuisance.

Battery room shall be provided with PVC doors in PVC framing. For Air washer room steel doors shall be used which shall be airtight. No window shall be provided in air washer room.

Control room and electronic cubicle room is to be provided with false ceiling. False ceiling shall be designed aesthetically properly arranging, supply air diffuser, return air grill, fire protection sprinklers and light fittings. Aluminum ceiling system shall be provided. Under deck insulation shall be provided on the ceiling, on the walls and beams above false ceiling. Under deck insulation shall be provided for air washer room also.

Floor above control room where APRDS and other pipes are located as well as floor below the deaerator area shall be provided with proper drains to prevent any accumulation of water. This is very important to prevent seepage of water into the control room.

All openings in floor for switchgear and other panels shall be sealed with fireproof material after cables are connected.

11.3 **MILL AND BUNKER BAY BUILDING**

The framing shall be of structural steel. This shall be designed as a moment connected framing in the transverse direction and braced in the longitudinal direction. These structures primarily support coalbunkers, coal feeders and tripper arrangement to feed the coal into coal bunker.

The bunker shall be circular in plan and shall have the capacity as per the requirement of steam generator.

A mill maintenance platform shall be provided at appropriate elevation to attend to routine maintenance. This platform shall be of chequered plate or gratings over steel framing with handrail all around. Above this floor a framing shall be provided to support under slung crane used for handling mill maintenance work. The crane runway girders shall extend to the full length of mill bay to enable approach to the service bay also.

Framework for supporting the circular bunker are provided above the feeder floor based on geometry of the hopper. Preferably bunker shall be supported on equally spaced (min.) 8 supports.

Bunker shall be provided with a top steel cover with slit openings for entry of coal. On sides of the bunker necessary openings shall have to be provided for bunker ventilation / dust extraction.

Tripper floor is immediately above the bunker. This floor is of RCC supported on structural steel framework.

Tripper roof shall be of RCC supported on structural steel framework. A fall of about 300 mm is given for the roof framing to effect proper drainage. Tripper roof supports bunker ventilation / dust supporting structure. An RCC parapet shall be provided for the tripper roof. Access stair/ladder shall be provided from tripper floor to roof in each unit.

Deck sheet shall be used as a shuttering material for all RCC floors.

In addition to the above, framing arrangement for structural steel platform at various levels around the bunker shall be provided with proper access ladder, for poking, striking and attending to air canons

Tripper floor and roof shall be given access through boiler staircase / elevators.

Bunker supporting structure is normally left uncladded up to the bottom of tripper floor. For tripper floor upto 3000 mm above finished tripper floor level, brick wall shall be provided. Above this level permanent colour coated galvanized trough sheet cladding shall be provided. Fixed steel windows with

6mm thick wired glass shall be provided in the tripper house as per requirements for conveyor gallery.
Roof slab will be sloped to one side to permit easy drainage. Liquid membrane water proofing treatment is to be provided. As the roof is accessible and maintenance crew is likely to work on this floor, the entire roof shall be provided with min. 50 thick screed over the water proofing treatment.
Rainwater down take pipes shall be of MS.

One number goods cum passenger elevator and two nos. of staircase shall provide access to all floor/platforms extending upto the roof level. Requisite nos. of corridor as per operational requirements shall be provided to access steam generator building from Mill building. The Mill building and steam generator building shall have expansion gap and corridor shall be connected with sliding supports.

Stainless steel liners of thickness 5.14mm shall be provided in bunkers for the conical / hyperbolic as well as vertical portion of Bunker. The grade of SS liner shall be SS316L.

Metal deck sheet used below RCC floors shall be treated as shuttering material only. Uniform thickness of slab, excluding corrugations shall be min. 150mm. In this case, top of steel of beam shall be decided carefully.

11.4 STEAM GENERATOR AREA PAVING

For paving in steam generator area, refer clause 6.12,Chapter 6 of Volume VI.

11.5 TRANSFORMER YARD

Generator transformer, station transformer, unit auxiliary transformer and service transformer are located in front of the turbine building. Transformers shall be installed on RCC foundations with rails on the top and oil soak pits filled with hard stone aggregate. Burnt oil pits are provided to collect leaked oil from the soak pit through salt glazed pipes laid to slope. RCC blast wall / RCC frame with brick wall of adequate thickness and height to satisfy TAC regulations shall be provided in between transformers as fire barrier wall.

RCC foundations shall be provided with rail to transport transformers out of transformer yard during maintenance. Entire area shall be surrounded with 3m high chain link fencing with gates. Where rails cross the fencing, fencing shall be made of removable type to facilitate transport of transformer. Floors shall be paved with plain cement concrete and shall be sloped towards peripheral drains, which shall lead to a sump from which the drainage is led through an oil water separator. The clear water shall be led to plant drainage.

11.6 ESP CONTROL ROOM

ESP panel control room buildings shall be RCC framed building with brick walls plastered on both faces, complete with drains, space conditioning, and building lighting. The building shall have a separate air-conditioned area; and a separate non air-conditioned area except as required for the contained equipment. The contractor ascertains the building size according to the design requirements.

11.7 SWITCHYARD STRUCTURES & CONTROL BUILDING

Extent of switchyard and number of towers and gantries and the size of switchyard control room will be as per the layout of the switchyard which has been outlined in Vol. IV of the specification. For rest of the detail, refer chapter 22 of this specification.

11.8 CIRCULATING WATER SYSTEM

The circulating water system envisaged for the plant is by using clarified water.RCC cooling water channel shall be of rectangular in shape and is to be designed as uncracked section for water face and cracked section with crack width of 0.1mm for earth face as water retaining structures as per IS:3370 Part-I to Part-IV. Depth of channel and width of channel shall match with the width and depth of the cooling water channel from cooling tower. These branch channels shall join together and form common channel leading to the forebay of the CW pump house.

Expansion joints shall be given at spacing of about 30m. Pedestrian crossover shall be given across the channel at approx. 300m centers. The channel shall smoothly diverge and form the forebay in front of the pump house.

11.9 CW PUMP HOUSE & FOREBAY

The pump house structures shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. Crane girder shall be of steel. Cage ladder shall be provided for access to crane platform. Side of the pump house up to motor floor level on the pump discharge side shall be of RCC. Maintenance bay of the pump house shall have RCC grade slab with granolithic finish and non-metallic floor hardener. Motor floor shall also have similar finish.

Pump sump structure shall be designed as uncracked section for water face and cracked section with crack width limited to 0.1mm for earth face. Each sump shall be provided with stainless steel (SS 316L) groove for inserting coarse screen, fine screen and stop logs. Grooves for stop log shall be provided before and after the screens. The stop log shall be epoxy painted and coarse / fine screens shall have stainless steel mesh over galvanized MS frame. Number of pump sump and stop log shall be as per the requirement of mechanical design. This floor shall have openings for lowering the lifting of stop logs and screens. These openings shall be covered with epoxy coated mild steel gratings when the screens are placed in position. Provision for handling of the screens and stop logs shall be made. Sufficient paved space shall be provided to keep the stop log when not in use and also for maintenance of screens. Galvanized MS handrails shall be provided on 3 sides of the pump floor (sump roof). Each individual pump sump shall also be provided with a drain sump to empty the sump for attending to maintenance of pump.

Crack width to be adopted for design of CW channel and forebay shall be as per IS: 3370 considering severe" exposure condition. Vertical turbine pumps are envisaged in the Plant.

An annex to the CW pump house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding to accommodate switchgear and control room with cable vault below, chlorinator room and toilet block. All floor shall be of RCC. Roof shall be given proper slope and water proofing. Roofs shall be made accessible by MS cage ladder.

Roof of CW pump house and annex shall be provided with troughed profile permanently colour coated sheet on outside and plain permanently colour coated sheet on inside with 50mm thick mineral wool insulation in between the two sheets. A slope of 1 in 5 shall be provided for quick drainage of rain water. Mineral wool insulation (as per IS: 8183) having a density of 32 kg/cum for glass wool or 48 kg/cum for rock wool, bound in polythene bags shall be used, with or without framed strips 25x3mm (min.) at maximum 300mm c/c to hold the insulation between the runners, keeping in position with galvanized hexagonal wire netting of 0.3mm wire dia. & 19mm mesh size as per manufacturer's recommendations. Roof shall be made accessible by MS cage ladder.

Roof must be designed considering load of solar panel.

All doors shall be of flush welded steel construction. For switch gear room, the main entrance door shall be of adequate size to transport the panels. All windows shall be steel glazed side hung. Wall in front of transformer yard shall be designed to satisfy fire rating as per TAC regulations.

An auxiliary transformer yard may be required in front of the switchgear room. Civil work similar to the transformer yard in front of MCC room shall be included in the scope of work.

In the pump house support blocks for butterfly valves and pipes along with proper handling facility shall be provided.

Foundation system for CW pump House shall be designed carefully keeping in view the nature of soil. For CW forebay and CW channel structure PRV can be used to relieve uplift water pressure on the base slab. In this case, base slab of the CW forebay shall be designed for 60% of water uplift pressure.

Suitable thrust block to hold CW pipe line at various locations as per mechanical requirement is also in the scope of BIDDER.

11.10 CW INLET AND OUTLET CONDUITS

Cooling water conduits of adequate size shall be provided from C.W pumps to condenser and hot water conduits from condenser to cooling tower. These conduits shall be formed of structural steel conforming to IS: 2062. Pipe shall be provided with 3 coats of epoxy paint of minimum DFT of 350 microns over two coats of compatible primer after sand blasting. The pipes shall be tested before commissioning of the system. Following design requirements shall be met:

a) Provide a minimum clear distance of 2.0 m between ground level and the top of RC encasement.

b) The design pressure shall be the highest of the following:
   (i) Pump shut off head + Static head difference between normal water level at CW sump and the lowest invert elevation of the CW conduit.
   (ii) Maximum pressure due to surges.

c) The conduit shall also be designed for vacuum pressure inside and overburden pressure outside. The Vacuum pressure shall be based on the surge analysis but in no case less than 0.9 Kg/sq cm for the inlet and outlet pipes from the condenser and the delivery pipes from pump discharge up to the header and 0.5 kg /sq cm for the main inlet and discharge pipes. Suitable protection devices such as air release valves shall be provided to ensure that design vacuum pressures are not exceeded.

d) The conduit shall be designed for surcharge of 2 t/m2 in addition to overburden pressure of soil.

e) The design shall be checked for other loading combinations of surcharge, transformer load, ground water pressure etc.,

f) Manholes shall be provided at a maximum spacing of 150 m in straight reach of conduit. One manhole shall be provided at all horizontal bends and one at the lowest stretch between two vertical bends.

g) Thrust block / anchor blocks shall be provided at bends.

11.11 CLARIFIED WATER TANK AND FIRE WATER PUMP HOUSE

Capacity of clarified water tank and fire water tank shall be as mentioned in Vol-III of tech. specification.

Fire Water sump shall be water tight RCC construction with covered RCC roof. Vent pipes shall be provided at the roof. The Fire Water pump house shall be single storied steel framed building with colour coated metal sheeting as side cladding. Monorail & gantry shall be provided for handling pumps.

The building shall be complete with doors, windows and rolling shutter.

11.12 SERVICE BUILDING

The service building shall be a reinforced concrete framed building. The building shall generally not exceed four storeys and shall be directly connected to the main plant building at operating floor. The floor area shall not be less than 1000 sqm for each floor. The building shall generally be air conditioned with false ceiling. Elevators as indicated in Vol III shall be provided at the entrance loby. Entrance to lift shall be decorated with rose wood architrave and matching granite tile dado. Number of staircases provided shall be decided based on statutory regulations. For the staircases in the lobby the treads and dado shall match with the floor finish. Handrail shall also be of aesthetic appearance and made of stainless steel. At least one staircase shall lead to the roof.

Specially designed long RCC porch shall be given in front at the main entrance for receiving cars of VIP"s. Length of the porch shall be at least 15 m. Special attention shall be given in front of service building in landscaping the area and developing garden with flowering plants.

A grid of concrete beams and columns shall support the reinforced concrete roof (minimum 3% slope) and the floor slabs. The walls shall be of masonry construction, plastered internally and externally. The service building shall have the following provisions:

a. Seating accommodation for senior O&M executive along with supporting staff including furniture of latest style. For the accommodation of all Executives permanent brick wall not to be provided, instead wooden partition wall of cubicle type is to be provided.

b. Safety and Welfare Cell, First aid room

c. Reception, drawing hall, library, print rooms and records room/ archives.

d. Conference hall with all amenities like latest style furniture, loud speaker systems, LCD display equipments, service room etc.

e. Mini conference hall with furniture near UCB.

f. Relay testing lab, electrical lab, C&I repair lab and transmitter lab.

g. Pantry

h. Toilets – Ladies & Gents in each floor as per specification.

i. Telephone Exchange of 500 lines.

j. Electrical and LAN points at each seat in the cubicle, cabins & conference rooms with wiring and fittings.

k. Model room, change room with lockers for the operating and maintenance workmen, battery room, stores, air washer room.

l. Cabins for senior officers and conference room shall have attached toilets.

The bidder has to furnish the three dimensional architectural plans along with the colour codes for the above buildings for approval of the Purchaser for adopting one among the alternatives proposed.

11.13 STORAGE YARD

A storage yard of 6,000sqm shall be provided with a provision 3000sqm. Covered area. The storage yard shall have compound wall of 3m height with anti climbing device. Covered area shall be of framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding.

Roof shall be provided with troughed profile permanently colour coated sheet on outside and plain permanently colour coated sheet on inside with 50mm thick mineral wool insulation in between the two sheets. A slope of 1 in 5 shall be provided for quick drainage of rain water. Mineral wool insulation (as per IS: 8183) having a density of 32 kg/cum for glass wool or 48 kg/cum for rock wool, bound in polythene bags shall be used, with or without framed strips 25x3mm (min.) at maximum 300mm c/c to hold the insulation between the runners, keeping in position with galvanized hexagonal wire netting of 0.3mm wire dia. & 19mm mesh size as per manufacturer's recommendations. Roof shall be made accessible by MS cage ladder.

Roof must be designed considering load of solar panel.

Office space and toilets shall also be provided. Entry & exit of trucks shall be thru rolling shutters of adequate size. In addition a 2 single leaf steel flush door shall be provided for entry of the staff. Adequate windows shall be provided. The covered sheds shall be connected with bituminous roads in side storage yards. The storage yard shall be provided with 150mm thick gravel paving along with suitable drainage arrangement connected to plant drainage system. Location of storage yard will be decided during detail engineering as per availability of space at site.

11.14 PARKING SHEDS

Parking sheds shall be provided at service building, security complex, at CW pump house area etc., at all locations for operating staff. The parking sheds shall be of steel framed construction.

11.15 AIR WASHER ROOM

This shall be a single/double storied steel framed building adjoining to the Turbo generator bay. Roof shall be of RCC supported on colour coated trough shaped permanent decking supported on steel beams. Side cladding shall be by brick supported on concrete encased steel beams. Internal wall surfaces shall receive cement mortar plastering mixed with water proofing compound. Water tank and RCC supporting structures for louvers, filter and foundation for equipment such as fans and pumps are also included in the scope. Proper drainage of the floor has to be provided for. Doors shall be of flush welded steel and they shall be made airtight. Rolling shutter of adequate size should be provided for taking the equipment inside and truck with compressor. The roof framing shall support an underslung crane of adequate capacity. Compressor foundation shall be isolated from the grade slab. Air receiver and Air drier can be supported from RCC grade slab. All trenches shall be sloped towards drain sumps. Trenches shall be provided with chequered plate cover. Steel glazed windows shall be provided for ventilation and natural lighting. A minimum of 2 flush type steel door shall be provided for movement of personnel. Dimension of the building shall be decided by the CONTRACTOR to suit the dimension of the equipment he is supplying duly taking into account maintenance requirements.

11.16 COMPRESSOR HOUSE

This shall be of framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding with electric hoist. The dimension of the building shall be decided by the CONTRACTOR to suit equipment supplied. D.G set foundation shall be isolated from the floor.

All trenches shall be of RCC and shall be designed as water retaining structure. There shall be no entry of cables / pipes to these trenches below grade level from outside. All these trenches shall be covered with chequered plate over steel framing. Adequate number of sumps shall be provided to drain these trenches.

11.17 PIPE RACKS AND CABLE RACKS

All cable and pipe routing in outlying area shall be clubbed and shall run over ground on structural steel ‘pipe / cable’ racks at a height not less than 3000 mm clear above grade level. Where the pipes cross roads / railway clear headroom shall be 8000 mm. The racks can be multi-tiered. Cable shall normally be laid above the pipes.

Pipe racks/cable racks shall be of structural steel frame and longitudinally braced and shall be designed for worst combination of loadings. Expansion provision shall be provided wherever there is a change in direction or where length of the rack exceeds 100 meters.
Pipe racks for all connections from the existing station, existing pipe racks is to be used with necessary modification (or) new rack is to be erected

Necessary access ladders and platforms to be provided for maintenance. Where so required chequered plate platforms shall be provided for maintenance purpose. Pipe rack columns shall be supported on RCC foundation with bottom of base plate 300mm above adjoining ground level.

11.18 FUEL OIL HANDLING SYSTEM

Unloading pump houses to unload oil from road tankers or rail wagons shall be of single storey structural steel frame structure with GI sheet roofing and Brick walls. A paved platform shall be provided between the pump house and the rail wagon / road tanker parking area with plain cement concrete over rubble soling, sloped towards a peripheral drain. The drain will be led to a sump with oil water separator. No cable trenches will be permitted in the pump house.

Fuel oil pressurization pump house will house fuel oil pumps, heaters and MCC's. This is also single storied structural steel framed structure with GI sheet roofing. The pumps will be located in an R.C.C basement. Protective hand rail shall be provided all round the basement. MCC shall be located at plinth level. Proper access shall be given to the basement. Basement shall be given proper drainage facility. The oil / water mixture collected in the sump will be led to an oil water separator. The basement shall be designed as a water retaining structure. Electric hoist crane or monorail facilities will have to be provided in all the pump houses as specified in the Mechanical section of the specification.

Fuel oil tanks shall be of structural steel designed as per IS:803. Foundation of the fuel oil storage tank shall be provided with bitumen sand mixture laid over confined river sand bedding formed with RCC ring beam. The type of foundation to be adopted will depend on the soil condition. Where soil is very poor, tank may have to be founded on concrete pad resting on piles or the bearing capacity will be improved using ground improvement technique.

The storage tanks shall be surrounded by RCC wall to prevent the spread of fire or leakage of oil from a leaking tank to other areas. The 750 mm wide walkway shall be provided on the dyke wall all-round. The height of the wall, c/c spacing of tanks as well as area provided within the concrete wall are to be decided based on the statutory requirements for the type of oil stored and the quantity of oil stored. The entire area outside the tank foundation and within the tank farm shall be paved with concrete. The paving shall slope towards RCC peripheral drains which shall lead to an oil water separator. RCC crossovers shall be provided at appropriate locations for entry of personal to the tank farm. Fuel oil storage area shall be protected by chain link fencing as in the case of Transformer yard. Extent of fencing shall be to satisfy statutory requirement. Foundations for trestles and pedestals for supporting the pipes, anchor blocks etc shall provided in RCC at appropriate locations.

11.19 RAW MATERIAL (LIME STONE) HANDLING AND STORAGE FACILITY

The raw material (Lime Stone) handling and storage facility shall comprise of all required facilities. Some of which are described below.

11.19.1 Lime stone storage shed

The storage shed shall be of composite construction with structural steel roof truss supported on RC columns and with height suitable for smooth movement of the dozer & dumper trucks. The shed shall be provided with permanently colour coated profiled steel sheet for roof and partial cover on sides, grade slab and RCC foundations. Roof shall be provided with adequate slope for drainage of rain water.

11.19.2 Lime stone mill building & Storage silos

The structure shall be multi storied RCC framed structure. The ground floor of the building shall comprise of the mill area along with associated facilities. Two numbers of steel silos shall be supported over the building structure. It shall house Ball mill, mill separator tank, Lime Slurry tank etc

11.19.3 Conveyor galleries & trestles

As described in chapter 14.

11.19.4 Tunnel, Pent house & tranfer houses

As described in chapter 14.

11.19.5 Surface feeder

This building shall necessarily house the surface feeder which will receive the limestone unloaded by trucks. The size of the building shall be decided based on the size of the surface feeder, road access considering the motorable ramp, there maintenance and handling requirements. The building will be designed as an steel framed structure.

11.19.6 Limestone unloading shed

Limestone storage shed shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. The foundation & grade slab shall be RCC. Plinth protection shall be given with necessary garland drain.

Adequate open paved area shall be provided for parking of 20 (Twenty) number of limestone trucks.

11.19.7 **Limestone crusher house**

Limestone crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. The foundation shall be RCC. Plinth protection shall be given with necessary garland drain.

It should be noted that for structural design, unit weight of lime shall be assumed as 1700 Kg ./Cu.M.& unit weight of gypsum shall be assumed as 1250 Kgs./Cu.m.

11.20.00 **FGD PLANT AREA**

The FGD plant area comprises of several tanks, foundations and structures. Few are as described below.

11.20.1 **Absorber unit with foundation**

The absorber unit shall be steel structure, with steel platforms and accessories within it. The absorber unit structure shall be supplied as equipment in totality. Types of foundation for the structures are covered under separate section based on the subsoil condition and recommendation based on detailed approved geotechnical investigation.

11.20.2 **Absorber recirculation pump house**

This building shall necessarily house the recirculation pumps and oxidation blowers and shall have crane for handling heavy equipment. The size of the building shall be decided based on the size of the pump, there maintenance and handling requirements unless the overall size of the pump. The building will be designed as an R.C.C framed structure.

11.20.3 **Duct foundations**

Duct supporting structure shall be provided for supporting ducts between booster fan, absorber and the chimney for transporting the flue gas appropriately. The structure shall be of structural steel. Types of foundation for the structures are covered under separate section based on the subsoil condition and recommendation based on detailed geotechnical investigation

11.21.00 **GYPSUM HANDLING SYSTEM AND STORAGE FACILITY**

The gypsum handling system shall comprise of all required facilities. Some of which are described below.

11.21.1 **Gypsum processing building**

The Gypsum Processing building shall be twin storied RCC building. The ground floor shall comprise of gypsum dumping space and shall be open on sides. The upper floor shall house the gypsum belt conveyor. The building shall be covered with brick cladding on the sides to match the existing buildings in the plant.

11.21.2 **Gypsum storage shed**

The storage shed shall be of composite construction with structural steel roof truss supported on RC columns. The shed shall be provided with permanently colour coated profiled steel sheet for roof and partial cover on sides, grade slab and RCC foundations. Roof shall be provided with adequate slope for drainage of rain water.

11.21.3 Electrical & control Building

This shall be RCC/Steel framed structure. The building shall accommodate cable vault, toilet, staircase, switchgear room, AC control room, Separate Engineering station control room, AC VFD room and all other required electrical and C&I facilities for FGD system. Side cladding shall be of brick wall/ concrete block/ aerated concrete block wall.

Staircase area shall be protected from fire safety angle as per TAC/NFPA regulations. Main door to switchgear room shall be steel sliding door having adequate area to admit switchgear. There shall be minimum two doors to the switchgear room of flush welded steel type. Control room shall have one swing type aluminium glazed double panel door and one single panel door. Windows shall be steel glazed for switchgear room with wired glass. For control room if window is provided the same shall be fixed with 6.0 mm thick sheet glass. Main entrance of the building shall be of rolling shutter with appropriate ramp approach. False ceiling of Aluminium type shall be provided in the Control room.

Roof shall be given access by means of staircase. An equipment hatch shall be given in the first floor with lifting beam to lift the switch gear / control panel to the first floor.

Roof shall be given a slope of minimum 1 in 100. Adequate number of rain water down take pipe shall be provided .Garland drain as well as plinth protection shall be given around the building.

11.21.4 Liquid storage Tanks

Liquid storage tanks such as emergency quenching tanks, reagent / slurry storage tank, etc., shall be of structural steel designed as per IS: 803. The foundations for the tanks shall be provided with bitumen sand mixture laid over confined river sand bedding formed with RCC ring beam. The type of foundation to be adopted will depend on the soil condition. Where soil is very poor, tank may have to be founded on concrete pad resting on piles or the bearing capacity shall be improved using ground improvement technique. Details of subsoil conditions shall be covered in detailed geotechnical report submitted by Bidder.

All tanks that stores reagent/ slurry/ filtrate water shall be surrounded by RCC dyke wall to prevent the leakage of any reagent/ slurry/ liquid from a leaking tank to other areas. The height of the wall, centre to centre spacing of tanks as well as area provided within the concrete wall shall be decided by BIDDER based on the statutory requirements for the type and quantity of reagent/ slurry/ liquid stored. The area outside the tank foundation shall be paved with concrete with provision of corrosion resistant tiles as per system requirement. The paving shall slope towards RCC peripheral drains, which shall lead to nearest main drain. Foundations for pipe rack and pedestals/sleepers for supporting the pipes, anchor blocks etc., shall be provided in RCC at appropriate locations.

A paved platform shall be strategically located in the unloading & storage area with RCC minimum 150mm thick over rubble soling, sloped towards a peripheral drain, to facilitate the unloading of the reagent from tankers. A separate parking space for tankers shall be provided adjacent to the unloading and storage area.

11.22 RAILWAY SIDING SYSTEM

11.22.1 General

The intention of this section is to specify the functional requirement for handling coal rakes and oil wagons which are brought in the plant for unloading fuel. The railway line net work to be laid as per the system requirement for handing loaded and empty wagons of fuel received in plant without any interruption of fuel handling system.The work shall be carried out as per the latest Indian Standard / recognized international standards and should be capable of handling 4 wheeler wagons / box wagon / N-type wagon runs on broad gauge line. The lines shall be laid as per the layout approved by Indian Railway.

11.22.2 Description

The requirements of railway siding and Marshalling yard in the scope of EPC Contractor are described below: -

LINE FROM KALANOUR STATION TO INSIDE PLANT BOUNDARY

There is an existing Broad gauge line up to Kalanour Station which is approximately 2 KM away from the plant boundary. The EPC contractor shall provide additional railway lines in the plant by tapping of from this railway line.

11.22.3 Coal handling marshalling yard

Required number of lines for handling coal shall be laid so that coal rake can be unloaded by wagon tippler as specified in coal handling system in the stipulated free time of six (6) hours and bunching empty rake formation for dispatch from the time it is received at site. Adequate number of lines for following minimum service shall be provided apart from any other service as required under EPC Contract.

- Coal Rake receipt lines
- Empty rake formation lines
- Empty rake dispatch lines
- Tippler in haul & out haul line
- Sick wagon isolation lines
- Shunting neck
- Engine run around line

Required loco shed shall be provided.

11.23.4 GENERAL DESIGN REQUIREMENT

Line to be laid	-	Broad gauge (1676 mm)
Rail size	-	As approved by Indian Railway
Carrying capacity	-	58.0 t (Approx.)

each wagon		
No. of wagons in full rake	-	58 Box wagons (Approx.)
Full rake length	-	700 m
Rail sleepers	-	Steel plate / wood / RCC
No. of tracks	-	As per system requirement to be identified by Bidder and subjected to owner's approval and railway authorities during detailed engineering. However, min Four Nos. tracks shall be provided.

11.24 Comprehensive study for the marshalling yard shall be done by the EPC contractor through approved agencies like RITES. Saturatory approval for the marshalling yard from railways other agencies is included in scope of bidder. Complete track layout & other recommendation, If any of the agency like RITES on the marshalling yard is in scope of bidder.

11.25 **If desired by contractor TG building, CW Pump house super structure, Fire water pump house, Storage yard, Parking, Air washer room, Compressor house including temporary buildings during construction can be constructed by Prefab construction using high strength steel, In this case minimum thickness of plate for Girt and purlin may be 3.2mm .However, Other design parameter and minimum thickness criteria for other elements of building will be same as mentioned elsewhere in the specification.**

CHAPTER – 12

REINFORCED CONCRETE CHIMNEY

12.1 SCOPE

This specification covers the general requirements for design and construction of reinforced concrete single flue chimney of circular cross section including RCC shell, steel flue, internal platforms, staircase, appurtenances, fixtures, fittings, conduit and other embedment, lift (inside windshield), natural ventilation etc. complete. **Height of Chimney shall be fixed as per criteria mentioned in Chapter 2 of this Volume.**

12.2 CODES AND STANDARDS

a)	IS:456-2000	:	Code of practice and reinforced concrete
b)	IS:4998	:	Criteria for design of reinforced concrete chimneys – Part 1 Design Criteria -1975
c)	IS:4998	:	Criteria for design of reinforced concrete Part 1 Assessment of loads - 1992
d)	IS:875 (All Parts)	:	Code of Practice for Design loads for buildings & Structures
e)	IS:1893-2002 (Part-1) Fifth revision	:	Criteria for earthquake resistant design of structures
f)	IS:1893-2002 (Part-4)	:	Criteria for earthquake resistant design of structures: Part 4- Industrial structures including Stack like structures
g)	IS:432 (Part 1)	:	Mild steel and tensile medium steel bars
h)	IS:1786	:	Cold twisted steel bars for concrete reinforcement
i)	IS:800	:	Code of Practice for general building construction steel.
j)	IS:158	:	Ready mixed paint, brushing, bituminous, black. lead free, acid, alkali, water and heat resisting for general purposes.
k)	IS:1239	:	Mild steel tubes, tubulars and other wrought steel fittings, Part-1 – Mild steel tubes
l)	IS:1904	:	Code of practice for design and construction of foundations in soils : General requirements
m)	IS:2062	:	Hot Rolled low, medium & high tensile structural steel.
n)	IS:3043	:	Code of practice for earthing

o)	IS:3346	:	Method for the determination of thermal conductivity of thermal insulation materials (two slab guarded hot plate method)
p)	IS:3677	:	Un-bonded rock and slag wool for thermal insulation.
q)	IS:8183	:	Bonded mineral wool.
r)	ASCE-1975	:	Design and construction of steel chimney liners. Task committee on steel chimney liners, Fossil Power Committee, Power Division, ASCE.
s)	IS: 6533 (Part1 &2)	:	Design construction of steel chimney- code of Practice
t)	IS:6	:	Moderate heat duty dire clay refractories.
u)	IS:732	:	Code of practice for electrical wiring installations
v)	IS:808	:	Dimensions for hot rolled steel beam, column, channel and angle section.
w)	IS:814		Covered electrodes for manual arc welding of carbon and carbon manganese steel- specification
x)	IS:816	:	Code of practice for use of metal arc welding for general construction in mild steel.
y)	IS:1080	:	Code of practice for design and construction of shallow foundations in soils (other than raft, ring and shell) .
z)	IS:1161	:	Steel tubes for structural purposes – specification
aa)	IS:2309	:	Code of Practice for protection of buildings and allied structures against lighting
bb)	IS:2750	:	Specification for Steel scaffoldings
cc)	IS:2911	:	Code of practice for design and construction of pile foundations. (Parts 1 to 4)
dd)	IS:2932	:	Enamel, synthetic, exterior (a) under coating (b) finishing- Specification.
ee)	IS:2933	:	Enamel exterior (a) undercoating, (b) finishing ·
ff)	IS:3150	:	Specifications for hexagonal wire netting for general purposes.
gg)	IS:3696	:	Safety code for scaffolds and ladders -Part 1 &2.
hh)	IS:4014	:	Code of practice for steel tubular scaffolding Part 1&2.
ii)	IS:4289	:	Specification for Flexible cables for lifts and other

flexible connections : Part 1 Elastomer insulated cables.

jj) IS:4456 : Methods of test for chemical resistant mortars: Part 1 Silicate type and Resin type.

kk) IS:4457 : Specification for Ceramic unglazed vitreous Acid resisting tiles- Specification.

ll) IS:4687 : Gaskets and packing – Gland packing asbestos- Specification.

mm) IS:4832 : Specification for chemical resistant mortars Part- 1 silicate type.

nn) IS:4860 : Specification for Acid resistant bricks.

oo)IS:5410 : Cement Paint.

pp) IS:8112 : Specification for 43 grade ordinary Portland cement.

qq)IS:12330 : Specification for sulphate resisting Portland cement

rr)IS:13311 : Non destructive testing of concrete – Method of test part-1 Ultrasonic pulse velocity

ss)IS:13947 : Low voltage switchgear and control gear: Part 1 General rules

tt)IS:13947 : Low voltage switchgear and control gear: Part 1 General rules

uu)Annexure 14 : International Standards and Recommended Practices Aerodromes- International Civil Aviation Organization Indian Electricity Rules.

vv) Vickery, B.J "Wind Induced Loads on Reinforced Concrete Chimneys" Paper presented at National Seminar on Tall Reinforced Concrete Chimneys, 25-27 April, 1985, New Delhi.

ww) Vickery, B.J. and Basu, "The response of reinforced concrete chimneys to vortex shedding", R I Journal of Engineering Structures, 1984, Volume-6.

xx) Manohar, S.N. "Tall Chimneys – Design and Construction", Tata McGraw Hill Publishing Company limited, New Delhi.

yy) Pinfold, G.M, "Reinforced Concrete Chimneys and Towers", View Point Publication, cement and concrete association, U.K.

zz) The requirements of department of Civil Aviation, Government of India.

aaa) Reference may also be made to ACI:307-1979 " Specification for design and construction of RC Chimney", if some items are not covered in India Codes.

12.3 LOADING & THEIR COMBINATIONS

12.3.1 Dead Load

All permanent loads due to the weight of chimney shell, internal platforms and lining supported on them, ladders, flue ducts, staircases, other accessories etc.

12.3.2 Imposed Load

i) Imposed load on service platform around Chimney shall, 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.

12.3.3 Local Loads

Effect of local loads such as moment produced by corbels, platforms, ovalling, oscillation and thermal gradient in addition to other if any shall also be considered. The group efficiency factor for the pile in foundation of chimney shall not been less than 3.

12.3.4 Thermal Effect

Due to the effect of temperature gradient ΔT, vertical and circumferential stresses are developed. These stresses induced in the concrete shall not exceed values given in IS:4998.

Flue gas temperature at inlet / exit 127^0C (approx.)

The temperature gradient ΔT across the shell thickness of windshield shall be calculated as per IS: 4998 (Part-I) – 1975 but subject to a minimum of 20^0C. Temperature stresses will be calculated according to the procedures given in ACI-307 and IS: 4998.

12.3.5 Seismic / Earthquake Load

Earthquake forces acting on the Chimney and analysis for the same shall be carried out as per IS: 1893-2016 using the Response Spectrum Method. Damping factor to be adopted shall not be more than 3% for reinforced cement stacks. The number of modes to be used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90% of the total seismic mass.

Importance factor to be considerd for seismic analysis of chimney is 1.75

12.3.6 Wind Load

Wind load calculation will be done as per IS:4998 (Part-1) and IS:875 (Part-3) Dynamic analysis will be carried out and stability ensured under such condition.

12.3.7 Along Wind Static Analysis.

Wind parameters to be considered for calculating design wind speed and pressure shall be as follows.

Basic wind speed = 47 m/s (upto 10m above normal ground level) as per IS:875 (Part-3) : 1987.

K1	=	1.07
K2	=	(Table 2 & Table 33, Category = 1, Class-B)
K3	=	1.0

A provision of 10% increase in the wind load forces (due to dynamic interference effect) as calculated based on relevant codes, shall be considered in the initial designs. However, for final designs, the increase can be as per the recommendations of the agency carrying out wind tunnel studies.

The "gust factor" will be calculated according to the method given in IS:4998 (Part-I) – 1992. Dynamic modulus of Elasticity of concrete as recommended in IS:4998 (Part-1) – 1992 will be used for calculating the natural frequencies of the chimney.

C_d will be taken as 0.8 for the concrete shell in general.

Along wind response of chimney shall be calculated both by gust factor method in A-5.1 and simplified method in A-4.1 of IS:4998 Part-1, 1992. For design, higher of the along wind loads shall be used.

12.3.8 **Across Wind**

The across wind response of the Chimney will be evaluated as per IS:4998 (Part-1)/ACI307-98. Chimney shall be designed without considering provision of strakes.

12.3.9 **Ring Moments Due to Wind**

The circumferential ring moment due to wind will be calculated in accordance with clause 5.4 of IS:4998 (Part-I) – 1992. The wind induced stresses in concrete and steel shall be calculated in accordance with Cl. No. D-2.2.7, D-2.2.8 and D-2.2.9 of IS:4998 (Part-I) – 1975.

12.3.10 **Component Design Critirea**

The concrete shell shall be designed as per working stress method as per following load combinations. The modular ratio shall be calculated as per Annexure B of IS 456.

a) Dead load.

b) Dead load + Wind Load

c) Dead load + Earthquake forces.

d) Dead load + Temperature effect.

e) Dead load + Wind load + Temperature effect.

f) Dead load + Earthquake force + Temperature effect.

g) Circumferential stresses due to temperature effect.

h) Circumferential tensile stresses due to wind inducing ring moment.
i) Circumferential compressive stress due to wind induced ring moment combined with temperature.

In Load combinations (a) to (i) above, dead load considered shall be with or without the weight of steel lining for flues & platforms, whichever condition is more critical.

1. 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.

2. The thickness of RCC shell shall be provided as required by stress calculations. However, the thickness of the shell has also to be determined on the basis of wind tunnel model studies and any increase, in the thickness of shell or quantities required to be made as per report shall be followed without any extra cost. Minimum thickness of the shell at top shall be 500mm & at junction of shell & pile cap shall be 950mm.

3. Stresses in the shell shall be checked at 10metre intervals along the height of the shell or at every corbel location or whichever distance is less these stresses shall be within permissible limits.

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 pile cap.

5. The dynamic modulus or 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.

6. The static modulus of elasticity of concrete shall be taken as under.

   5000√ fck for instantaneous loadings. Where fck is the characteristic compressive strength of concrete as per clause 6.2.3 of IS: 456-2000.

7. At any section of the shell vertical bars shall be uniformly spaced. Non uniform spacing of vertical bars is not acceptable.

8. Reinforcement in the shell shall be provided as per IS:4998 (Part-I) – 2015. Minimum vertical reinforcement in the shell shall be 0.3% of concrete area. The maximum spacing of vertical reinforcement bars shall not be more than 250mm on each face. The minimum circumferential reinforcement shall be o.25% of concrete area. The maximum spacing of horizontal reinforcement bars shall not be more than 200mm on each face. The circumferential reinforcement for a height from the top equal to half the shell outer diameter or 3 meters whichever is more shall be twice that required from design forces. The clear cover to reinforcement shall be 50mm & 75mm for foundation/pile cap. Circumferential reinforcement shall be placed around the exterior of and securely wired or welded to the vertical bars at an interval of not more than 600mm.

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

While providing vertical reinforcement, the total number of vertical bars shall be continued till such height when alternate bars can discontinued. However, reduction of bar diameter along the height is permissible. At any section of the shell, vertical bars shall be uniformly spaced.

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

Laps for the vertical reinforcement shall be staggered. Not more than one-third of the bars shall be lapped at any one level. The laps at a level should be distributed around the perimeter and not concentrated in only one part of the perimeter of the shell. Where vertical reinforcement is required to be lapped above openings, lap shall be allowed only after a height of B/2 above the opening for the whole section, where B=width of opening. While curtailing the reinforcement above openings, care shall be taken to ensure proper transfer of tensile forces if present in the section to the subsequent section by provision of adequate reinforcement. The bars shall not be curtailed abruptly and an adequate development length shall be allowed.

9. Openings in the shell shall be provided for ductworks, 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 centre of the concrete shell.

   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 (Part-I)

   b) ACI 307.

   c) Reinforced concrete chimney and tower by M.G. Pinfield. The value of K1 shall be taken as 0.11 as per data on page No. 186.

   d) Minimum half number of extra horizontal bars in shell around the openings to continue for complete circle round for both faces and both sides.

   e) In addition to the reinforcement determined from structural considerations as well as to meet temperature and other stresses, extra reinforcement shall be provided around and at corners of openings. The extra reinforcement shall be placed near the outside surface of the chimney shell as close to the opening as proper detailing of reinforcement will permit. Unless otherwise specified, all such extra reinforcement shall extend past the opening by a length equal to its development length in tension.

   f) At each of the openings, the extra vertical reinforcement shall have a total area equal to the design reinforcement for one-half of the width of the opening. This steel shall be placed on each side of the opening within a distance not exceeding 1.5 times the shell thickness wherever column design procedure specified in clause 3.11 above is not applicable. The extra reinforcement shall extend past the opening by a length equal to 1/2 the width of opening plus its development length in tension.

g) At both top and bottom of each opening, extra horizontal reinforcement shall be placed having an area at least equal to one-half of the design circumferential reinforcement interrupted by the openings but the area 'As' of this extra reinforcement shall not be less than that given by the following: As (mm2) = fck.t.s/c Where, fck = characteristic strength of concrete in N/mm2, t = shell thickness at opening in mm, s = width of opening in mm, c = 16000 and 13000 for high yield strength deformed bars and mild steel bars, respectively.

h) One half of this extra reinforcement as stipulated in clauseg above, shall extend completely around the circumference of the chimney and the other half shall extend beyond the opening to a length equal to the development length of the bars in tension. This steel shall be placed within a height not exceeding the thickness of the shell.

i) Diagonal reinforcement with a total cross sectional area in sq.mm of not less than 5 times the shell thickness (in mm) shall be placed at each corner of an opening. These bars shall also extend on either side of the corner a distance equal to the development length of the bars in tension.

j) Additional steel of a total cross sectional area in sq. mm of not less than 3.5 times the shell thickness (in mm) shall be placed horizontally/vertically. These bars which shall extend to a distance equal to the development length in tension on either side shall be in addition to the entire steel already provided.

k) 25% extra reinforcement over and above the area of reinforcement around openings calculated as above shall be provided. Minimum half the number of extra horizontal bars in shell around the opening to continue for complete circle all-round for both faces and both sides.

10. If the circumferential tensile stress in concrete due to wind induced ring moment exceeds the value specified in clause 7.1.1 (g) of IS:4998-Part I, additional reinforcement shall be provided in two layers limiting the stress in reinforcement steel to value specified in clause 7.1.2(g) of IS 4998 Part I.

11. The safety factor against overturning under worst combination of loads, shall not be less than 1.5 in any direction during construction and 2.0 after construction is complete. For the purpose of calculating safety factor against overturning, only 90% of the dead loads as calculated from dimensions and densities of materials shall be taken into account.

12. For estimating the deflections of the chimney in lined and unlined conditions, the static modulus of elasticity of concrete shall be used as 5000 sqrt(fck).
13. Air inlets, sloped up towards inside, shall be provided near the base with GI wire mesh cover over the openings so as to prevent dirt or tiny creatures entering the air gap. The number and size of the inlet openings in the shell shall have a total area of not less than two third of the area of the minimum air gap at top of chimney.

14. Embedments to support the stair case shall be provided in the shell.

15. Expansion anchors shall be used to attach conduit, lightning and protection equipments, lighting fixtures and other lightweight appurtenances.

16. Air outlets with stainless steel wire mesh mounted on stainless steel frame shall be provided at the top of the shell. These openings shall be suitably spaced and their total area shall not be less than that provided for air inlets.

17. An opening will be permitted in the windshield at the grade slab level for erection of steel flue cans

12.3.11 Permissible Stresses for Chimney Shell

The stress in concrete and steel reinforcement shall not exceed the limits given CL-7.0 of IS:4998(Part-1)-1975 for various load combinations, excepting the stress in concrete for the case of dead load + wind load which shall not exceed 0.25Fck. The stress in concrete at the junction of shell and foundation will be limited to 0.28Fck where Fck is the characteristic compressive strength of the weaker concrete between shell and foundation.

12.4 GRADES OF CONCRETE AND STEEL

Concrete grade to be used for foundation and shell shall be M30 (minimum). Cement content in concrete shall not be less than 400kg/m^3.

Cement to be used for pile cap and above grade level shall be 43 grade ordinary port land cement. Only one grade of cement shall be used throughout the structure.

In case geotechnical investigation reveals presence of sulphate in the subsoil, high sulphate resistant cement conforming to IS: 12330 shall be used below ground level.

HYSD bars of grade Fe 500D bars conforming to IS 1786 shall be used as reinforcement.

The source and type of the basic ingredients of concrete, viz. cement , aggregates, water and approved admixtures, if any, shall be unchanged throughout the construction of the chimney shell, particularly in case, slipforming technique is adopted for shell construction.

The maximum size of coarse aggregates, unless specified otherwise, shall not be larger than 1/8th the narrowest dimension between forms nor larger than one half the clear distance between reinforcing bars nor more than 40mm. However, for wind shield and roof slab 20mm downgraded aggregates shall be used.

Natural gravel and aggregates of acceptable quality shall be preferred

to broken stone with sharp angular corners for slipform work, in particular.

When slipforming is adopted, the slump shall be between 100 mm and 150 mm at the point of placement. However, precise requirements in this regard shall be established from field tests and shall be subject to OWNER"s approval.

If necessary, approved admixtures such as retarders/ plasticizers to maintain

the workability shall be used with the prior consent of the OWNER. Such admixtures shall be identified after preliminary tests to prove their satisfactory performance and compatibility with the particular type of cement envisaged to be used in the shell construction. After identification and determination of dosage for varying weather conditions, the total quantity of admixture required for complete work shall be estimated and shall be procured in batches to ensure that the same is utilised before expiry of its shelf life. In no case shall the admixtures be used if its shelf life has expired due to delay in construction activities. No additional payment shall be made to CONTRACTOR for providing retarders / plasticizers.

Duly considering the need to support the main girder supporting the steel flue without causing eccentric loading to the wind shield the minimum thickness of wind shield, shall be kept as 400mm at top. Minimum thickness of roof slab shall be 250mm laid to slope towards rain water outlets.

<u>For design of chimney raft/ pile cap enhancement of shear strength near support as per clause 40.5.1 and 40.5.2 of IS 456 will not be permitted. The shear shall be checked at a distance of "d" from the face of support for foundation resting on soil and "d/2" for pile caps. The design strength shall be calculated in accordance with table 23 of IS 456 and appropriate shear reinforcement shall be provided.</u>

For transfer of vertical reaction to wind shield from the supporting beams at platform level, increase in permissible bearing pressure in concrete shall not be considered as permitted at the base of column as per clause 34.4 of IS 456.

12.5 STEEL LINER (FLUE)

12.5.1 General

Liners shall essentially be constructed from structural steel and shall be of the hung type (i.e. of tension type). The liners shall be provided with externally wrapped thermal insulation. The portion of the liners projecting above the chimney roof shall be constructed of stainless steel. Stainless steel liner shall commence immediately above the flue supporting platform but below the roof supporting structure.

The liner shall be of corrosion resistant steel type "COR-TEN B" of minimum 10 mm thick. Top 10m length or length equal to 2 times flue diameter whichever is larger shall be provided using material confirming to AISI:316L or BS:1449. <u>The liner shall be supported atleast at three different levels, and restrained laterally at several levels, with a small length at the bottom near breach elevation supported from the bottom with a suitable expansion compensator in between.</u>

The structural steel transition inlet ducting shall be bottom supported. The transition ducting shall be suitably profiled from a rectangular shape at the chimney inlet to a circular shape up inside the chimney where it shall be connected to the suspended circular steel liners through suitable (non-metallic) fluroelastomeric fabric expansion compensator.

Clean–out door shall be provided below the flue for removal of ash.

Load Bearing and Side Restraints of Flues

Load bearing insulation assembly to have (i) a properly machined mild steel plate with recess at its top for seating PTFE (Poly Tetra Fluoro Ethylene) sheets conforming to BS:5400 (ii) saddle plate (MS) in the middle having stainless steel plate fixed at its bottom surface and lead / elastomeric sheet at top, and (iii) top late formed of two numbers insulation blocks each made of minimum 50 mm thick rigid, non-combustible asbestos fibre reinforced lime-silica board (SINDANYO BLOCKS NATURAL GRADE CS-51) or equivalent bonded to mild steel plates at top and bottom. For side restraints assembly of insulation blocks of SINDANYO Natural Grade CS-51 or equivalent and stainless steel plate shall be used. All stainless steel in these assemblies shall conform to AISI-316L and mild steel to IS:2062. SINDANYO BLOCKS or equivalent shall be suitable for operation at 320°C and shall primarily satisfy the following physical properties:

i) Minimum compressive stress prior to onset of compression yield of not less than 12 N/sq.mm.

ii) Minimum shear strength of 30 N/sq.mm when tested in accordance with BS:3497-1979.

iii) Thermal conductivity shall not exceed 0.67 W/m Deg.C at a mean temperature of 200°C and its coeff. of linear expansion not to exceed $1.2x10^{-5}$ per Deg.C.

iv) Adhesive used for bonding purposes shall be of material with equivalent high temperature properties as approved Foundation Engineer. It may be of "Fortafix Fiborclad Adhesive" as manufactured by Fortaxfix Ltd., England or equivalent.

12.5.2 **Design of Steel Liners**

Steel liners shall, in general, be designed meeting the requirements of the document, "Design and construction of steel chimney liners", prepared by Task committee on steel chimney liners, Fossil power committee, Power division published by ASCE-1975.

The flue diameter shall be so sized to ensure that the flue gas exit velocity shall not exceed 18.3 meters/second at the normal continuous operating load. It should be ensured that the flue gas exit velocity at the lowest continuous unit load is high enough to enable adequate dispersion of the flue gases. For this purpose, 100% turbine MCR condition with design coal firing shall be considered as normal continuous operating condition, and 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.

The supporting / restraining arrangement of the liners at intermediate platform should be such that expansion of the liners longitudinally or circumferentially is not restrained.

Permissible stress for design of bearing shall be restricted to 8N/sqmm.

The liners shall be independently supported and shall be designed to avoid contact with each other, the concrete shell or any subsystem supported by the concrete shell. Minimum clearance between the liners and the liner and shell or other subsystem generally shall be not less than 1.2 metres.

Sampling ports for measurement of Nox, Sox and The liners shall be independently supported and shall be designed to avoid contact with each other, the concrete shell or any subsystem supported by the concrete shell. Minimum clearance between the liners and the liner and shell or other subsystem generally shall be not less than 1.2 metres.

Sampling ports for measurement of Nox, Sox and opacity of flue gas through openings (stainless steel pipes) shall be installed in liners at a height as required during detailed design.

12.6 INSULATION

On exterior surface of flue

The flue shall be insulated externally. The insulation shall be semi-rigid, resin bonded type, in the form of slabs and shall conform to IS:8183.

Blanket type insulation shall not be used. The density of insulation shall not be less than 80 kg/cum for resin bonded glass insulation and 200kg/cum for resein bonded rock wool.

The coeffient thermal conductivity of insulation shall be 0.52mW/cm/hr/°c at a mean temperature of 100°C. Insulation / wrapping over fluecan shall be done at ground level before erection.

The insulation thickness shall be determined based on the maximum ambient temperature, surface air velocity worked out based on the draught of ventilation air in the annular space between the flue liner and chimney shell, insulation surface emissivity of 0.3 and the insulation cold face maximum temperature not exceeding 60°C. The draught of air in the annular space shall be the natural draught by the heating of air by the flue liner and the air being vented out through the openings in the chimney shell. The increase in the annular air temperature due to the rising heated air shall be taken into account while calculating the insulation thickness. However, a minimum of 100 mm thick insulation shall be provided on the external face of flue.

Stainless steel hood shall also be provided to cover the annular space between the stainless steel flues and openings provided in the roof slab.

The insulation shall be tightly secured to the exterior surface of the liner by impaling them on studs welded to the surface at 450mm c/c both horizontally and vertically. The studs shall be galvanized plated and be of a minimum thickness of 10 gauge and 75 mm wide. The studs shall extend a minimum of 25 mm beyond the thickness of insulation. 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 galvanized 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 centers. Any form of lacing the mesh fibres together will not be permitted.

Insulation for the exposed portion of flue at the top shall consist of 6 layers of insulation material each of a minimum thickness of 25 mm and all joints shall be staggered. The material shall have a minimum density of 200 kg/cum. This shall be protected from the elements by means of a stainless steel cladding, flashing and hood of grade 316 L stainless steel.

Testing of insulation material to satisfy the specific requirements and properties as outlined in this specification IS: 8183 and in the relevant drawings by the contractor shall be carried out.

Insulation materials shall be added to walls where necessary to reduce cooling loads. Also, insulation shall be used for sound absorption on walls which enclose equipment that has been determined as generating excessive noise. This sound insulation shall be provided in interior concrete block, sound block, or insulated metal wall panel liners as appropriate. The liner panels shall be as described above, except they shall include perforations and insulation enclosed in plastic bags. The overall noise Reduction Coefficient shall be 0.80 or better.

12.7 LINER HOOD

The liner hood provided at top of flue shall be fabricated from 6mm thick (minimum) stainless steel sheets of grade 316L. The hood shall completely cover the annular area packed with insulation material between the stainless steel flue and cladding. All sections of the hood shall be anchored in places with stainless steel bolts / nuts. Slot holes shall be provided to make allowances for differential expansions / movements.

12.8 LINER FOR STEEL FLUE OF RCC CHIMNEY

Treated flue gas from the absorber shall be discharged through the chimney flues. The wet steel flues of existing chimney shall be suitably lined. The flue duct shall be lined with 51 mm thick Borosilicate glass blocks. External surface of chimney flue liner projecting over the chimney roof shall be wrapped with 3 mm thick Titanium sheet. The design & construction of steel chimney liners shall be based on the guidelines of EPRI Revised Wet Stack Design guide.

To avoid the carryover of the condensate/acidic dews/water droplets/ gypsum coming out of the wet chimney a condensate collection system shall be provided. Design of the condensate system should be such that the liquid condensate film near the exit of the stack is collected in the chimney and preventing falling of the acidic dews/water droplet/gypsum from the chimney in the nearby area.

12.8.1 Chimney Liner Materials

All materials shall conform to IS Codes. However, the following shall apply: The flue duct shall be lined internally with Borosilicate glass blocks of 51mm thick. External surface of chimney flue liner projecting over the chimney roof shall be wrapped with 3 mm thick Titanium sheet over insulation.

The insulation shall be semi-rigid, resin bonded type, in the form of slabs and shall conform to IS: 8183. The Insulation shall consist of 6 layers of insulation material (resin bonded rock wool) each of a minimum thickness of 25 mm and all joints shall be staggered. The material shall have a minimum density of 200 kg/cum. Blanket type insulation shall not be used. This shall be protected from the elements by wrapping with 3mm thick Titanium/C-276 sheet cladding. Testing of insulation material to satisfy the specific requirements and properties as outlined in this specification IS: 8183 and in the relevant drawings by the contractor shall be carried out.

The thickness of Borosilicate shall be 51 mm. The lining material should with stand minimum 200°C for continuous operation of minimum 30 minutes duration.

Alternatively the chimney flue liner cladding shall be made of 2 mm thick Titanium (Grade 2 as per ASME SB265) or C-276 (ASTM B575, UNS N10276) alloy over 8 mm thick (minimum) mild steel base metal of flue liner. Cladding shall be done by explosion bonding or hot rolling to achieve the required quality as per ASTM B 898-11. In case of Titanium as liner, the flue diameter shall be so sized to ensure that the flue gas exit velocity shall not exceed 16.8 meters/second at the normal continuous operating load.

12.8.2 SPECIFICATION FOR BOROSILICATE LINING

Borosilicate Glass Block Internal lining material, for the flues for the entire height including the lining of flue gas duct up to chimney inlet flange (including transition duct)..

i) Borosilicate Cellular Glass Block, 51 mm thick, as required
ii) Epoxy Primer
iii) Adhesive membrane
iv) Stack condensate collection system to avoid the carryover of the condensate/acidic dews/water droplets coming out of the stack.

Borosilicate Blocks:

The lining system shall use closed cell borosilicate glass blocks with the following physical properties:

i) A coefficient of linear thermal expansion not greater than 5.5 x 10(-6)/°C, as per ASTM E228

ii) Compressive strength of at least 1.38 Mpa / 1.1 N/Sq.mm as per ASTM C.165

iii) Flexural strength of at least 0.62 Mpa / 0.8N/Sq.mm as per ASTM C.203/C.240

iv) Thermal conductivity of 0.087 W/m°K at a mean temperature of 38 °C as per ASTM C177 and ASTM C518

Adhesive membrane

The adhesive membrane shall be a 2-component urethane asphalt mastic having excellent elastomeric properties and be acid & heat resistant. The adhesive membrane shall be applied in between and behind the blocks in a 3.2mm thick layer ensuring a proper bond and adhesion. The adhesive membrane shall have the following properties.

i) Tensile strength at 23° C of 1.0 N/mm2 as per ASTM D.412

ii) Elongation at 23° C of 147.0 % as per ASTM D.412

iii) Moisture vapor transmission of 0.0048 Perm inches as per ASTM C.96 Method E

iv) The adhesive shall show no slump after 5 hours conditioned at 60ºC with a film thickness of 3/32" as per ASTM 6511, standard test methods for solvent bearing bituminous compounds, section 12 behavior at 60ºC.

Specification of primer

Primer to be applied on steel substrate receiving borosilicate glass block lining system shall have the following properties including thickness, physical & chemical properties.

i) The primer shall be a high performance epoxy primer. the primer shall be applied in 1 layer with a WFT of 3 to 5 mils

ii) The primer shall be applied either by rolling or spray gun Welds and joints shall receive an additional layer of primer by brush prior to rolling or spraying

iii) The solids by volume of the high performance epoxy primer shall be no less than 50%

iv) The bonding of the primer to the steel shall be at least 1400 psi. as per ASTM D4541

Specification for surface preparation for steel substrate.

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

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

Wet stack properties of the lining system

The lining system (borosilicate glass block and adhesive) shall be tested for its wet stack surface properties by an independent approved institute, subject to acceptance by the Purchaser, and has during such testing been shown to allow, without any significant re-entrainment of flue gas condensate, a flue gas velocity of 18.3 m/s.

Bidder shall provide a project specific "Wet Stack" study, performed by an independent approved institute, subject to acceptance by the Purchaser, liquid drains to ensure minimization of liquids and condensates entering the chimney.

Installation of Borosilicate block lining system

Surface Preparation & Surface Cleaning

Lining of the chimney shall include necessary cleaning, surface preparation and all arrangements for man material shifting, approach facilities, inspection etc.

Mixing of Adhesive Membrane

- The Adhesive membrane shall be mixed according to the direction for the product use in the correct mixing ratio.
- The temperature for mixing the main material and hardener shall be about 24 deg C.
- Appropriate mixing method shall be used for equal mixing and should be blended for the required appropriate time.
- Sufficient time shall be allowed for curing

Mixing machine

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

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

- The mixing machine must be CE – approved.

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

- Adequate number of mixing machines shall be employed for completion of the installation works for the two units/flue cans within the scheduled time.

Mixing of Epoxy Primer

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

- Mixing ratio shall be as recommended by OEM

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

Installation of Borosilicate Block

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

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

- Block whose edge is broken shall not be used.

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

- It is important that the liner substrate be fully covered with the adhesive material to ensure that a continuous chemical- and moisture-resistant barrier is formed between the inside and outside of the flue. A nominal adhesive thickness of 3.2 mm is recommended behind and between each block. A 1.6-mm thick layer should be toweled onto the liner, as well as to the sides and back of each brick, before installation. This double-buttering technique ensures a full bond of each block to the liner and to each other. Excess adhesive material squeezed out during placement of the block should be struck clean. Ensure the proper radial alignment of the blocks and to strike the adhesive/mastic flush with the inside surface of the liner. The surface of the block should be clean and free from smeared adhesive/mastic material. If the maximum projection or offset between bricks on the interior surface of the liner shall not exceed (3.1 mm).

Inspection

- Inspection and testing including adhesion shall be as per approved QAP.
- The mixing, curing and adhesion characteristics of the adhesive membrane shall be evaluated by applying it onto a test area of the same material and surface preparation of the substrate. Work life and initial set time may be visually observed. Cure shall be uniform.
- The installation procedure of the lining system shall be verified by installing the system on a transparent panel. Visual inspection shall be made of back, end and side joints.

Testing

- Borosilicate Lining Block should withstand Hydrolytic resistance as per ISO 719.
- The lining system manufacturer shall demonstrate a proven quality control system that monitors and documents the key physical properties mentioned in the specification.
- Bidder shall check and provide satisfactory proof to owner, that the back joint adhesive of the borosilicate lining system will not exceed its supplier recommended operating temperature during any operating condition that can occur before and after FGD system commissioning.
- The Borosilicate Block shall withstand EPRI parameters of 18.3 m/s flue gas velocity

Heat cycling resistance

- The lining system shall, through documented testing, have been proven resistant to thermal shock, for a minimum of 1000 cycles, where each cycle results in the lining surface temperature to rise from ambient temperature to 180 °C, and back to ambient temperature.
- The lining system shall also withstand occasional excursion of flue gas temperature of more than 200°C.

On site supervision and QA/QC services

- The lining system (borosilicate glass block and adhesive) supplier shall provide on-site technical support and QA/QC supervision, and shall employ QA/QC supervisors with a demonstrated experience of at least 5 years in technical support and QA/QC supervision of the subject lining system.

Performance, safety and fire risk

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

Requirement in Flues

Sample Point

- Borosilicate block primer and high nickel steel bar will be applied to sample points to make it acid resistant.
- The nozzle (Pipe tube) shall be of suitable alloy steel to withstand design operating environment.
- Nozzle shall be fully seal-welded both inside and outside of the steel duct plate. The inside weld shall be ground smooth.
- The nozzle shall be flanged and not threaded.
- The Glass Blocks shall be Cut and shaped as required to fit. The block shall be fully bonded to the exterior surface of the nozzle with adhesive membrane.

Manhole and Access doors

- Manholes/Access doors shall be modified by application of borosilicate blocks.
- High nickel alloy stop bars of 2mm thickness for protection from acidic condensate.
- Fibre gaskets shall be used for sealing.

Collection gutter

- The condensate generated in flue gas while FGD is under operation, shall be collected and discharged from bottom of the flues.
- The material of gutter including drain and base plates shall be made of suitable alloy steel to withstand design operating environment.
- All welds shall be full seal welds.
- The surfaces of the alloy materials which will be in contact with the lining system shall be blasted and primed with Epoxy Primer.
- The Glass Blocks shall be fully bonded to the alloy steel.

Puddle Flange

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

Expansion Joints (if any)

- Expansion joints cannot withstand the acidic flue gas during FGD operation and hence shall be provided with acid resistant elastomeric fabric bellows.

12.9 INTERNAL PLATFORMS

Minimum 3 number of Internal platforms shall be provided, unless indicated otherwise elsewhere.

The platform shall be designed for dead, imposed (live), errection work and other possible loadings and temperature effects. These platforms shall provide support and lateral restraint to the steel liners and provide access for inspections & maintenance. Forces imposed on the floor due to lateral restraint of flues shall be enhanced for impact effects. These platforms shall also be designed suitably for liner errection works.
The platform shall be supported on a grid work of structural steel beams supported from the wind shield. Top most grid work shall support RCC roof slab, where as other grid work shall support M.S. gratings as required from functional requirement. Corrosion allowance of 2 mm (minimum) shall be kept in the design of girders. Live load for the design of platform shall be 5 kN/sqm.

The members of the beam grid shall be assembled by high precision bolted connections only. The member dimensions shall be made to suit the as built dimension within the wind shield. The beams shall be painted with 2 coats of zinc silicate primer and 2 coats of heat & acid resistant epoxy paint of approved brand and shade after surface preparation as per IS:1477.

The support of the beams on the R.C.C. shell shall be so designed that only vertical load is transferred to the wind shield without any temperature effect and local torsional / local bending moment.

After fabricating, the members of the individual platforms shall be pre-assembled at ground level land checked for trueness with respect to dimensions and orientation.

The gratings shall be fabricated from M.S. flats comprising of 40x5 thick bracing bars spaced at 40 c/c and 25x4 thick space bar. The grating shall be hot dip galvanized.

Handrails shall be provided with kick plates 65x8 mm along the platform edges. Openings for the elevator shall also be surrounded by a handrail as above, with a hinged gate section on the elevator door side only. The same arrangements shall be provided at all stair case landing/ladder access points, stopper plates shall be provided to prevent gates from swinging outwards. 32mm galvanized steel pipe posts at not more than 1500mm spacing shall be provided for handrail. Height of hand railing shall not be less than 1250mm. There shall be minimum of three handrails at 450mm, 850mm, & 1250mm above platform level. 32mm dia G.I. drainage spouts shall be provided in the platform for drainage of water.

Maximum defection of main plate girders supporting flues and gratings shall be restricted to L/600, however maximum defection for secondary beams supported on main girder shall be L/325.

12.10 **EXTERNAL PLATFORM**

External platform shall be provided as per directorate of air routes and aerodromes (DARA) circular for locating aviation warning lights. The platforms shall be equally spaced at a spacing of 40m (maximum)

The minimum clear width of platform shall be 1200mm and a minimum live load of 500 kg per m^2 shall be considered for design in addition to dead loads and incidental loads.

Hand railing shall be provided all around external platforms including hood platforms using 32 NP GI pipes. The spacing of railing of posts shall not be more than 1500mm center to centre. Height shall be 1250mm. There shall be 3 hand rails at about 450mm, 850mm & 1250mm respectively above platform level.

32mm GI drainage spouts shall be provided in platforms for drainage of rain water.

12.11 **DESIGN OF TRANSITION DUCTING**

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 provision of restraint / support arrangement as required.

The CONTRACTOR shall be responsible for furnishing, fabricating, shop painting and delivery of ducting which shall run from the chimney liner to the flange of the boiler vendor's duct including all necessary auxiliary ducting as well as soot collecting hoppers located outside the chimney shell. Soot hoppers shall be lined with SS grade AISI 304. Suitable flange connection shall be provided at the exit of the hopper to provide SS / CI pipe connection to drain ash / condensed acid mixed water.

The duct work profile and the guide vanes shall be so configurated and sized to achieve the desired flue gas flow characteristic and to minimize flue gas pressure losses.

The plate thickness of the ducts shall be arrived at from minimum (i.e. codal) requirements, structural considerations and corrosion allowances. Material of construction shall be COR-TEN steel conforming to IS:2062. Minimum thickness shall be 10 mm.

The duct work shall be insulated with 75 mm thick insulation (3 layers of 25 thick sheets) as per requirements of clause 18.11 and protected with aluminium foil of minimum 1mm thickness. Access doors shall be provided for the ducting where required for inspection and cleaning.

The duct work and its supporting structures shall be designed for the most severe of the possible combinations of gravity loading (accounting for ash accumulation), seismic loading, wind loading, flue gas pressure loading and thermal loading.

12.12 EXPANSION COMPENSATOR

The suspended portion of the liner shall be connected to the bottom supported portion of the liner by an expansion joint. The joint shall be able to compensate for the large thermal movements of the steel flue, gas tight, acid resistant, heat resistant and provide an adequate insulating medium to avoid excessive overheating in the access void.

The materials used for the fabrication of the expansion joints shall be suitable for the flue gas conditions specified herein, and shall not deteriorate during transit, site handling, storage and installation.

The expansion compensator shall be made of flexible fabric and bolster. They should be air tight and impermeable and should withstand the maximum serviceable temperatures of the flue gas. CONTRACTOR shall ensure that the units are transported, stored and installed in proper manner. The joints shall conform to all the requirements specified herein. The contractor shall replace the whole unit if the expansion joint is not manufactured/ installed as per the instructions of the manufacturer nor does it satisfy the tolerance limits specified by the manufacturer approved by the ENGINEER during procurement stage.

The CONTRACTOR shall furnish in complete an installation, dismantling and maintenance user handbook. A draft of the handbook shall be submitted to the EMPLOYER for his approval well before the installation commences.

The CONTRACTOR shall also supply spare expansion joints complete with instructions for storage, fitting, instructions, spare accessories, tools for installation, etc., to replace faulty / used expansion joints at a later date. The spares should withstand a storage period of not less than 10 years.

The flexible type of expansion fabric shall typically consist of 5 layers of materials as indicated below. The layers are described from inside to outside.

a) Two layers of texturised glass cloth with anti dust treatment having minimum 1.6mm thickness and weight of minimum 1300gms/m2 of each layer

b) One layer of needled glass felt having minimum thickness of 10mm and minimum weight of 1500gms/m2

c) One layer of PTFE film having minimum thickness of 0.2mm and minimum weight of 450gms/m2

d) One layer of fluropolymer coated glass fibre fabric having a minimum thickness of 0.95mm and minimum weight of 1200gms/m2

e) In addition the flanges shall be reinforced with one layer as described in a).

Bolsters shall be manufactured of glass felt of density not less than 24kg/m3 confined in texturised glass fabric of weight not less than 400grams/sqm and thickness not less than 0.25mm to withstand a temperature of 300degC. The bolster shall have a final covering of stainless steel wire mesh having a mesh size not more than 16mmx16mm made of wires of dia. not less than 0.3mm. The glass fibre and SS wire mesh shall extend upto end of the flange and shall be bolted along with the expansion joint material to keep the bolster in position.

The type of expansion joint outlined above is only a typical joint. If the

CONTRACTOR wishes to deviate from the above, he shall propose an alternative arrangement clearly spelling out its advantages/superiority over the one outlined herein for the ENGINEER's review during bid stage.

The CONTRACTOR shall test the materials for chemical and physical properties, namely acid resistance, maximum and minimum temperatures, pressures and movements. The test procedures along with their acceptance standards shall be submitted by the CONTRACTOR to the ENGINEER for his review and approval well before the procurement of the units.

The CONTRACTOR shall procure the units from an experienced specialist manufacturer, fabricating the type of expansion compensator outlined above.

12.13 LINER TEST PORTS

Six gas sampling ports on vertical face of MS flue duct, for mounting particulate emission monitor and other analysers shall be provided. In addition to this, four numbers of gas sampling ports on vertical face of MS flue duct, for laboratory gas sampling purpose.The sampling equipment is in the scope of this contract. The CONTRACTOR shall provide all the necessary fittings required for the port holes.

Gas sampling ports fabricated from stainless steel with flanged ends shall be provided for liner at platform levels where indicated including proper insulation, blank plates, nuts, bolts, etc. The location, orientation and level of ports inclusive of size and thickness of material to be used shall be as per Central Pollution Control Board regulations. Two opacity measurement ports fabricated from stainless steel pipe shall also be provided in each liner at the same platform level of the gas sampling ports.

Bidder shall provide for the purposes of instrumentation other than the sampling ports mentioned above required number of 38 NB conduits including pull wires, junction boxes and pull boxes, all securely tacked / anchored to internal of shell and S316 L plates below each pipe insert for fixing of measuring instruments.

It shall also include providing UPS power connection with 10.0 Amps/230V power supply near port holes. Access platforms for installation/maintenance of sampling ports shall be provided by the contractor. Necessary instrument air supply is to be provided near holes for piping purpose.

12.14 STAIRCASE

A structural steel staircase shall be provided inside the wind shield, connecting the grade slab to the topmost platform below the roof slab. The staircase shall be supported by a structural steel framework supported from platform to platform independently of the wind shield. Connection of the structural support to the platform beam shall be so chosen as to permit unrestrained deflection of the platform supporting beam. Clear width of the stair treads inside stringers shall be 750 mm. Tread shall be of 25 mm thick M.S. gratings hot dip galvanized with anti-skid nosing. Tread shall be minimum 250 mm wide. Maximum riser shall be 175 mm. Handrail shall be of M.S. pipe type medium of 32 mm NB as per IS:1161 with toe protection of 65x8 mm flats, the complete handrail being hot dip galvanized. 32mm galvanized steel pipes posts at not more than 2000 mm spacing shall be provided for handrail. Height of hand railing shall not be less than 1250 mm. There shall be minimum of three handrails at 450 mm, 850 mm & 1250 mm above platform level. All structural steel work other than stair treads shall be provided with 2 coats of zinc chromate red oxide primer followed by 3 coats of synthetic enamel painting of approved brand and shade. All field connection shall be by bolting only. The arrangement of staircase shall ensure easy accessibility to elevators. Staircase and its connection shall be designed for a live load of 5 kN/sqm.

12.15 LADDER

Steel cage ladder hot dip galvanized shall be provided from the last platform to the roof slab. Stringers shall be of flat 75x75x8 with a 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 stays connected to the platform supporting framework. The ladder and its connection shall be designed for a load of 175 kg at any location.

These stringers shall be supported from box column which in turn supported from top most support platform and roof beam so chosen as to permit unrestraint deflection of the roof beam.
An open able hatch of stainless steel grade AISI 304 L shall be provided in the roof slab for above the cage ladder to prevent entry of rain water.

12.16 LIFT

Lift shall be provided for the chimney inside the wind shield. The lift shall be of open cage type and suitable for corrosive and dusty atmosphere that generally exists in thermal power stations/industrial complexes. It shall generally confirm to the provisions of IS:1860 and IS:4289 unless otherwise specified.

The lift shall have a minimum carrying capacity of 400 kg at a speed of 40 M/sec. The lift shall be of rack and pinion driven service type of approved make.

All the control devices inside the car shall be housed in a dust free and water proof enclosure. Only copper conductor FRLS insulated armoured cable of suitable size shall be included in BIDDER's scope.

Landing at all locations of platforms shall be provided unless otherwise specified elsewhere.

Construction of guard cage and supply of other accessories required for satisfactory and safe operation of lift shall be included in BIDDER's scope. BIDDER shall also supply and install safety devices such as automatic stop equipment, over speed governor etc. all complete as per Manufacturer's recommendation.

All the embedments for the lift structure, approach platforms at landing levels and the lift supporting structure including lift car shall be hot dip galvanized.

12.17 ENCLOSURE WALLS

Reinforced concrete walls shall be provided at grade level around staircase & elevator to make the enclosed space air tight and free from ash & dust for the comfort & safety of personal, who are required to go into the chimney for maintenance and inspection purpose. Height of enclosure wall shall be 10m (minimum) or as per the requirement of client. All materials for the design of walls shall be as per relevant IS codes.

12.18 DOORS

(a) Clean Outdoors

Steel flue shall be provided with clean outdoor having clear dimension of 650 mm x 825 mm at appropriate location with proper access for operating the door. The edges of the doors shall be of hollow steel construction with inner plate of 8 mm and outer plate of 6 mm with suitable infill of stiffeners. The hollow space shall be filled up with insulation of the type used around flues. 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 both from inside and outside.

(b) Removable Cladding / Access Door

Opening provided near the base of the wind shield for the purposes of flue can erection shall be closed using a removable type of colour coated galvanized aluminium sheet min. 0.6 mm thick on structural steel framing which also can be dismantled if required. Within the cladding area, an access door of size 2100x1000 mm shall be provided with sill level at 300 mm from paved level. This door shall be similar to hollow steel doors provided in other buildings. The door shall be provided with a minimum two coats of acid and alkali resistant paint conforming to IS:158 type I to give a DFT of 75 microns. The outside surface shall be provided with 2 coats of zinc red oxide primer and two coats of synthetic enamel paint.The door shall be provided with suitable locking arrangement.

12.19 CHIMNEY ROOF & ROOF DRAINAGE

The chimney roof shall be of RCC slab suitably supported on MS beams. The roof shall be sloped towards rain water down take catch pits covered with CI gratings. The roof shall be designed to cater for differential movement between the shell and the liners including circumferential expansion and contraction due to temperature variation. 1200 mm high RCC parapet formed by windshield shall be provided at roof level.

The roof shall be provided with a hatch for access from the flue support platform. The hatch shall have a single leaf door with a minimum thickness of 6 mm to cover a clear opening of 750 mm x 1000 mm. The hatch shall include the door, metal curb, draft seal, spring latch, hold-open device and all hardware. All joints shall be welded and ground smooth. The curb shall be 300 mm in height with a suitable lip which shall include a continuous neoprene seal strip to make the hatch air-tight when the cover is closed. The hatch shall be openable from both inside and outside and shall be provided with automatic hold open arm, easy one hand release and spring latch. All the items of the door shall be of stainless steel of grade 316 L and then painted with heavy duty acid and heat resistant paint as per requirement of IS:158.

The roof slab and the inside surfaces of the wind shield shall be lined with 20 mm thick acid proof tiles conforming to IS: 4457. Bedding mortar (of average thickness 10 mm) shall conform to IS: 4832 Part I and shall be of potassium silicate base.

Roof slab structure shall be designed to serve as a lifting platform for supporting the weight of flues during erection.

The tiles shall be pointed using a phenolic based resin cement mortar conforming to IS:4832 (Part-2).

The bedding mortar and phenolic based resin mortar should be acid-proof, chemical resistant and water–proof. They shall in particular be resistant to sulphuric acid and hydrochloric acid.

CI/UPVC rain water pipes shall be provided within the interior of the shell to remove rain water collected on the roof. Rain water inlet into the pipes at roof level shall be provided with CI grating. The rain water down take pipe shall be led to a manhole chamber inside wind shield suitably lined with acid / alkali resistant brick lining. From the manhole the drainage water shall be led out of the chimney wind shield through CI pipe to a manhole chamber outside wind shield and from there to Effluent Treatment Plant.

12.20 ACID DRAINS AND MANHOLES

In the event of flue gas condensation within the flues acids may be drained out at the base with the provision of stainless steel pipes connected to the soot hopper outlets in each flue located outside the wind shield.

The stainless steel pipes, bends, bolts, fixing sleeves, collecting sumps, etc., shall conform to relevant IS codes or BS:3605, and shall be procured, supplied, fabricated and erected in position by the BIDDER.

The sumps shall be of adequate size suitable lined with acid resistant bricks and provided with a RC roof and a heavy duty manhole cover. The effluent shall be led by means of stoneware pipe to the nearest manhole of effluent treatment system.

Flues shall be provided with 2nos clean out/ access manholes at location of each platform. Manhole covers shall have an inner and outer plate and shall be bolted to the flue with suitable gasket to prevent flue gas leakage. Removable insulation shall be provided to cover the manholes.

12.21 LOUVRES

Air outlet louvers shall be provided as per the requirement of this specification near the top. The louver fins shall be of Z-shape in cross section and made from anodized aluminium plates of a minimum thickness of 4 mm. The frame work supporting the louver fins shall be made from extruded aluminium sections of minimum thickness 6 mm. The louvers 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 EMPLOYER before installation. To outside face of louvers ST mesh on SST mesh frame work shall be provided.

12.22 ASH HOPPER

Ash hopper shall be suspended from the bottom portion of the flue. The angle of inclination of the hopper to the horizontal shall be a minimum of 30deg. The hopper shall be fabricated out of structural steel of grade E250 (Fe410W) quality grade B (killed and normalized) of minimum 10mm thickness ,with 5mm thick liner of stainless steel grade AISI 304L.

Just above the ash hopper an inspection platform 1000mm wide with removable GI gratings and adequate toe protection shall be provided spanning two manholes.

Suitable flange connection shall be provided at the bottom of the hopper to facilitate periodic emptying of the hopper.

12.23 FABRICATION

Fabrication shall commence only on the basis of fabrication drawing prepared by the CONTRACTOR. OWNER reserves the right to scrutinise the fabrication drawings if deemed necessary in OWNER"s opinion.

The CONTRACTOR shall establish a full fledged fabrication shop at site with adequate machinery for cutting, bending, welding, testing and proper handling facilities. Complete fabrication shall be carried out at site.

The individual cans of the flue shall be joined together using high tensile structural steel of property class 8.8, and product grade "C" as per IS 1367, conforming to IS 3757. Nuts shall be of high strength structural steel hardened and tempered nuts (property class 8.8 as per IS 1367) conforming to IS 6623 with hardened and tempered washers conforming to IS 6649. All nuts shall be provided with helical spring locking washers. After tightening of the bolts at the flange location, the cans shall be butt welded all round from inside to result in gas tight joint. The weld shall not be considered to participate in load transfer. Duly considering the fact that the steel is always subjected to high temperature, and the same is hung from the top and is subjected to movements, additional factor of safety of at least Two(2) shall be considered for design of the joints over and above normal factor of safety.

Each flue can shall have only two circumferential joints, thus forming a maximum of three rings. These rings shall be provided with full strength butt welding. Root runs of all the butt welds shall be tested by DPT. Seam welds in adjacent rings shall be staggered at least by 2000mm. seam welds shall also be provided with full strength butt welding. Root runs of all seam welds shall be inspected with DPT.

The CONTRACTOR shall arrange inspection of welds in the presence of OWNER"s representative as described below.

100% of the welds shall be subjected to visual inspection to detect visual imperfection.

At least 10% fillet welds shall be subjected to Dye penetration tests (DPT) at random.

100% of the root runs for butt welding shall be subjected to DPT after back gouging.

10% of butt welds chosen at random both for circumferential and seam welds

shall be subjected to spot radiographic tests. All welding / weld testing procedure shall in general follow AWS standards .

Proper spiders shall be provided at both ends of individual flue cans to prevent distortion of flue/ flanges during transportation and erection.

Fabrication drawing for the flue cans shall also incorporate all bracket required for connecting wire ropes during erection. Local strengthening of flue skin plate at location of the bracket if needed shall be incorporated in the fabrication drawing. The factor of safety of brackets and the connection shall be atleast 2 over the values specified in IS 800.

12.24 ERECTION

CONTRACTOR shall submit to the OWNER a method statement for erection of the steel flues and loading on the roof framing due to erection of flues, erection equipment to be deployed, equipment and accessories complete for approval. CONTRACTOR shall make sure that there are adequate spares for the erection equipments and at no cost will a delay be permitted due to inferior or faulty erection equipment.

CONTRACTOR shall furnish necessary details such as number of jacks he proposes to use, their supporting arrangement, collars, rod hangers, high tensile steel cables/rods to lift or suspend the flue, temporary staging arrangement and fixing details. The capacity of the jacks, etc. shall be double the actual load proposed to be lifted / borne by them. Factor of safety for cables shall however be five on their rated capacity. All jacks shall be hydraulically operated and no manually operated jacks will be allowed.

CONTRACTOR shall ensure that deviations shall not exceed the specified tolerances spelt out herein below for fabrication and erection of steel flues. The permissible deviations from the true form are as under:

Internal diameter shall not differ from the true or design diameter by more than +20mm in the horizontal plane.

Horizontal centre of any section shall not deviate more than 12 mm from the shell vertical centre line in any 15 m height and never more than 1:2500 of height plus 12 mm at any level considered.

Locally, the variation of the bent plates from true circular form (flat spots) should not exceed the plate thickness. All measurement/ checking shall be done by a segmental circular template having the design radius and a chord length of 0.15 times the design radius.

12.25 GRADE SLAB AND FLOOR DRAINAGE

Inside the chimney wind shield 150mm thick R.C.C grade slab shall be provided nominal reinforcement of 8 dia. HYSD bars 200 c/c both ways at top and bottom. The grade slab shall be provided over well compacted ground, 230 thickness stone soling and 75 mm PCC of grade 10. The grade slab shall be sloped towards the peripheral drain.

Roof drainage shall be directed from the sump provided below the roof

drainage pipe, to the central drain chamber. From the central drain chamber the drainage water will be taken out of the wind shield through a 200 mm dia. C.I pipe with a sump outside the wind shield. Necessary pipe sleeve has to be left in the wind shield to take out the drain pipe.

A 300 mm wide R.C.C drain shall be provided all round the chimney, located at a distance of 1500 mm from the edge of chimney. This drain will take the roof drainage from the drain chamber to the nearest drain of the project storm water drainage system.

All drain including sump shall be provided with A.R lining and shall be provided with 40 mm thick C.I & G.I grilles at top.

The space between wind shield and the drain shall be provided with 100 mm thick plinth protection with nominal concrete of grade M20.

12.26 ROLL-UP DOOR/ROLLING SHUTTER

A rolling steel chain operated door shall be installed at the base of the chimney shell so that a truck could go inside the chimney for the removal of ash from ash hoppers in case of emergency. The door shall be installed complete with guides, hood, hardware, weather baffles, combination endlocks and wind locks, mechanisms and accessories as required for proper operation and weather protection. The complete details of rolling shutter shall conform to IS: 6248 (latest edition) "Metal Rolling Shutters & Rolling Girds" and to these specifications.

The roll up door shall be mounted on the inside face of the shell. Additional supports and framing shall be installed as required to support the loads and to fit the curvature of the shell. Curtain shall be flat slat type, 20 gauge minimum. Curtain shall have double angle bottom bar fitted with compressible rubber vinyl or neoprene weather seal. The door shall be fitted with a bar type locking device and padlock keyed "to match the keying of the grade level hollow metal swing door.

All steel materials in the door assembly including door frame and closure shall be painted with primer and finish painted with two coats of aluminum paint of the quality as approved by the Engineer-in-Charge.

The door shall be installed in accordance with the details and the manufacturer's directions. When installed, the door shall be free from warp, twist, or distortion, and shall be lubricated and adjusted to operate freely and smoothly.

12.27 INSPECTION/MAINTENANCE DOORS

Two steel leak proof doors of size 750 x 1000 mm and 750 x 600 mm shall be provided diametrically opposite in each brick liner at all those levels where external platforms are provided. The doors shall be hollow metal door, hollow space filled up with insulating material of such thickness so as the temperature of outside surface of door is not more than 50° C.

Proper sealing arrangement using asbestos ropes shall be provided in the doors so that there is no leakage of flue gases from brick flues into the annular space between liners and shell through these doors.

These doors shall swing to bear against the seals under the pressure created by the annulus pressurisation fans. All components of doors and frames shall be designed to continuously withstand without distress or excessive deflection twice the static pressure generated by the annulus pressurisation fans and also the chemical attack by flue gases.

The doors shall be constructed of two outer sheets not less than 6 mm thick mild steel reinforced inside with steel stiffeners not more than 600 mm centres. Hollow space between two plates shall be filled up with insulating material such as bonded glass wool/mineral wool. The doors shall be hinged and shall be provided with locking device such as swivel studs with wing nuts.

All surfaces of doors & frames internal as well as external shall be painted with one coat of primer and finish painted with two coats of acid and heat resistant paint.

12.28 HATCHES

A mild steel hatch shall be provided as an access to the hood of the chimney and one hatch shall be provided in the ash hopper platform for taking the equipments up to any level for maintenance and repairs.

The hatches and frames shall be designed to continuously withstand without distress or excessive deflection twice the static pressure generated by the annulus pressurization fans. The hatches shall be constructed of two outer sheets not less than 3 mm thick mild steel reinforced inside with steel stiffeners not more than 600 mm centres. In addition, they shall also be designed to withstand a live load of 300 Kg/m2.

Hatches shall be painted with one coat of primer and finish painted with two coats of acid and heat resistant paint on both sides.

Other requirements with regard to design and construction shall be same as for personal/access doors.

The hatches shall be flat type and shall be operate-able upwards. They shall be provided with locking arrangements from under side for the hatch for hood & from above for equipment hatch at ash hopper platform.

12.29 BEARINGS

A fully moulded elastomeric bearing shall be provided to accommodate thermal movements and to provide a suitable distribution of load between liner support platform beams and the corbels.

The contractor shall submit manufacturer and catalogue information to enable the Engineer-in-Charge/Consultants to evaluate the proposed bearings. Written approval of the bearings to be used shall be obtained from the Engineer-in-Charge/Consultants.

12.26 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 internals of the chimney.

A lifting beam shall be provided at platform level to cater for lifting of materials during maintenance and painting. The size and capacity of the lifting beams shall be as indicated in relevant drawings.

12.27 CHIMNEY PAINTING

The entire inside surface of the shell for full height shall be painted with four coats of acid and heat resistant black bitumen paint over a coat of compatible primer as per IS:158 with total DFT 150microns.

The top 50m of the outside surface of the shell and paraphet above roof slab including embedments etc. shall be painted with 4-coats of acid and heat resistant paint (Polyurethane) over a coat of primer with total DFT 150 microns in alternate bands of signal red and white colour.

The remaining portion of the outside surface of the shell shall be painted with 4-coats of Synthetic enamel paint (IS:5410) with total DFT 150 microns over a coat of primer in alternate bands of signal red and white colour.

Each band with a band width of H/7 metres (H=Height of chimney) and bands at the extremities being of Orange or Red shade. This shall be done after removing all loose and foreign matter to give a smooth and uniform finish.

External painting shall commence immediately after the shell construction/platform is completed and the concrete is well cured. The painting shall preferably be started from the top. This is to ensure visibility of stack to low flying aircraft during day time even during the period of construction of the internals of the chimney.

The laser scanning of chimney shell after every 70 M height and on completion should be performed.

12.28 ELECTRICAL REQUIREMENTS

Refer Vol IV of technical specification

12.29 FOUNDATION

The chimney foundation will be resting on piles. Solid circular pile cap of uniform thickness shall be provided. The pile cap (min. M-30) shall be designed as rigid member with uniform thickness and no tapering of thickness shall be allowed. Minimum thickness of pile cap shall neither be less 0.09 times the diameter of pile cap or 0.4 times the overhang of the foundation beyond shell whichever is greater. Foundation diameter to depth ratio shall not exceed 12. Minimum reinforcement shall not be less than 0.12% in either face and in each direction. Wind and earthquake shall be treated as normal load and no enhancement of stress is permitted on this account in soil, concrete and steel. No tension will be allowed under the pile cap during earthquake and wind. Working stress method shall be adopted for design of foundation. Foundation will be designed for SRSS of moments of along wind response and across wind response. The effect of water table shall be considered and the foundation shall be checked for overturning for minimum and maximum vertical loads. The diameter of the reinforcing bar for the main radial and tangential reinforcement for the foundation shall not be less than 25mm. The spacing of radial steel at the outer edge of the foundation shall not be more than 250mm.

For the purposes of analysis/ design, the following shall be assumed:

a) Stiffness of shell shall not be considered for design of the foundation.

b) Shell fixed to foundation for shell design.

12.30 CONSTRUCTION OF SHELL BY SLIP-FORM METHOD

12.30.1 Shell construction has to be done by slip form shuttering technique. 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.

12.30.2 The Contractor should furnish a brief but comprehensive statement indicating the planning & programme and method of work to be followed, for the approval of Purchaser 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
vi) Proposed workability requirement of concrete and type of cement and admixture to be used
vii) Quality assurance programme
viii) Method of transportation of material
ix) Method of curing and rectification of defects
x) Planned interruption, if proposed, and activities during planned interruption. Treatment of construction joint.

xi) Contingency solution for unplanned interruption
xii) Time of completion

12.30.3 While selecting the Contractor, due consideration will be given to the merit of the above mentioned statement proposed by the Contractor and minimum time of completion, apart from his past experience in such types of work as also technical and financial resources of the Contractor.

12.30.4 Notwithstanding what have been specified in earlier clauses, following guide lines are being presented which should be kept in view by intending Contractor, while quoting for slip form method of construction.

a.) Care to be taken to prevent dragging of concrete along with upward movement of the shuttering. For this purpose following steps are advisable:

i 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.

ii 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.

iii 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 IS 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.

iv Mix design also should be so done that it has a slump of 50mm at the point where concrete is placed under an ambient temperature of around 40 Deg.C. This will also keep vibration by needle vibrators to required minimum. Slump should not drop down to zero in less than 45 min. Suitable retarding agent and plasticizer of approved manufacture may be added in mix to achive this purpose. These admixtures to be properly identified by preliminary tests both for Performance and for compatibility with particular type of cement Prosed to be used.

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 40oC.

b.) 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 to this work together with rectifying any defect.

c.) Every endeavor has to be made so as not to occur any tilt in the shutter assembly. To achieve this following steps need be taken:

i 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 5mm.

ii Loading on slip form truss has to be fairly equal.

iii 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 1mm to 1.5 mm around.

d.) 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.

e.) In designing the mix following aspects should be borne in mind :

i) Cement used should have an initial setting time of not less than 50 minutes and preferably should have a specific surface of around 3600 sq.cm per gram.

ii) Coarse and fine aggregate should be well graded and angular 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 be preferably be used unless reinforcement detailing calls for lesser size aggregates.

iii) From the creep point of view, shrinkage as well as initial setting property of concrete, cement content should not preferably be more than 400 kg per cum of concrete.

iv) Minimum compressive strength (after 4 to 6 hours of mixing) of concrete immediately below the shutter as slip form proceeds should be between 0.1 to 0.2 Newton/sq.mm.

f.) 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. Atleast two nos. standby vibrator units should always be maintained on top of working deck at all times during the entire period of slip form operation.

g.) It is preferable to have membrane curing compounds sprayed on fresh surfaces emerging out of shutter panels for ensuring proper curing at greater 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 standby pump for effective utilization of the system.

h.) If slip forming 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.

i.) 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 slip form 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 meters 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.

j.) Atleast 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.

k.) In sections where thickness is 500 mm or more it is prudent to go in for two nos. of jacks for each slip form yoke.

l.) For effective utility of this technique following areas need careful attention at the very conceptual stage:

i) Detailed quality assurance programme
ii) Advance planning and preparations
iii) Arrangement for on site supervision and adequate access facilities.

m.) 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, descriptions and frequency of various checks and tests for slip form 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 before hand by executing agency and to be approved by Engineer before starting the actual work.

n.) 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 slip form system.

o.) It is desirable to have a break of atleast one day for every two weeks of continuous operation. Such break should be utilized for various maintenance activities, removal of jacks rods etc.

p.) 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.

q.) 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 slip form.

r.) Winches for lifting men and material and mixers, if located within unsafe area around chimney, should be protected by adequate shelter from possible damage.

s.) Proper telecommunication system has to be established between the personnel working on top of chimney and control room below.

t.) 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 theodolite instruments for survey purpose arrangement should also be kept for lasers.

u.) In case of interruption in the course of slipping of formwork following measures should be taken:

i) Provision of a key and additional reinforcement at the junction of new and old concrete.

ii) Slip form system should be brought up freely to have a minimum overlap of 100 mm or so over previously cast concrete.

iii) Washing of old concrete surface with compressed air and water jet and thereafter pouring a layer of neat cement grout.

iv) Clearing of shuttering panels of loose materials, concrete etc. by compressed air and applying a coat of epoxy paint, if felt necessary by Engineer.

v) Neatly preferable the interface of old or new concrete as soon as it comes out of shutter panel.

v.) It is preferable to suspend the construction work under high wind condition.

w.) It is of utmost importance that for effective implementation of this system an Engineer fully conversant with slip 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.

x.) Operation of slip form 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.

y.) 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:

i.) Safety helmets and belts to be provided to all supervising staff and workers.
ii.) Safety nets to be provided below both inside and outside platforms as instructed by Engineer.
iii.) Hand railing and toe guard to be provided around all openings and platforms.
iv.) Regular maintenance of equipment, checking of hoists, scaffolding etc.
v.) Passenger hoist must have multiple ropes with adequate factor of safety.
vi.) 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 slip form method or construction.
vii.) Emergency vehicles, first aid facilities must be kept ready during the entire period of work.

Under no circumstances shall the point of discharge of the concrete into the forms be more than 1.5 m above the concrete surface on which it is to be deposited. Also, not more than 2 metres height of chimney shall be concreted on any one day.

Concrete in the shell shall be poured in about 200 mm layers uniformly. The concrete in each lift (where jump form is used) shall be laid in one continuous operation for the full circumference of the shell so that there will be no vertical or inclined construction joints. Horizontal construction joints shall be 0maintained at uniform spacing throughout the height of the chimney.

Pulse Velocity (UPV) test on the bottom portion of the wind shield concrete, to a height of 30metre from top of raft shall be conducted immediately after the construction up to 30m. In addition if the ENGINEER so requires, the CONTRACTOR shall make immediate arrangements, through an approved agency, to undertake ultrasonic tests to prove the quality of concrete in other areas. The quality of concrete shall be considered as satisfactory if it meets specification requirements and the sonic velocity is at least 4000 m/s. If the tests prove that the quality of concrete is not satisfactory, then all costs associated with the tests and any rectification shall be borne by the CONTRACTOR.

The interior and exterior surfaces of the shell shall be kept moist for 14 days after exposure from the forms as the chimney construction progresses upwards. For this purpose, circumferential perforated pipes shall be hung from immediately below the forms and raised along with them.

12.31 Physical Checks

Some of the mandatory physical checks to ensure that construction tolerances are met with shall be carried out by the CONTRACTOR, as under :

a) The twist or rotation of the slipform every 60 minutes.

b) Level of top of jacks every thirty minutes.

c) Verticality with the help of lasers atleast once in four hours.

d) Inside and outside diameters/dimensions and wall thickness, once in each shift of 8 hours.

e) Level of top of form panels once initially and subsequently after each interruption.

f) Level of working platforms once initially and subsequently after each interruption.

g) Batter of the form panels and yoke legs once on erection and subsequently after each interruption.

h) Condition of jack rods for ovality, indentation, buckling, moving out of alignment, etc., before fixing each rod.

i) Bracing of jack rods passing through openings.

j) Live load on working deck to avoid accidental overloads.

k) Workability of concrete at mixer and at point of Placement, once an hour.

l) Temperature of concrete, once in 4 hours

12.32 **Construction tolerances**

The following shall be the limit of construction tolerances to be strictly adhered to by the contractor:

Wall thickness: (±) 10mm

Shell diameter: (±) 10mm for every 3m diameter without any abrupt changes but in no case more than (+) 40mm.

Verticality: 1 in 1000 subject to a maximum of 75 mm.

Spiralling : Rate of spiralling of forms not greater than 10 circumferential rotation at the outer face of the concrete per metre of vertical travel.

Openings, inserts, pocket : ± 12 mm ·

Cover : ± 5 mm

Level of any part of structure : ± 20 mm

In addition, no two points 10m apart vertically shall be more than 20mm out of plumb w.r.t. each other.

12.33 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/schedule of items issued with the tender papers and any other special requirement implied with the adoption of the slip form method, which may include but need not be limited to the following items as applicable:

i Particular requirement of type and brand of cement, if any.

ii. Special admixture to be added to concrete

iii. Any change required in the geometry of the chimney including the shell thickness or side slope from that shown in the NIT drawing.

iv. Any change/special requirement in the arrangement of reinforcement.

v. Implications if any of necessary in-situ bending of rebars for /brackets etc. and straightening/cleaning of the same prior to casting of brackets.

vi. Any additional constructional opening in the shell required at ground level for concreting.

All deviations from specification must be justified and tender price shall include all such variation / deviation. Such deviation without assigning any reason will be rejected.

12.34 **Information to be furnished by the Bidder Along With Bid**

All the Data Sheets and Schedules duly filled up with soft copies of the same.

Description literature/catalogues and write-ups for the offered equipment/systems.

Type test certificates/reports for the equipment covered in the specification

12.35 **Data to be furnished after Award of Contract**

a) Quality Control Plans for all equipment with detailed procedure for the proposed equipment/material

b) Technical data sheets, general arrangement drawings, control schematics, etc. for all equipment

c) Earthing & lightning protection system layout drawings, lighting layout drawings, cable carrier system layout drawings, etc.

d) Inspection & Test Plan (ITP) with detailed procedure.

CHAPTER – 13

NATURAL DRAUGHT COOLING TOWER

13.1 SCOPE

This specification covers the general requirements of engineering by the Bidder, of material, design, supply, manufacture, construction, testing and commissioning for satisfactory performance of natural draught cooling tower including all associated appurtenances and equipment as well as electrical works.

13.2 CODES AND STANDARDS

a.	IS: 383	Coarse and fine aggregates from natural Sources for concrete.
b.	IS: 432	Mild steel and medium tensile steel and bars (parts 1 & 2) and hard drawn steel wire for concrete reinforcement.
c.	IS: 702	Industrial bitumen.
d.	IS: 780	Sluice valves for water works purposes (50-300mm size).
e.	IS: 1536	centrifugally cast (spun) iron pressure pipes for Water, gas and sewage.
f.	IS: 1554	PVC insulated (Heavy duty) electric cables. (Part 1)
g.	IS: 1785 (Parts 1&2)	Plain hard drawn steel wire for pre-stressed concrete.
h.	IS:1786	High strength deformed steel bars and wires for concrete reinforcement.
i.	IS: 1834	Hot applied sealing compound for joint in concrete.
j.	IS: 1838 (Part 1)	preformed fillers for expansion joint in concrete pavements and structures (non-extruding and resilient type: Part-1 bitumen impregnated fibre).
k.	IS: 2062	Steel for general structural purposes.
l.	IS: 2267	Polystyrene moulding and extrusion materials.
m.	IS: 3042	Single faced sluice gates (200-1200 mm size)
n.	IS: 3589	Seamless or electrically welded steel pipes for Water, gas and sewage (168.3mm - 2032mm).
o.	IS: 5620	Recommendations for structural design criteria for low head slide gates.
p.	IS: 5666	Etch primer.
q.	IS: 8112	43 Grade Ordinary Portland cement(Part 1 to 4)
r.	IS: 9862	Ready mixed paint brushing, bituminous, black,

lead free acid, alkali, water and chlorine resisting.

s.	IS 12330	Sulphate resistant Portland cement
t.	IS: 456	Code of practice for plain and reinforced concrete.
u.	IS: 800	Code of practice for general construction in steel.
v.	IS:875 (part 1 to part 5)	Code of practice for design loads (other than earthquakes for building and structures).
w.	IS:1080	Code of practice for design and construction of simple spread foundations.
x.	IS:1343	Code of practice for pre-stressed concrete.
y.	IS:1893	Criteria for earthquake resistant design of structures.
z.	IS:2210	Criteria for the design of reinforced concrete shell structures and folded plates.
aa.	IS:2309	Code of practice for the protection of buildings and allied structures against lightning.
bb.	IS:2395 (parts 1&2)	Code of practice for painting, concrete, masonry and plaster surfaces.
cc.	IS:2502	Code of practice for bending and fixing bars for concrete reinforcement.
dd.	IS:2629	Recommended practice for hot dip galvanising on iron and steel.
ee.	IS:2633	Methods of testing uniformity of coating of zinc coated articles.
ff.	IS:2751	Recommended practice for welding of mild steel bars for reinforced concrete construction.
gg.	IS:2950 (part 1)	Code for practice for design and construction of raft foundation.
hh.	IS:3043	Code of practice for earthing.
ii.	IS:3370	Code of practice for concrete structures for storage
jj	IS:4558	Code of practice for under drainage of lined canals.
kk.	IS:11504	Criteria for structural design of reinforced concrete natural draft cooling towers.
ll.	IS:12200	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams.
mm.	IS:15498 (2004)	Guide lines for improving the cyclonic resistance of low rise house and other buildings
nn.	BS:4485	Specification for water cooling towers. (All parts)
oo.	VGB Guidelines	Structural design of cooling towers.
pp.		ATC - 105 Specification for Cooling Towers - Cooling Tower Institute – USA
qq.	IS: 2911:	Code for practice for design and construction of (part1to4) pile foundations.
rr.	IS: 13620:	Fusion bonded epoxy coated reinforcement bars

ss. IS:13920: Ductile detailing of reinforced concrete structures subjected to seismic forces

tt. BS: 8007: B.S.Code of Practice for design of Concrete structures for retaining aqueous liquid.

All local applicable statutes, regulations and safety codes for locality where the cooling tower will be installed, shall be complied fully with.

13.2.1 Wherever the above Standards are in conflict with the stipulations of this specification, decision of the OWNER / ONWER CONSULTANT will dictate.

13.3 GENERAL

The cooling tower shall be capable of cooling the rated quantity of water through the specified thermal range at the design wet bulb temperature and it shall conform to the other design parameters as stipulated in Mechanical section of this document.

The scope of the Contractor’s work for a cooling tower shall include preparation of detailed designs and construction drawings and execution of work, wind tunnel study but not limited to, supply of all material for foundations, shell, basin, fill with its supporting structure, staircases/walkways/platforms with handrailing, cold water outlet channels including gates, screens with handling arrangement, painting, access doors, water distribution system, aviation warning system, lighting, lightning protection system, with their associated hardware, etc., complete all as required to give satisfactory performance and as stipulated in various clauses in this document.

CONTRACTOR shall submit detailed design calculations and construction drawings to OWNER for obtaining his approval prior to commencement of work at site. Owner“s/consultant“s approval to the design/drawings shall not absolve the contractor of their responsibility for correctness of design, accuracy of dimensions, loading details etc. of safety and stability of the structure including foundations, accessories, apprutenances etc. All design calculations and drawings shall be in English and shall be in SI units.

In the event, Contractor has quoted in collaboration with another firm (either Indian or foreign), each and every drawing and design calculations submitted shall bear collaborator’s seal and signature indicating their approval. Contractor shall also furnish, along with the offer, back-up guarantee for the performance of the cooling tower from the collaborator.

For NDCT, three dimensional finite element analysis of the entire system consisting of tower shell, column supports, pedestal, pile cap, pile and soil mass shall be carried out in a single step so that effect of soil structure interaction can be taken care.

13.4 GRADE OF CONCRETE & STEEL

Minimum grade of concrete to be used for all the structural elements shall be as specified below:

STRUCTURAL CONCRETE		Minimum Grade
a)	Foundations	M30
b)	Basin	M35
c)	Shell	M35
d)	Precast works (Fill Supporting Structure)	M35
e)	Diagonal columns	M40
f)	Mud Mat	M10

Materials, design, construction and workmanship of prestressed concrete members shall be in accordance with IS:1343.

Cement used shall be Ordinary Portland Cement complying IS: 8112. Same brand of cement shall be used as far as possible throughout the construction of the entire structure to enable achieve uniform colour and surface finish throughout the shell. In locations where sulphate content in soil and ground water is high, sulphate resisting cement shall be used for all concrete work below the ground level.

Fine and coarse aggregates shall be from natural sources complying with IS: 383. Particular attention shall be paid to the selection of dense aggregates of low drying shrinkage to reduce adverse effects on the strength, density, shrinkage, moisture movement and durability of the concrete. Aggregates shall be obtained from a single approved source and it shall be ensured that they are free from any impurities which could cause staining and affect achieving uniform surface finish and colour throughout the shell. Care shall be exercised to ensure maintenance of constant grading of the aggregates, particularly the fine aggregates. Maximum size of coarse aggregate shall not exceed 2/3rd the specified cover to the reinforcement less 5mm or 20mm whichever is lower.

While selecting the proportions of cement, aggregates and water to be used, specific attention should be paid to achieving the maximum possible density in-situ, having regard to the means of placing and compacting to be adopted at the site.

Surface finish and colour of the concrete could also be affected by changes in the condition of formwork, release agent, stripping time, curing method, etc. All these factors shall, therefore, be maintained constant throughout the work on the shell. Cleaning of any droppings and closing up of any holes of the form work shall be carried out simultaneously as construction proceeds.

Admixtures shall not normally be used unless such admixtures are proven to be wholly beneficial, as in special circumstances requiring retardation of setting time or on control of workability and further only with the written approval to this effect by the OWNER. Admixtures shall be free of all chlorides and in accordance with relevant IS codes. BIDDER shall furnish along with the bid, manufacturer"s literature and test certificates for the brand of admixture, if so contemplated to be used in the works. During execution no admixtures shall be permitted, unless its use has been accepted and made part of the contract. Use of admixtures shall be at no extra cost to the OWNER.

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 Purchaser.

Durability of concrete shall as per IS: 456. Expose category shall be considered as "**severe**" for the basin and other underground structures. For Superstructure the expose category shall be taken as "**very severe**". Cover to reinforcement, minimum cement content and minimum water cement ratio shall be as per requirements of IS456 for the appropriate exposure category (Refer Table 5 and 16 of IS456). Material, design, construction and workmanship in general shall conform to IS: 456 and IS: 3370.For prestressed concrete works, design, construction, and workmanship shall in accordance with IS: 1343.

Concrete in the cooling tower shell in each lift shall be so laid that the number 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 Engineer.

Reinforcement shall conform to grade Fe 500D as per IS: 1786 except noted otherwise. All reinforcements used in RCC structure shall be corrosion resistant variety (CRS of TATA STEEL, SAIL, RINL or its equivalent).

Steel wires for prestressing shall conform to IS: 1785 (part 1&2).

Steel for all structural steel works shall conform to IS: 2062.

All exposed steel work shall be protected by hot dip galvanising. The minimum coating of zinc shall be 910 gm/sq.m. and comply with the requirements of IS:2629 and IS:2633. In addition, galvanizing shall be followed by the application of one coat of etching primer conforming to IS: 5666 and 2 coats of bituminous paint conforming to IS: 9862.

Exposed steel work which should be galvanized includes components/ general hardware such as access doors, hand railing, access ladders, door hinges/handles, manhole covers, monorails, bolts, nuts and washers etc. Manhole covers, door hinges/handles shall be of robust type.

All welding for steel work shall be carried out before galvanizing. Any site joints required shall be either flanged or screwed type. Where galvanised mild steel bolts are used, the threads shall be coated with bitumen after assembly to protect areas which are damaged.

Unprotected steel fixings for formwork, scaffoldings or for any other purpose shall not extend to the surface of concrete. Steel fixings left embedded in concrete shall have a concrete cover of at least 40mm and be adequately protected against corrosion. Fixings extending to the surface of concrete shall be of corrosion resistant material.

Precast Concrete Components

Materials for precast concrete components including joint fixings, lifting hooks and other exposed steel components shall conform to the requirements of this specification.

Prestressed Concrete

Materials, design, construction and workmanship of prestressed concrete members shall be in accordance with IS: 1343. Steel wires of prestressing shall conform to IS: 1785 (part 1&2).

Particular attention shall be paid for achieving an effective bond of the wires in pretensioned units. For this purpose, use of indented wire is recommended. BIDDER shall furnish a write-up on the method proposed to be adopted for the manufacture of pre-stressed concrete elements.

Also, requirement of table 4 & 5 of IS 456 shall be satisfied depending on exposure condition.

13.5 DESIGN CRITERIA

13.5.1 Wind Load

Basic wind speed as well as factors K1/K2/K3/K4 shall be taken from IS: 875. Additional intensification factor to be considered due to natural turbulence in the incident wind / induced turbulence owing to nearby tall structures shall be 1.43 or based on wind tunnel studies, whichever is higher.

Steady pressure distribution around the shell for the wind loading shall be as per clause 5.1.3 of IS: 11504, for cooling towers not more than 120m in height and not more than 100 m in base diameter. The value obtained shall be increased by 10 percent to take into account any geometrical imperfections.

For cooling towers of height more than 120m and/or more than 100m in base diameter, wind pressure distribution shall be as determined by model test in a wind tunnel.

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 bidder 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 bidder 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 including cooling tower. The model test shall be carried out in a well reputed institute/testing laboratory after obtaining prior approval from the Owner. The testing agency selected by the bidder shall have requisite experience and should have successfully carried out tests in the past for at least one cooling tower of similar capacity. The model tests shall be duly witnessed and approved by the Owner. 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 (p) for the tower shell (without meridional ribs) shall be obtained from the "Criteria for Structural design of Reinforced concrete Natural 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. This design net pressure coefficient (p) and the distribution along the circumference of tower shall be used at all heights of the tower. The above design net pressure coefficient (p) includes the effect of internal suction. In order to compute the quasi-static design wind pressure at a given height along the circumference of the tower, the net design pressure coefficient (p) shall be multiplied by the wind pressure acting at that height [P(z)] as specified above.

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. 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. Design of the tower shall satisfy quasi-static method & Gust factor method.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented. The wind load as specified in clause above shall be the minimum loading to be considered for analysis and design. However, bidder shall also carry out the entire analysis and design on the basis of BS 4485 (latest) for smooth shell surface. The design of entire tower including foundation shall be checked as per BS 4485 as the case may be.

The final design shall be based on the worst case situation i.e. each element including foundation of the tower shall be designed on the basis of highest loading/ stresses computed as per above. However, the basis of wind speed shall be as per clause above.

While calculating wind pressure on structure suitable consideration shall be given to factor k4 as mentioned in IS: 15498, In addition to clause 6.6 of IS:875-Part-3-2015.

13.5.2 **Earthquake Load**

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 as described in IS: 1893 part 1 and part 4.

Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant reference where the same has been successfully implemented. Importance factor shall be as specified elsewhere.

The coefficient of horizontal acceleration shall be for the appropriate seismic zone as per IS:1893. Earthquake forces in all the three directions (x,y,z) shall be considered in the analysis of NDCT.

13.5.3 **Dead Load**

For assessing the self weight of the structure, the specific weight of the concrete shell shall be taken as 25kN per cubic meter. All other dead loads shall be assessed as per IS: 875.

The loadings brought upon the shell by permanent fixings shall be minimised to the greatest extent possible. However, when these attachments are made, their effect upon the structure shall be thoroughly investigated.

13.5.4 **Constructional Loadings**

Contractor shall be fully responsible for ensuring safety by checking the designs, for all the temporary construction loadings as applicable.

13.5.5 **Miscellaneous Loads**

Effect on account of the following loads shall also be investigated.

a) Loads due to temperature effects

The cooling tower shell shall be designed for stress due to axisymmetric temperature distribution corresponding to external ambient temperature variation from -1.1 °C to 48 °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 nonaxisymmetric temperature loading shall be carried out. In such nonsymmetric temperature loading, the calculation shall be based upon the operating specification. Besides, the shell shall be designed for one sided solar radiation effect also. Nevertheless an effective temperature difference of at least 25°C across the shell thickness constant over the height and following a sine functions along half the circumference shall be considered.
Entire analysis and designs adopted shall be fully supported with authenticated literatures/documents along with relevant references where the same has been successfully implemented

b) Subsoil deformation.

Differential settlement between adjacent sections of foundation shall be considered under most unfavorable load combination.
All loads likely to act on cooling tower but not specified herein shall also be considered for the design of cooling tower structures.

13.5.6 Load Combinations and Permissible Stresses

All structural components except Fill Supporting Structures, Stairs and Platforms of the cooling tower shall be designed by both working stress and limit state method. The following load / load combinations shall be followed in addition to codal requirement:

a. For working stress method
   i. DL + WL
   ii. DL + 1/3WL + EQ

b. For limit state method
   i. 1.5DL + 1.5WL
   ii. 0.9DL + 1.5WL
   iii. 1.5DL + 1.5EQ + 0.5WL
   iv. 0.9DL + 1.5EQ + 0.5 WL

Where, DL = Dead Load
WL = Wind Load
EQ = Earthquake Load

While considering the above load combinations, the appropriate stress resultants shall be superimposed most unfavourable. Stress due to subsoil deformation, temperature and constructional loads shall also be added to arrive at the most unfavourable load combination.

Wind load indicated in the combination are enhanced load taking into account enhancement factors obtained from model study / from code of practice. Besides above load combination, other load combinations as per relevant IS codes shall be followed.

<u>Since cooling tower is more a wind predominant structure, increase in permissible stresses as per B – 2.3 Annexure – B of IS 456, shall not be allowed. Increase in safe bearing capacity/pile capacity for design of foundation under wind load combination shall also not be permitted.</u>

13.6 FOUNDATIONS

The design and construction of cooling tower foundations shall be in accordance with the requirements stipulated in IS:1080/IS:2911/IS:2950 as applicable. Continuous foundations shall be provided for cooling towers more than 75 m in height.

The foundation structure shall be designed for loads and load combinations indicated above of this specification and shall in addition consider the following:

a. Thermally induced local loading where supply culverts pass through the foundation structure without structural isolation.
b. Cold water basin floor loading.
c. Surcharge load of 25 KN per sq.metre at the ground / grade level.
d. In case of subsoil with varying degrees of stiffness, non-uniform settlements due to the varying stiffnesses have to be determined. The redistribution of stress resulting from interaction effects between the subsoil and the shell structure have to be taken into account.

For the load combination 0.9DL+1.5WL, uplift of the foundation, not exceeding a sector of 15 degrees is permitted, provided the foundation is a continuous annular raft foundation.

No pressure relief valve shall be provided in any part including foundation & basin slab of NDCT.

13.7 BASIN AND COLD WATER OUTLET

The basin shall be divided into two compartments to facilitate complete isolation of one half of the basin for the purpose of cleaning and maintenance, while the other half is in service. A drain sump shall be provided for each half.

The basin floor of each compartment shall be sloped with a slope not less than 1 in 120 towards a collecting sump for effectively draining the water to permit desilting/desludging. To minimize obstructions to the flow of water, only the columns supporting the Fill structure shall be projected above the basin floor. Water shall be drained from the sump into a drain chamber outside the basin by CI drain pipe confirming to class B of IS:1536 ,embedded below the basin floor. Suitable sluice gates of the rising spindle type conforming to IS:3042 or sluice valve conforming to IS:780 shall be provided in the drain chamber with provision of platform with access lader/rungs for operating the gates/walls and pump suction pipe with foot walls. Drainage arrangement from drain chamber to suitable location shall also be made.

A minimum of 300mm free board shall be provided for the basin over the maximum design water level. The basin wall shall project a minimum of 500 mm over the surrounding grade level

Each compartment of the basin shall be provided with a concrete channel for outlet of cold water. The outlets for each compartment shall be combined into one channel and routed.PVC water stop 225mm wide shall be provided at the end of the channel in the wall and floor. Cold water outlet channels shall be provided with grooves formed out of hot dip galvanized steel channel sections for introducing the stoplogs and screens.

Stoplogs shall be fabricated out of structural steel plate and rolled sections and provided with rubber seals conforming to IS:5620/ IS:11855 to prevent leakage. Musical note type of rubber seals shall be provided at the edges and wedge type at the base suitably fixed using clamps and stainless steel screws for effective water tightness. Two numbers of stoplog shall be supplied per tower. Structural steel for stop log shall be provided with epoxy painting system consisting of a primer ,an intermediate and a final coat over surface blast cleaned to grade Sa 21/2, resulting in total protective coating of about 250micron. Stoplogs shall be hot dip galvanised and provided with etch primer and bituminous paint.

Screens shall be out of 8 gauge 25mm clear opening SS-316L grade crimped wire netting welded to frame of structural steel section/flats. Frame work shall be hot dip galvanized and provided with etch primer and bituminous painting. Two numbers of screens shall be supplied per tower.

Suitable arrangement of monorails with hoist shall be provided for handling stop logs and screens.

The basin walls, floor slab and outlet channels shall be of reinforced concrete construction. The design and construction of these water retaining structures shall be in accordance with IS:3370 with provision of construction/contraction and expansion joints. Resistance to cracking shall be checked as per cl. 4.5.2 and cl. 4.5.3 of IS: 3370 (PART 2): 2009. Minimum thickness of structural concrete elements shall be 230mm.Basin walls shall also be designed for condition of external surcharge load along with ground water table and basin being empty.

The basin and channel walls shall be designed for a minimum surcharge load of 25kN per sqm. to allow for construction plant operating in the vicinity. In case the actual loading is higher that specified, then appropriate loading shall be considered in design.

External pressure due to earth and ground water shall not be relied upon to reduce the effect of the internal water pressure, but account shall be taken of the ground water pressure when considering buoyancy or stresses in the empty water retaining structure.

Construction of the basin and channel shall be watertight with the provision of minimum 230mm wide approved quality PVC ribbed water stops with central bulb of minimum 10mm at all construction joints and expansion joints._The basin wall shall be designed to resist full water including the free board to take into account possible surge from normal pump operation.

The water retaining structures shall be tested for water-tightness in accordance with IS: 3370, without the backfill, if any, placed in position. The water level for test shall be full basin level including free board. Any rectification measures required to satisfy the test criteria shall be executed by the CONTRACTOR at his own cost all as per the directions of the OWNER.

All round Cold water basin, plinth protection in M20, 150 mm thick shall be provided for a width of 3000 mm, sloping away from the basin. Dry rubble soling of 150 mm thick shall be provided below the concrete paving. Suitable drain shall also be provided along plinth protection with a sum at appropriate location.

Any loose pockets of soil below the basin floor shall be removed and filled back with plain cement concrete of mix M15.

Basin floor shall be casted in panels ensuring that the maximum width of the panel does not exceed 7.5m in alternate bays in chess board pattern. Curing shall be carried out for a minimum period of 10 days. Interval between casting of two adjacent strips/panels shall be a minimum of four days period.

Expansion joints in floor shall be spaced at not more than 30m apart.

No through bolts for shuttering shall be permitted.

During the construction stage of the cooling tower, basin floor shall always be covered with atleast 50mm depth of water by forming suitable bunds using sand cement mix.

Basin floor slab shall be designed for uplift water pressure/buoyancy by adding suitable self weight. The effect of provision of flap valves/pressure release valves shall not be considered in the design of CT basin the cold water basin including sludge pits, cold water channels, shall be designed for the following condition:

i) Water filled inside up to maximum level and no earth outside.

ii) Earth pressure with surcharge load of 2.5 T/M2, as applicable, and with/ without ground water table at final graded ground level outside and no water inside.

Construction of the basin and channel shall be watertight with the provision of 225mm wide approved quality PVC ribbed water stops at all construction joints and expansion joints. For Basin and channel base, kicker type of PVC water stops is preferred, whereas in walls water stops with Central Bulb and End Grip will be preferred. It shall be ensured that 225mm wide water stops are also provided all along the edges of common outlet channel and left projecting by half its width, to facilitate later construction.

<u>In any case, the basin slab shall not be used to give lateral resistant to piles below main tower shell structure.</u>

13.8 TOWER SHELL

13.8.1 Shell Geometry

The shape of the tower shall be hyperboloid in vertical section and circular in plan.

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

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 rake column from super-structure considering various load combinations. <u>Effective length factor for racker column shall be considered as 1.0.</u>

13.8.2 **Thickness**

The tower shell shall have a minimum thickness of 250mm.

A minimum factor of safety of five (5) against buckling shall be ensured at all levels.

Tower Shell Boundary conditions

Shell Analysis

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

a) At upper Edge

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

b) At Lower Edge

The lower edge of the shell shall be thickened to form a lower ring beam. The thickness transition from shell to lower ring beam shall be smooth and shall be considered as an integral part of the shell. The lower boundary of the shell shall be considered as elastically supported by discrete columns. The influence of both support structure flexibility and foundation settlement shall be considered in the analysis and design of cooling tower shell. The shell analysis should include following information at every 10m and at not more than 0.05 of the shell height interval:

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

ii) Meridional and circumferential bending moments

iii) Displacements normal to the shell mid-surface.

Buckling of Tower shells

Critical dynamic pressure (wind pressure), at buckling shall be as given below:

Pcr = 0.07 Ec (d /r)7/3

Where, Pcr = Critical dynamic pressure.
Ec = Modulus of elasticity of concrete of the shell (short term modulus)
d = Thickness of the shell
r = Throat radius of the shell

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

Openings in Shell

Openings through the shell shall be avoided wherever possible. Any openings through the shell, if required, shall be kept to the minimum size and shall be so shaped to avoid sharp corners to minimize stress concentrations.

Openings through the shell shall be at right angles to the middle surface of the shell, so as to avoid acute angled edges to holes.

Any thickening necessary at the edges shall be smoothly tapered back to the shell thickness. No horizontal thrust due to inlet piping shall be transmitted to the shell.

Formwork

The type of formwork proposed to be adopted and its effect shall be considered in the design and analysis of the shell.

Formwork shall be properly designed so as to avoid vertical construction joints.

The supervision, setting out, checking and shuttering system shall be such as to ensure production of a smooth surface, without geometrical discontinuities and achieving a high degree of dimensional accuracy.

Latest and hydraulically operated jump formwork equipped with sophisticated instruments to check the accuracy of shell geometry alignment and profile shall be used.

The BIDDER shall submit the details of jump formwork to be used in construction of shell to the OWNER for approval atleast 2 months before the start of construction of shell. A scheme showing various checks to be performed and methodology for checking shall accompany the formwork details.

A shell lift check card as desired by the Engineer-in-charge of the OWNER for total quality control shall be submitted by the VENDOR before concreting of shell.

13.8.3 Design

The tower shell shall be designed based on bending analysis and as per elastic theory for thin shells.

Consideration shall also be given to the following effects of temperature and moisture variations that occur in the shell:

a) The strain resulting from a temperature gradient across the shell thickness.

b) The strain resulting from moisture content variations through the shell thickness, and

c) The strain resulting from variations of conditions (a) and (b) caused by rain and sunshine on one side of the tower or partial operation of the tower.

The effect of stress concentration due to any fixtures shall be taken into account.

13.8.4 Reinforcement and Cover

Reinforcement shall be provided on each face of the shell in both directions.

The shell reinforcement of high yield strength deformed bars, in either direction and on each face shall be not less than 0.15% of the concrete cross-sectional area. Further, the circumferential reinforcement on each face shall be not less than 0.20% of the concrete cross sectional area in the top one third height of the shell.

The maximum spacing of reinforcement in either direction on each face shall be restricted to twice the thickness of the shell or 200 mm whichever less is. Further, not more than one third of the reinforcement at any level or section shall be lapped.

Minimum lap lengths in shell shall be 1.3 times L_d where L_d is the development length as described in cl 26.2.1 of IS:456.

Column reinforcing bars shall be carefully anchored in the shell and in the foundations. The minimum anchorage length in the shell shall be $2L_d$ or 80 times the diameter of the bar.

Minimum size of deformed bars used shall be 8mm for circumferential reinforcement and 10mm for Meridional steel.

The concrete cover shall be 50 mm minimum. However, the clear cover shall not be less than 1.5 dia of bars. (For severe exposure condition).

Openings through the shell shall be provided with additional reinforcement at each edge, equal to 75% of the reinforcement intercepted by the opening, in the direction parallel to the edges. Extension of vertical reinforcement shall be equal to 1.3 Ld + B/2 where B=width of opening. In addition, diagonal reinforcement shall be provided at each corner equal to a cross sectional area in cm^2 of 0.5 d, where d is the thickness of the shell in cm.

13.8.5 Tolerances

The shell should be constructed within the dimensional tolerances stipulated in clause 7.3 of IS: 11504. Permissible allowances for survey inaccuracies while checking of shell geometry shall be as per clause 7.4 of IS: 11504.

13.9 FILL

PVC splash type bars fill arrangement shall be provided.

The fill shall be adequately supported to minimize sag, possibility of dislodgment and damage as a consequence of induced vibrations in the fill.

The supporting hanger rods/tubes shall be of stainless steel conforming to ASTM 316L.

Density of fill to be considered for the design of fill supporting structure shall be 100 kg/m^3 minimum

13.10 **FILL SUPPORTING STRUCTURE**

Fill supporting structure with its foundation shall be of reinforced concrete construction.
Fill supporting structure, where formed of precast concrete units, shall be made stable by the use of either bolted, cast-in-situ or glued joints. Members of precast concrete structure shall be either pre-stressed or reinforced concrete units. Where bolts are used for permanent connections, they shall be of a material highly resistant to corrosion or fully protected by embedment or coating.

Fill support structures, which are made up by the use of a large number of similar prefabricated members shall be manufactured to close tolerances to prevent unacceptable cumulative errors being introduced during erection.

Concrete work for the Fill and Fill supporting structure shall be of a very high standard of construction so that deterioration through spalling of concrete, rusting of reinforcement or damage during transport, handling and erection are avoided

The columns and beams supporting the Fill shall be adequately braced in all directions. The design of all members shall be checked for resistance to buckling.
The stability of the Fill support structure shall be checked for its capacity to resist a horizontal force of 2% of self-weight, the Fill and supporting structure, assumed to act horizontally in any direction. The structure shall also be checked for the appropriates earthquake loading as applicable.

During erection, care shall be taken to ensure the stability of the potentially unstable, partially completed structure.

The Fill support structure members shall be designed to cater for the likely loads to be imposed thereon, including:

a) Temporary loadings: they are subjected to during handling, transportation and erection at normal design stresses.

b) Loading due to scaffolding for the erection crew if so envisaged to be supported.

c) Loading of personnel during maintenance of pipe work and sprinkler system. The appropriate parts of the pack support structure shall be designed to support a point load of 1.5 KN at any position.

Reinforced concrete members shall be designed for self-weight and permanent loadings by working stress method with allowable stresses limited to 80% of those specified in IS:456.

13.11 MAINTENANCE ACCESS FACILITIES

All areas of the cooling tower requiring inspection, cleaning, repairs and/or adjustment shall be easily and safely accessible by suitable provision of stairs, platforms etc., as per the requirement described herein below:

13.11.1 Stairs

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 steps shall have a rise of about 125 mm and tread of about 250 mm. Anti-skid nosing at each step shall be provided. All access doors shall be of size minimum 1200 mm wide and 2100 mm height, minimum.

13.11.2 Platforms

Reinforced concrete platform of 1.2m clear width shall be provided all-round the circumference at the top of the cooling tower on the outside for fixing aviation warning beacons.

12mm wide radial gaps shall be provided in the platform at locations approved by the OWNER.

75mm internal diameter puddle flanged C.I. pipes totaling 48 numbers and equally spaced, shall be embedded in the platform to facilitate passing ropes during maintenance of the tower shell.

13.11.3 Walkways

RCC walkways having a minimum clear width of 1.50 m shall be provided all-round the circumference inside the cooling tower above the Fill to provide access for inspection and maintenance of all hot water distribution pipes/ducts and nozzles. Walkways shall be supported independent of the Fill structure.

Walkways shall be free from all obstructions.

Walkways along with the bearers supporting them shall be designed to carry such loads as would be encountered during the maintenance of the towers. The minimum live load, however, shall not be less than 500 kg/ m2.

13.11.4 Ladders

Four numbers of hot dip galvanized mild steel rung ladders with etch primer and bituminous painting shall be provided equally spaced around the circumference of the tower.

Ladders shall be 600mm wide fabricated out of 60mm x 10mm flats with 20mm diameter rungs at 300mm centers. Stays shall be provided at every 2.25m intervals connecting the ladder with the concrete shell.

Safety cage for the ladder shall be provided for the ladders located on the external surface of the tower upto the throat level.

Safety cage for the ladder shall be fabricated out of 5 nos. verticals of 50mm x 6mm flats with 50 mm x 6 mm flat straps at 800 mm centres. Safety cage shall be provided for the ladders located on the external surface of the tower upto the throat level.

Ladders shall be continued along the inside surface of the tower up to the top of the tower and then on to the top platform. At the throat level a reinforced concrete landing of 1.2m minimum width shall be provided with a hot dip galvanized steel access door for the interchange.

Two of the ladders leading to the platform at the top of the tower shall have approach from the reinforced concrete stairs. Other two ladders shall be directly from the ground level itself.

Intermediate landings of reinforced concrete of size not less than 750mm x 1500mm shall be provided at every 8 to 10m height of the ladders. Some of these landings shall be suitably adjusted/spaced to give access for maintenance of aviation warning beacons.

13.11.5 Handrailings

Handrailing shall be provided on both sides at the edges of platforms, landing slabs, sides of stairs, walkways and cold water outlet channel.
Handrailing shall be of hot dip galvanized construction and shall be out of 32 mm NB pipes of medium class conforming to IS: 1239 and provided with etch primer and bituminous painting.
Handrailing shall be 1300 mm high with two intermediate rails at 450mm and 900 mm with the top rail at 1300 mm above the surface of slab/steps. Handrail posts shall be spaced at not more than1.5 m centers.
A toe plate of hot dip galvanized mild steel of size 65 mm x 8 mm shall be provided for all handrailing.

13.12 PAINTING TO CONCRETE SURFACES

Painting to the concrete surfaces specified herein below shall be with 100% solid high build Polyurethane coating of 2000 microns over compatible primer as per manufacturer's requirement. The prior approval of manufacturer shall be obtained from OWNER for painting of cooling tower.

a) Basin floor

b) Internal & External surfaces of basin wall including the partition wall.

c) Diagonal columns over complete height.

d) Fill support columns and beams for the full height and length respectively.

e) Internal and external surfaces of hot water duct.

f) Internal and external surfaces of cold water channel upto the terminal point.

g) Internal and external surfaces of the drain chamber.

h) Complete internal surface of the shell. For external surface at least 1 meter on the shell at top.

The preparation of concrete surface for painting shall conform to IS: 2395(Part-I). For new surface, it is preferable that the surface left unpainted for as long as possible to allow drying. Before painting, the surface shall be thoroughly brushed to remove all dirt and remains of loose or powdered materials.

All other exposed concrete surfaces shall be given two coat of water proof cement paint of approved make and colour after the surfaces are rubbed down suitably and as approved by the OWNER. All concrete surfaces which are in contact with the earth shall be applied with anticorrosive coat system.

13.13 WATER DISTRIBUTION SYSTEM

The arrangement of water distribution system shall permit a satisfactory distribution of water over the whole area of the tower at all reasonable loads.

Hot water Inlet pipe shall conform to the requirements of Class I of IS: 3589 and steel shall conform to IS: 2062.
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.

Distribution system shall be designed to handle turbid water during monsoon months.

The hot water inlet pipes shall be properly embedded in the flume or shell. No horizontal thrust due to inlet piping shall be transmitted to the shell.

All sections of the water distribution system shall have adequate flow capacity to meet the maximum requirements of thermal design of the tower.

The structural design of the water distribution system shall also consider the following loading, combined as appropriate: a) Self weight. b) Hydraulic pressures during normal operations, including pressure surges. c) Hydraulic pressures due to mal-operation of tower or supply pumps.

Seismic loading on the water distribution system shall also be considered.

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.

The possibility of vibrations being imposed on the distribution system shall be investigated in the design.

The distribution troughs/pipes shall not be laid on top of walkways to avoid obstruction to movement on the walkways.

Access ladder shall be provided from the top of hot water duct to surge shaft.

13.14 LIGHTNING PROTECTION

The cooling tower shall be protected against damage by lightning. The installation work shall conform to the requirements of IS: 2309.

CONTRACTOR's scope of work includes supply and installation of the complete system upto and including the earth electrodes and connecting to the plant earthing grid.

For detailed specification of lightning protection system refer electrical section of this document.

Lighting protection requirement shall be provided as per mentioned specification of Volume IV.

13.15 AVIATION WARNING SYSTEM, LIGHTING AND POWER RECEPTACLES

CONTRACTOR"s scope of work includes supply and installation of the complete aviation warning system, lighting and power receptacles including the cabling between the main incoming 63A switch and aviation warning beacons and 30A receptacles.

CONTRACTOR shall provide and fix aviation warning beacons with their supports at the top platform, at the throat level of the tower and at every 45m height or part thereof, between the ground level and the throat level. The beacons shall conform to the requirement of the civil aviation department, Govt. of India. The beacons at the top of the tower should be at least 2 metres below the top of the tower to prevent them from being obscured by vapor.

Temporary warning lights shall be installed during construction suitably located above the top most point of obstruction and shall be shifted up as the construction progresses. These lights need be installed only after the level of obstruction is greater than 45 m above the grade level.

13.16 DRIFT ELIMINATORS

Drift eliminators shall pbe provided in the tower as per design requirement.

TECHNICAL DATA SHEET- A

Specific Technical Requirements

1	**Number of cooling towers**		As per Mechanical Section
2	**Design & Operating Conditions**		
	Refer Volume-III Mechanical)		
3	**Features**		
	Refer Volume-III (Mechanical)		
4	**Elevations**		
	Grade level in m		To be decided during detail engineering.
	Sill level in m		-do-
	Basin depth in m		-do-
5	**Primary Loads** **Wind load (as per IS875)**		
	i)	Basic wind speed	47m/sec
	ii)	Factor K1	1.07
	iii)	Terrain category factor K2 For Terrain Category 1	Varies w.r.t. height,
	iv)	Factor K3	1.0
	v)	Intensification factor	as per spec.
6	**Earth quake load**.		
	i)	Zone as per IS: 1893	IV
	ii)	Importance factor	1.75
7	**Foundation Criteria**		
	i)	Ground water table	At grade level.
	ii)	Type of foundation	Pile
	iii)	Safe bearing capacity of soil	As per soil report
	iv)	Type of pile	As per soil report
	v)	Pile capacity and termination depth belowground level	As per soil report
	vi)	Minimum thickness of basin base slab	250mm
	vii)	Pressure relief valves in the basin floor slab	Not to be provided

CHAPTER – 14

COAL HANDLING SYSTEM

Coal handling will consist of junction towers, under ground tunnels, pent house, conveyor galleries, trestles, MCC room, wagon trippler, wagon trippler shed, pump house, raw water tank for water supply,crusher house, stacker reclaimer foundation, coal stock pile, stock yard drainage, water sprinkler system, dust extraction system etc.

Necessary statutory clearances/approval from Railways/Highway Authority / PWD shall be obtained by Contractor at his own cost.

14.1 WAGON TIPPLER, RECLAIM HOPPER AND UNDERGROUND TUNNEL

Wagon Tippler shall consist of underground portion, which shall be of R. C. C., and above ground portion, which shall be of structural steel shed covered with permanently Colour coated profiled steel sheets.

The vertical and inclined portion of coal hopper, the beams in the wagon tippler hopper structure as shown in the tender drawing shall be provided with 50 mm thick guniting (shotcreting). Complete inside surfaces of Wagon tippler & reclaim hopper shall also be provided with 50mm thick guniting. Details of shotcreting have been given elsewhere in this specification. <u>Guniting should be protected by provoding MS plate in similar pattern as provided in existing hoppers.</u>

Expansion joints shall be provided at a maximum distance of 40m unless otherwise shown in the tender drawing. 600 mm wide water stop fabricated with 22G copper plate with bitumen board fillers and polysulphide sealing compound as specified elsewhere shall be used as expansion joint material. Detailing of expansion joints shall be as per details in the tender drawing. Construction joints shall also be provided with 600mm wide water stop 22G copper plate.

Floor shall be provided with cross slope not flatter than 1 in 50 towards side drains. Side drains shall be sloped towards sump where sump pumps as specified elsewhere, shall be provided. The slope of side drains shall not be flatter than 1 in 400. Side drains and sump shall have removable type steel grating cover. Gratings shall be galvanized to grade 610 gm/m2.

Water proofing / Damp proofing of under ground portion of and Wagon tippler, reclaim hoppers, tunnels, underground (i. e. basement) portion of transfer houses shall be done as mentioned in chapter 10.

Steel gratings of mesh size 350 mm x 320 mm for wagon tippler hopper shall be provided. The grating shall be built of min. **200mm x 28mm thick flats in main direction and min. 100mm x 20mm thick in secondary direction**. The hopper and gratings shall be designed for movement of front end loader/ bulldozer over them. Bull-dozer weight shall be considered as about 35T. **No painting/galvanization shall be provided in gratings. However, two coats of Red oxide Primer to be provided immediately after fabrication.**

The wagon tippler are deep underground structures which are subjected to direct load from the loaded wagons / loco due to the rake movement over it, in addition to load due to coal filled hopper and lateral earth pressure. The railway loads, analysis and design of wagon tippler, transfer point and the portion of tunnel subjected to rail loads shall be as specified in design criteria. Coefficient of dynamic augmentation shall be worked out for a train speed of 30 kms per hour

Earth pressure to be considered for design shall be due to earth pressure at rest (Ko) condition only. Earth pressure due to surcharge intensity of Railway Loads (where applicable) or Uniformly Distributed Load (U. D. L) of intensity 2 T / Sq. M. whichever is critical, shall be considered in the design.

A minimum safety factor of 1.2 against uplift of wagon tippler, transfer points (underground or with basement) and tunnels, due to ground water shall be ensured during execution and after execution, considering dead weight of the structure to be 0.9 times only, ground water table at adjoining formation level and soil wedge angle of not more than 15 degrees.

Also, FOS against uplift, to be taken as 1.0, considering the dead wt. of structure and soil resting on side projections if any in the vertical plane. Inclined wedge action of soil shall not be considered in this case.

Walkway width and hand railing shall be provided as specified in the tender drawing.

Wherever, slope of tunnel exceeds 10°, R. C. C. steps shall be provided for the entire width of each walkway.

Structure shall be analyzed and designed for the worst load combinations. However, it shall be analyzed for the following load combinations also.

a) Load Combination – I

(1) Hopper full
(2) Maximum load from Railway Track
(3) Earth pressure without surcharge and subsoil water pressure
(4) Maximum load from steel columns for shed
(5) Maximum load from paddle feeder support
(6) Maximum load from coal tray.

b) Load Combination – II

(1) Hopper full
(2) Maximum load from Railway Track
(3) Earth pressure with surcharge and subsoil water pressure
(4) Maximum load from steel columns for shed
(5) Maximum load from paddle feeder support
(6) Maximum load from coal tray.

c) Load Combination – III

(1) Hopper empty
(2) No load on Railway Track

(3) Earth pressure with surcharge and subsoil water pressure
(4) No load from steel columns for shed
(5) Dead load only from paddle feeder supporting structure
(6) Dead load only from coal tray

14.2 OVERHEAD / GROUND CONVEYOR GALLERIES AND TRESTLES

Overhead conveyors shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam or single channel section (ISMB or ISMC) or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girders shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans. Roof truss shall be provided at upper node points of latticed girders to form an enclosure. The maximum span of overhead gallery shall be limited to 25 meters unless higher span is required due to site conditions, which shall be subject to approval of the Engineer. In case length of Conveyor Gallery exceeds 25m dynamic analysis shall be carried out for the same. The gallery should as far as possible be erected as a box section.

Keeping all the vertical and horizontal bracing tied in proper position. The gallery should be checked for all erection stresses that are likely to develop during handling and erection and if required, temporary strengthening of gallery members during erection shall be made.

Seal plates under the conveyor galleries shall be provided in such a way that complete gallery bottom shall form a leak proof floor.

The ground conveyors shall be located in suitably enclosed gallery of structural steel consisting of rigid portal frames spaced at regular intervals and suitably braced. Plinth protection along with drains shall be routed along the ground conveyors.

For double stream conveyor gallery, two side and one central walkway of minimum width 800 mm and 1100 mm respectively shall be provided. The minimum width of two side walkways for single stream conveyor gallery (except tripper conveyor) shall be 800 mm and 1100 mm respectively. For tripper conveyor, the width of walkways shall be as per functional requirement. Both sides of central and side walkways shall be provided with pipe handrails all along the conveyor gallery with curb plates using pipe type'Medium'as per IS:1161 having 32mm nominal size. Hand railing should not be supported on conveyor supporting stringers. The walkways shall be chequered plate construction of minimum 8mm thick with anti - skid arrangement. The anti - skid arrangement will consist of welding of 10 mm square steel bars at a maximum Spacing of 500 mm along the length of the gallery. Where the slope of walkway is more than 10^{o}, chequered plate steps with nosing and toe guard shall be provided. The floor of conveyor gallery all along the gallery length, shall be provided with minimum 12 gauge thick seal plates and other drainage arrangements as specified elsewhere

Conveyor gallery shall have permanently colour coated steel sheet covers on roof and both sides. However in roof, a panel of minimum 1.5 m x 1.5 m area at about 6.0 m center shall be provided with translucent sheets of polycarbonate material for natural lighting. Roof framing shall be given a slope of 1 vertical:4 horizontal. A continuous slit opening of 500 mm height shall be provided on both sides just below the roof sheeting. These openings shall be covered with bird screens.Adequate provision of windows shall be kept on both sides of conveyor gallery as appended in Mechanical Section (Belt conveyor system). Windows shall be provided with wire mesh as specified elsewhere in this specification.

Cross - over with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 100 M intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

For railway tracks passing below overhead conveyor gallery and along conveyors, the railway clearances both underground as well as over ground shall have to be adhered to for design, execution and erection of foundations, trestles, galleries etc., so that movement of locomotives and wagons is not hampered in any way during execution and afterwards. However at the location where the overhead conveyor gallery crosses road / rail line, minimum clearance of 8.0m above the road crest / rail top shall be provided.

For calculation of coal load on moving conveyor, a multiplication factor 1.6 shall be used to take care of inertia force, casual over burden and impact factor etc.

Thus coal load per unit length of each moving conveyor shall be

Rated Capacity of Conveyor system 1200 TPH

1.6 X -- X -----

Conveyor Belt Speed 800

It should be noted that for structural design, unit weight of coal shall be assumed as 1100 Kg/Cu. M. instead of 800 Kg/Cu. M. considered for system sizing purpose.

Conveyor Gallery structure shall be designed considering both conveyors operating simultaneously.

Conveyor gallery and supporting trestles located between transfer houses / buildings shall be arranged in any one of the following ways.

a) All gallery supporting trestles shall be four legged type only. One end of each gallery span shall be hinged to the supporting trestle and the other end shall be slide type. Slide type support shall be with P. T. F. E. bearings to allow both rotation & longitudinal movements.

OR

b) In between transfer houses / buildings, four legged trestles shall be placed at a maximum interval of 90 metres. The arrangement shall be such so as to ensure that force in the longitudinal direction (i. e. along the conveyor length) of conveyor gallery of length not more than 90 m is transferred to any four legged trestle. In the space between each successive four legged trestles, two legged trestles shall be provided at regular intervals. The end supports resting on the four-legged trestle can have either ends hinged or one hinge and the other on slide type depending on the arrangements. Slide type support shall be with P. T. F. E. bearings to allow both rotation & longitudinal movements.

End of conveyor gallery, which will be supported over transfer tower, shall be so detailed that only vertical reaction is transferred from conveyor gallery and no horizontal force in longitudinal direction is transferred from conveyor gallery to transfer house structure and vice- versa. This side of the gallery shall therefore be supported on sliding PTFE support. The top of pedestal for the foundations shall project 300 mm above the grade level.

For trestles and trestle foundations for conveyor galleries located adjacent to existing structures, over ground and under ground facilities, location and details of these trestles and foundations shall have to be decided such that there is no interference both underground as well as over ground with existing structures and facilities. Trestle columns / ground conveyor portal column base shall be kept 300 mm higher than the existing ground level.

Ground conveyor portals shall be provided at a maximum spacing of 3 m and the sides and roof covered with colour coated sheets and translucent sheets.

While designing the structures of conveyor galleries and trestles, provisions of clause 8.14 of IS 11592 in addition to requirement of IS800 shall be followed.

The trestles shall be so designed that transverse deflection at places where conveyor galleries meet crusher/ junction house, should be equal to the respective transverse deflection of crusher/ junction house.

Suitable expansion joints shall be provided in the longitudinal direction. The maximum distance of the expansion joint shall be as per the provisions of IS: 800. Slotted holes shall not be assumed to act as expansion joint for relieving of stresses and suitable bearings shall be provided at the supports

14.3 TRANSFER HOUSES

The over ground portion of all transfer houses shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding (from lowest working floor level till top) and R. C. C. floors over structural beams. However the lower portion of side cladding for a minimum height of 0.9 m above the finished floor level shall be one brick thick wall plastered on both side. In some areas like MCC floors etc., one brick thick wall cladding shall be provided. Brick wall cladding shall be supported on encased wall beams and suitably anchored to adjoining columns and beams. In all transfer points, contractor shall have option to use Tubular steel sections for bracings only. Vertical bracings shall be provided only on four sides along the periphery. Grade slab with 0.9m height one brick thick wall plastered on both side at periphery shall be provided for all transfer houses.

Adequate steel doors and windows for proper natural lighting and ventilation shall be provided. In addition to steel windows, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting.

Roof shall be provided with troughed profile permanently colour coated sheet on outside and plain permanently colour coated sheet on inside with 50mm thick mineral wool insulation in between the two sheets. A slope of 1 in 5 shall be provided for quick drainage of rain water. Mineral wool insulation (as per IS: 8183) having a density of 32 kg/cum for glass wool or 48 kg/cum for rock wool, bound in polythene bags shall be used, with or without framed strips 25x3mm (min.) at maximum 300mm c/c to hold the insulation between the runners, keeping in position with galvanized hexagonal wire netting of 0.3mm wire dia. & 19mm mesh size as per manufacturer's recommendations.

14.4 CRUSHER HOUSE

The crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding for a height of minimum 0.9m above the finished floor level shall be of one brick thick wall plastered on both faces. Floors shall be of R. C. C. supported on steel beams. Within this building, cubicles for resting room of operators shall be constructed with one brick thick brickwork having both sides plastered and roof slab. Adequate steel doors and windows for natural lighting and ventilation shall be provided. In Crusher house, contractor shall have option to use Tubular steel sections for bracings only. Vertical bracings shall be provided only on four sides along the periphery.

Roof shall be provided with troughed profile permanently colour coated sheet on outside and plain permanently colour coated sheet on inside with 50mm thick mineral wool insulation in between the two sheets. A slope of 1 in 5 shall be provided for quick drainage of rain water. Mineral wool insulation (as per IS: 8183) having a density of 32 kg/cum for glass wool or 48 kg/cum for rock wool, bound in polythene bags shall be used, with or without framed strips 25x3mm (min.) at maximum 300mm c/c to hold the insulation between the runners, keeping in position with galvanized hexagonal wire netting of 0.3mm wire dia. & 19mm mesh size as per manufacturer's recommendations.

Ring Granulator type Crushers shall be supported on R. C. C. deck, which in turn will rest on suitable vibration isolation system consisting of springs and dampers. This R. C. C. deck shall be isolated from the floor. However, the vibration isolation system consisting of springs and dampers may rest on main building framework. Detailed specification of vibration isolation system including the unbalanced force (due to ring granulator), frequency and amplitude criteria and other design requirements are appended elsewhere in this specification.

Two staircases shall be provided one inside and one outside, both of structural steel. Elevator shall also be provided serving all the floors. Elevator pit shall be RCC. Machine (M/C) room floor and roof shall be of RCC. An RCC curb wall of 300 mm shall be given allround the floor. Main door to M/C room shall be of steel of flush welded construction. Adequate ventilation shall be given using glazed windows. Elevator pit wall shall be kept at least 500 mm above general grade level to prevent flooding. A sump shall be provided inside the pit to collect and pump out water. Sump shall be given with access ladder. Toilet shall be provided in the crusher houses.

Piling shall be used for the foundation of crusher house.

14.5 STACKER RECLAIMER FOUNDATION

Stacker - Reclaimer foundation shall be in R. C. C. and shall be designed as a continuous wall or R. C. C. framed structures (in longitudinal & transverse direction). Lateral tie beams between two rail supporting elements shall be provided at a regular interval of approx. 3.0 m center. The foundation shall be designed for the most critical combination of loads as furnished by the equipment supplier.

The portion between the two rails shall be paved in concrete as per specification for grade slab of ground level specified elsewhere. However no metallic hardener finish over R. C. C. slabs is to be provided. Drains shall be provided along the rails for drainage of rain / dust suppression / floor washing water. Drains shall be routed on both sides of the foundation along the rail as shown in Tender Drawing. Drains shall be connected to the network drainage system for finally discharge into coal settling tank. RCC drains shall be provided in Coal stockyard area with precast RCC covers.

The beams supporting rails shall be given expansion gap as per design requirements.

14.6 COAL STOCK YARD

Entire area shall be excavated to average 250mm 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. 100mm thick sand cushion layer shall be placed over well compacted subgrade and consolidated by flooding. 150 mm thick boulder soling joint filled with sand shall be placed over sand cushion.Slope is to be maintained throughout the layer. The coal stock area shall be graded with suitable slope for draining the surface by longitudinal drains shall be of RCC trenches with graded gravel packets at about 1.5m intervals on the sides to trap coal dust. 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 drain to be provided by the Contractor by the side of the road. Retaining wall 1m depth to be provided around the crushed coal pile to prevent coal spillage into the drain. However RCC paving shall be provided in the area between the rails.

14.7 CONTROL BUILDING, M. C. C. BUILDINGS

These shall be R. C. C. framed structures with columns, beams, slabs and foundations etc.Cladding shall be of brickwork with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified elsewhere in the Technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

All air - conditioned areas, shall be provided with the suspended permanently colour coated aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

14.8 PUMP HOUSES

Pump House shall be of R.C.C framed structure. Cladding shall be of fly ash bricks with plastering on both sides. Roof shall be provided with water proofing treatment as specified elsewhere. Under ground sump shall be of R.C.C.

Galvanized steel ladder shall be provided for access to the roof of pump house and water tank.

14.9 PENT HOUSE

These shall be of R. C. C. framed structures with columns, beams, slabs and foundations etc. Cladding shall be of brickwork with plastering on both sides. Roof shall be provided with roof water proofing treatment as specified elsewhere. Adequate nos. of steel doors and windows shall be provided for natural lighting and ventilation.

14.10 TOILETS

Toilet with potable water line facilities shall be provided in each of the following locations:

Crusher House (Ground Floor)

In all M. C. C./ Control Room building

Each unit shall have brick enclosure, and the following fittings.

i) Squatting type, white, vitreous china Orissa fittings. In addition, for 1 control building one wall mounted glazed vitreous china European water closet with flushing valve shall be provided.

ii) White glazed vitreous china flat back lipped urinal with photovoltaic 1 control system for flushing and all requisite fittings

iii) Wash Basin 630 mm x 450 mm mounted over granite beveled edge 1 counter fitted with photovoltaic control system for water controls, bottle trap with two taps and all requisite items.

iv) Mirror 600 mm x 450 mm x 5.5 mm thick with bevelled edges 1 No. (Superior sheet glass)

v) C.P. Brass Towel Rod 600 x 20 mm-1 No.

vi) Liquid Soap Container 2 Nos.

vii) Washing Tap (CP Brass) 1 No.

viii) Overhead Polyethylene water tank 1 No.(min. 1000 litres capacity)

ix) For control room buildings, pantry with granite top counter & 1 No Stainless steel sink.

x) Suitable provision for installation of water coolers.

14.11 STAIRCASES

All floors of transfer houses/crusher house and roof/floors of all MCC/Control room buildings shall be accessible through staircase. Cage ladders (min. 450mm wide) shall be provided for access to roof of penthouses & mumty.

All stairs of overground portion of transfer houses & crusher house shall be of steel (minimum 1000 mm wide)and maximum rise should not be more than 180 mm and minimum tread width 250 mm. Stringers shall be of rolled steel channel(minimum ISMC 250)and tread shall be of electroforged steel gratings. Stairs shall be provided with 32 mm dia nominal bore medium duty M. S. pipe hand rail.

Handrails (for staircases, around openings, in walkways etc.) shall be of standard weight steel pipe of flush welded constructions, ground smooth using 32 mm nominal bore medium class pipe provided with double rail, top rail about 1.0 metre above platform level and pipe posts spaced not more than 1.5 metre apart. Angle handrail post may be provided when specifically called for in drawings approved by Engineering. Toe guard of size 100mm x 6mm shall be provided along the railing for all steel platforms/landings and RCC staircases.

Smooth uniform curves and bends shall be provided at stair returns and also where so ever required. Posts connected to curb plates shall have a neat closure at the bottom and a 6 mm thick plate neatly welded to posts for attachment to curb plate. All necessary fittings including inner dowels at splices, brackets, belts, bends, flanges and chains, where required shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the handrail.

Treads and landing shall be suitable for the prescribed loading. The maximum width of openings in gratings shall not exceed 40 mm. The minimum size of main bars shall be 25 x 6 mm and cross bar shall be 6mm. The usual span of grating will not generally exceed 1.5 meters. Stair case gratings shall be galvanized to grade 610g/m2.

Out side stairs to transfer points shall be open type. However sheeting shall be provided at the top.

Stairs of MCC/control room, reclaim hopper and underground TP's shall be of R. C. C. construction. The minimum width of stairs for MCC/Control room shall be 1200mm wide and for reclaim hopper/underground TP's shall be 1000mm. Maximum rise should not be more than 180 mm and minimum tread with 250 mm. Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection for treads of stairs in wagon tippler/ reclaim hopper/underground TP's.

Numbers and arrangement (including enclosures etc.) of stair cases shall be such as to meet the fire safety requirement as per guide lines of statutory regulatory bodies.

14.12 TRENCHES

All trenches for cables or any other underground facility as detailed out elsewhere shall be of R. C. C. Cable trenches shall be provided with pre - cast R. C. C. covers / chequered plate cover. Cable trenches as well as pre - cast covers shall be provided with edge protection angles and lifting hooks. All embedments / block outs as required and specified elsewhere in these specifications shall be provided. Trench pre - cast cover weight shall not be more than 65 Kgs. At road crossings & entry locations, trench covers designed for 10 T wheel load at centre shall be provided. Pre - cast covers shall be designed for central point load of 75 Kgs. R. C. C. cable trenches shall be filled with sand after erection of cables, up to top level and covered with pre - cast R. C. C. covers. For cable trenches outside buildings, top level shall be 200 mm above G. L and sand filling shall be overlaid with 50 thk. PCC.

Minimum 50 x 50 x 6 mm size angles with lugs shall be provided as edge protection all around cut outs / openings in floor slabs, edges of drains supporting grating/precast RCC covers, edges of R. C. C. trenches supporting pre - cast covers, supported edges of pre - cast cover.

14.13 DRAINAGE & WATER SUPPLY WORKS

14.13.1 Drainage System

The drainage arrangements shall be so planned so as to ensure quick disposal of drainage water without stagnation and / or overflow. It is envisaged to clean the conveyor galleries, transfer points, crusher building, penthouse etc. with water periodically.

Minimum 4 nos. down comers shall be provided in each transfer house / crusher house. In case of conveyor galleries, the down comer shall be provided at every trestle location.

Drainage of the complete coal stock pile, area around stacker reclaimer rails etc. shall be discharged into the coal slurry settling pond.

For Conveyors in Main plant area each down comer shall lead the water / coal slurry to RCC pit (of 2 Cu.M capacity) to allow settling of coal. The water from the pit shall overflow into R.C.C drain, which will lead the discharge finally into trunk drain routed alongside the nearby road.

For Conveyors in stock pile area, each down comer shall lead the water / coal slurry to RCC pit (of 2 Cu.M capacity) to allow settling of coal. The water from the pit shall overflow into R.C.C drain, which will lead the discharge finally to the coal settling pond.

For Crusher House, Pent Houses & TP’s in stock pile area, each down comer shall lead the water / coal slurry into the peripheral drains (Brick drains with steel gratings provided around the building) which will lead the water / coal slurry to water / coal slurry to RCC pit (of 2 Cu.M capacity) to allow settling of coal. The water from the pit shall overflow into R.C.C drain, which will lead the discharge finally to the coal settling pond.

For TP’s in Main plant area, each down comer shall lead the water / coal slurry into the peripheral drains (Brick drains with steel gratings provided around the building) which will lead the water / coal slurry to RCC drain and finally into trunk drain routed alongside the nearby road.

For reclaim hopper, peripheral drains (Brick drains with steel gratings provided around the building) shall lead the water / coal slurry to a local RCC pit (of 2 Cu. M. capacity) near each facility to allow settling of coal. The water from the pit shall overflow into R.C.C drain, which will lead the discharge finally to the coal settling pond.

In case of Control rooms and M. C. C. buildings, Pump houses, etc, water / coal slurry coming from down comers shall discharge into peripheral drains (Brick drains with steel gratings provided around the building) which will lead the water / coal slurry into R.C.C drain, which will lead the discharge finally into trunk drain routed alongside the nearby road/ coal settling pond.

Suitable kick plates/Curb beams shall be provided around the floor openings, stair case landings, in the transfer points, crusher house and other buildings.

Contractor’s scope shall also include construction of necessary culverts under the rail lines / roads as per railway / I. R. C. standards and approval of Railway culverts from concern Railway authorities.

14.13.2 **Internal and external water supply, drainage etc.:-**

The scope for potable water supply includes all distribution systems, tanks, pipes, fittings etc. as required and as described here or elsewhere in these specifications.

The scope for service water supply and dust control water supply shall be as described elsewhere in these specifications.

For water supply, medium class galvanized mild steel pipes conforming to IS: 1239 shall beused.

The scope for drainage of surface water shall include design, layout and construction of drains for and from buildings and drains required for coal stockyard area, drainage up to main coal slurry settling tank including connection with the tank. Drainage system shall be designed for maximum intensity of rainfall as 75 mm/hr and 60 % runoff coefficient. All buildings (including transfer houses and crusher house) shall be provided with open surface brick drains of minimum size of 300 mm width and 300 mm depth all around the periphery. All drains excepting the peripheral drains around the transfer points, crusher house, control / M. C. C. buildings, pumps house etc., shall be of R. C. C. construction. All open drains shall have removable steel grating designed for loads as specified under loading clause. Minimum size of main bar of grating (Galvanised to 610 gm/m2) shall be 12 mm x 3mm and cross bars 6mm. At all entry or road/rail crossing point’s RCC box/pipe culvert shall be provided. The opening size of grating shall not be more than 90 mm x 35 mm. All drains as well as pre - cast covers shall be provided with edge protection angles and lifting hooks.

However, drains in coal stockyard area shall have pre cast R. C. C. covers. RCC pre – cast cover weight shall not be more than 65 Kgs. RCC pre-cast covers near entry or at road crossings shall be designed for 10 T wheel load at centre. RCC pre - cast covers shall be designed for central point load of 75 Kgs.

The scope for foul water from toilets shall include layout and laying of sewers up to the main sewer line for sewerage system together with all fittings and fixtures and inclusive of ancillary works such as connections, manholes and inspection chambers within the building and from the building to the sewer line.

For rain water down comer and those to be used for conveying water / coal slurry generated from cleaning of walkway/floors, Galvanised MS pipes conforming to IS: 1239 (for 150 mm NB Medium grade pipes) with welded joints shall be used for MCC buildings, penthouse, control rooms and Galvanised steel ERW pipes (273mm OD, 4mm thk) of steel grade Fe330 conforming to IS: 3589 with welded joints shall be used for all TP's, Crusher house, and Conveyor galleries.

Galvanising shall be as per IS: 4736. The minimum mass of zinc coating shall not be less than 360 gms/sq.m. as per IS:6745. The zinc coating shall be smooth and shall be subjected to testing as per IS: 2633, for uniformity of coating. The zinc coating shall be free from all defects as per IS: 2629.

All rain water down comers shall be provided with roof drain heads and complete with shoes bends, junctions, sockets, adapters, brackets and finished with anti corrosive painting over a coat or primer.

For design of building drainage system IS: 1742 shall be followed.

For sanitary / sewerage pipes above ground, sand cast iron pipes conforming to IS : 1729 with leak proof lead joints.

For underground drain pipes, minimum class NP - 2 pipes conforming to IS: 458. At road crossings, concrete pipes of class NP 3 conforming to IS: 458 and at rail crossing R.C.C. box culvert to be provided.

For sewerage below ground stoneware pipes conforming to IS: 651 with concrete bedding and haunch.

14.14 ROOF DETAILS

Roof slab shall be minimum 150 mm thick and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom.

900 mm high and minimum 100 mm thick R. C. C. parapet wall shall be provided over roofs.,Parapet wall shall have suitable coping. External face of parapet wall of the buildings provided with metal cladding shall also be finished with metal cladding of design and colour as per approved architectural drawings.

Junction of roof and parapet shall be provided with 150 x 150 mm size concrete fillet.

Drain level shall be provided with 45 x 45 cm size khurras having minimum thickness of 30 mm of M-15 concrete over PVC sheet of 1 m x 1m x 400 micron and finished with 12 mm 1 : 3 cement : sand plaster.

Roofs of all M. C. C./control rooms, penthouse / JT's / Crusher House etc., shall have roof water proofing treatment. Roof water proofing treatment shall be as follows:

1) Application of polymerised mastic over the RCC roof to achieve smooth surface as primer coat.

2) Application of high solid content liquid applied urethane based elastomeric water proofing membrane, over the primer coat, to give uniform joint less dry film thickness of minimum 1.5 mm (as per ASTM C 836 and C 898).
3) For efficient disposal of rain water, the run off gradient for the roof shall not be less than 1: 100. This gradient shall be provided by screed concrete M-15 (using 12.5 mm coarse aggregate) and / or cement mortar (1: 4)

over the elastomeric water proofing membrane with 25mm thick cement mortar (1:4) topping.

4) Wearing course at top, shall consist of 25 mm thick P. C. C. (M-15) cast wire mesh and sealing of joints using sealing compound / elastomeric water proofing membrane. Pathways for handling of materials and movement of personnel shall be provided with 22 mm thick chequered cement concrete tiles as per IS : 13801 for a width of 1000 mm in place of P. C. C.

14.15 FLOORS AND GRADE LEVEL DETAILS

The floor slabs shall be minimum 150 mm thick and shall have minimum 10 dia HYSD reinforcement bars placed at 200 mm center both ways at top and bottom

Floors of transfer points shall have cross slope of not flatter than 1: 80, towards the floor washing drainage outlets, for efficient drainage. For ground conveyor & crusher house slope shall be 1:100.

Chequered plates (used for platforms, walkways etc.) shall be minimum 6 mm thick o/p or as indicated on drawings. The chequered plate pattern shall be approved by Employer / Engineer. Mild steel flats/angles of suitable size shall be welded to the bottom portion of chequered plates at a designed spacing to stiffen chequered plates to restrict deflection within span/200. Chequered plates shall be fixed by staggered welding of suitable size.

Toe guard of size 100 x 6 mm shall be provided at various openings provided in floors e.g. around stair case openings, chute openings and other similar cutouts. For conveyor walkways, angle runner to act as toe guard shall be provided.

All along the periphery of R. C. C. floors (where no brick masonry walls are provided) shall be provided with one brick thick 300 mm high brick wall and 700 mm high steel hand rails all around over this brick work.

The grade slab shall consists of 230 mm thick rubble soling (63 mm downgraded hard stone aggregate as per IRC specification, watering and compaction to minimum of 95% Standard Proctor density, including filling the interstices of stone aggregates with sand), over well compacted earth, overlaid by 75 mm thick P. C. C. M-7.5 and 100 mm thick R. C. C. of grade
M-20 with minimum 8 mm dia bars placed at 200 mm C / C in either direction respectively. There will be minimum 50 mm thick metallic hardener finish over the R. C. C. slab.

All buildings (including reclaim hopper, penthouse, MCC rooms, pump houses, transfer houses and crusher house) and ground conveyors shall be provided with 750 mm wide plinth protection all around. It consists of 50 mm thick P.C.C. M-20 grade with 12 mm maximum size aggregate over 200 mm thick stone soling using 40 mm nominal size rammed, consolidated and grouted with fine sand.

An area of 5 m width all round the reclaim hopper, around water tanks near pump house, transfer houses and crusher house shall be paved. This paving will be in addition to plinth protection. The paving construction shall be as per specifications for the grade slab at ground level. However, 50 mm thick metallic hardener finish is not required to be provided in paved area.

Plinth level of all buildings shall be kept above the finished grade / formation level as per CEA guide lines.

14.16 FENCING

Refer relevant clause No. 6.14 of chapter 6.

14.17 LOADING

For consideration of loads on structures IS : 875 - 'Code of practice for structural safety of buildings' shall be followed. In addition to the dead load, live load, equipment load (including impact / vibration). Temperature loads etc. various loading conditions arising due to operation and maintenance of equipment shall be considered in the design. The structure and equipment shall also be designed for seismic loads as per the "Criteria for Earthquake
Resistant Design of Structures and equipment" and the "Criteria for Wind Resistant Design of Structures and equipment". whichever is governing. Wind and seismic forces shall not be considered to act simultaneously. The following minimum live loads shall be adopted for the design of various structures. If actual expected load is more than the specified load, then actual load is to be considered.

Roofs	150 Kgs./m^2 for accessible roofs and 75 Kgs./m^2 for non - accessible roofs. In addition to this coal dust load(Dead load) of 150 Kgs. /m^2 on flat roofs & 75Kgs./ m^2 on inclined roofs shall also be considered.
R. C. C. floors	500 Kgs. / m^2
Stair and balconies	500 Kgs. / m^2
Toilet rooms	200 Kgs. / m^2
Chequered plate floors	400 Kgs. / m^2
Walkways (including walkways in conveyor/cable galleries)	300 Kgs. / m^2
Conveyor galleries	In addition to the live loads, loads due to cable trays, fire fighting / service water pipes shall also be considered @ 125 Kgs. / m (minimum) on each of the longitudinal girder. Roof-truss members are to be checked for supporting fire fighting pipes/ Service water pipes. Tentative locations and diameter for pipes are shown in Tender Drawing.
Road Culverts and its allied A structures including R. C. C. pipe crossing of trenches.	For class 'AA' loading and checked for class loading as per IRC standard.

Channels / trenches	In addition to earth pressure and water pressure, etc. additional earth pressure due to surcharge of 2T / m^2 shall also be considered for design.
Covers for trenches / channels	Covers for channels & trenches, shall be designed for a live load of 0.4T m^2 and loading as mentioned under clause in trenches, whichever is critical.
Sumps and tanks and other underground basement type structures	In addition to earth pressure with a surcharge of 2T / m^2 (or surcharge due to Railway loading whichever is critical for Railway load bearing structures etc.) and sub - soil water pressure etc. These are also to be designed for the following conditions : i) Water / liquid inside and no earth outside (applicable only to such structures which are liable to be filled up with water or any liquid). ii) Earth with surcharge outside and no water / liquid inside iii) For underground (basement) structures protection against buoyancy during execution and after execution shall be ensured without superimposed loadings with minimum factor of safety of 1.2 against buoyancy.

Unit weight of coal shall be taken as 1200 Kgs. / cum. for design purposes.

If the erection load is higher than the specified live loads on any floor or part thereof, then the erection loads are to be considered for the design.

Permissible increase in stresses of materials and bearing pressure of soil due to wind load or seismic load shall be as per relevant I. R. S. and I. S. code.

14.18 DESIGN CRITERIA

The loads for all railway load bearing structures and the analysis and the design of these structures (if any) shall be made strictly in accordance with the provisions of Indian Railway Bridge rules (latest edition), and Indian Railway Codes of practice (latest edition) with all amendments up to the date of opening of bids. The axle load for analysis and design shall be considered as "DFC loading (32.5t axle load)" of Heavy mineral loading as per Indian railway standard. The analysis, design and detailed drawing for tunnel, under ground transfer houses, culverts etc. coming directly below the railway track shall be got approved by the contractor from the concerned railway authorities before taking up construction. All necessary payment for the above work shall be made by the bidder to the railway authority.

The design of all R. C. C. structures shall be carried out as per 'code of practice for plain and reinforced concrete for general building construction', IS: 456 (latest).

The steel structures shall be designed and fabricated as per 'code of practice for use of structural steel in general building construction', IS : 800 and other relevant IS Standards. Minimum size of the angle section to be used as structural members shall be 50 X 50 X 6. Minimum weld size shall be 6 mm. The steel structures using tubular sections shall be designed and fabricated as per IS:806-"code of practice for use of steel tubes in general building construction." And EN 1993-1-8:2005. Minimum grade of steel & thickness of Tubular/Hollow sections shall be Yst 240 Mpa & 4.0mm respectively.

The building shall conform to local bye - laws, rules and regulations for industrial buildings and also B. I. S. publications, SP 32 and 41.

Slotted holes shall not be assumed to act as expansion joint for relieving of stresses and suitable bearings shall be provided at the supports.
All gallery supporting trestles shall be so proportioned that the transverse deflection of gallery due to wind / seismic load should not exceed trestle height / 1000 as stipulated in IS: 11592. This deflection condition shall be strictly followed. Peak wind speed method shall be considered for checking the transverse deflection.

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

Stresses for all CHP structures shall be checked for the higher of the forces obtained from gust factor method and the peak wind speed method.

The permissible vertical deflection for beams supporting drive machinery shall be restricted to span / 500 and for other beams it shall be within span / 325.

Horizontal bracing system shall be provided at floor levels around the openings.

Shear force in steel columns shall be transferred to the pedestals / foundations exclusively through the shear key arrangement.

Base plate for trestles shall be designed as gusseted base with shear lugs to transfer horizontal forces. Anchor bolts shall be designed for uplift forces only.

For design of liquid retaining structures, IS : 3370 (Part - I to IV) (latest) shall be followed. Face of the structure in contact with liquid shall be designed as un - cracked section. For design of R. C. C. pipes for culverts, latest editions of IS: 458, IS: 783 should be followed.

<u>For all other under ground structructers not in contact with liquid on inside face may be designed as cracked sections with crack width limited to 0.1mm for both faces.</u>

For design of all underground structures / foundations, ground water table shall be assumed at the formation level (i. e. the adjoining ground level).

Design of Hopper walls shall be done for both Static & Dynamic flow condition using Walker's theory.

Design of masonry walls shall be made as per IS : 1905.

Civil task drawing indicating various equipment loading and supporting arrangement and floor loads to be submitted along with the design calculation.

For metal roofing and side cladding, the spacing of purlins/runners shall be such that the deflection of metal sheet used is limited to span/250 under adverse loading condition.

Minimum reinforcement shall be provided at the top face of the footing, even if, no reinforcements are required as per design.

14.19 **SHOTCRETING**

14.19.1 **General Requirements**

Generally, shotcreting shall be done in accordance with IS : 9012.

Reinforcement for shotcreting shall be as detailed below, unless specified otherwise.

Reinforcement in one direction consisting of 6 mm M. S. bars at 750 mm c / c shall be connected to the lugs for fastening of the wire fabric. This shall be used in case of 50 mm or above thick shotcreting.
Wire fabric conforming to IS : 1566 shall be used as reinforcement and shall consist of wire, 3 mm diameter, spaced 50 mm both ways and shall be electrically cross welded. Wire fabric shall be securely tied to 6 mm bars for 50 mm thickness. Adjacent sheet of wire fabric shall be lapped at least 100 mm and tied.

Clear cover to reinforcement mesh shall not be less than 15 mm.
Minimum thickness of shotcreting shall be 50 mm. for abrasion resistant work and 25 mm for ordinary surface protection work.

14.19.2 **Material**

Generally, the materials shall be in accordance with aggregates specification given hereunder.

Fine aggregate shall consist of natural sand or crushed stone from a known source and shall be strong, hard, coarse, sharp, chemically inert, clean and free from any coating. It shall be free from clay, coal or coal residue, organic or any other impurities that may impair the strength or durability of the concrete and shall conform to IS : 383.

Fine aggregate (Sand) shall be well graded and particles shall range in size within the
following limits. The Engineer, may approved the use of any other grading as per requirement or as per IS : 9012.

The fineness modulus shall be preferably between 2.5 and 3.3. Any other value can be used, with prior approval of the Engineer.

14.19.3 Application

After the placement of reinforcement and / or welded mesh and not more than six hours prior to the application of shotcrete, the surface shall be thoroughly cleaned of all loose materials and dirt. The Contractor shall properly prepare the surfaces, reinforcement and / or welded mesh to receive the shotcrete. Cleaned surfaces shall be wetted not more than hour prior to shotcreting.

The mix as placed on surface shall be one part cement to three parts approved sand by mass. Cement and sand shall be dry mixed; no water shall be added after mixing and before using in the gun. The quantity of water when added shall be only that which is sufficient to hydrate the cement. For average atmospheric conditions, the water cement ratio for shotcrete in place shall be between 0.35 and 0.5 by mass. Suitable admixture shall be used wherever required.

A uniform pressure of not less than 3 Kg/cm2 at the nozzle shall be maintained. Necessary adjustments shall be made to ensure this pressure, taking into account the length of hose and height of the place to be shotcreted, above location of the machine.

The application shall proceed in an upward direction. Beams, stiffeners and intermediate walls, if any, shall be wrapped with wire fabric and completely covered with shotcreting. All rebound shall be removed from the area of application as the work progresses and such rebound material shall not be reused.

As soon as the freshly shotcreted surface shows the first dry patches, a fine spray of water shall be applied to keep too moist. After the surface has hardened, it shall be kept continuously moist for minimum seven days. If there is extreme heat, especially when accompanied by hot winds, the shotcreted surface, immediately upon completion, shall be covered with burlap or similar covering, which must be kept continuously moist for 14 days after shotcreting. The temperature of the lining shall not be permitted to exceed 38^{o}C during placing and curing.

14.20 VIBRATION ISOLATION SYSTEM

These specifications are meant for the design, supply and erection of vibration isolation system for supporting coal crushers (ring granulators).

14.20.1 Supporting Arrangement

The crushers shall be supported on vibration isolation system consisting of steel helical springs and viscous dampers. The supporting arrangement for each crusher shall consist of an R. C. C. deck supported on steel helical spring units and viscous damper units which in turn shall be supported on girders. The girders shall be an integral part of the crusher house building.

The part of the structure consisting of the R. C. C. deck, springs and viscous dampers shall hitherto be referred to as "spring supported foundation". The part of the structure, which is below the spring shall hitherto be called "supporting structure".

14.20.2 The Contractor should do the Engineering / design, supply and erection of vibration isolation system consisting of steel helical spring units and viscous dampers supporting the top deck which in turn would support the coal crushers. The vibrations isolation system supplied shall be of a proven make. The Contractor or his sub - contractor who designs and supplies the system should have designed, supplied and installed such systems for not less than five machines of speeds and unbalance forces comparable to the machine proposed by the vendor. The vibration isolation systems installed by the contractor or his sub - contractor in such machines should have been working satisfactorily for atleast five years.

14.20.3 **Engineering**

Design of the vibration isolation system using steel helical springs and viscous dampers to support an R. C. C. top deck supporting the coal crusher. This includes the static and dynamic analysis of the vibration isolation system with the R. C. C. top deck and the coal crusher.

Structural design of the R. C. C. top deck including preparation of General Arrangement drawings, detailed reinforcement drawings, bar - bending schedules etc.

Calculation of loads on the structure supporting the springs and viscous dampers, their points of application and the stiffness requirements of the supporting structure.

Drawings showing embedments and their locations and details on the R. C. C. top deck.

Drawings showing blockouts, recesses etc. on the top deck.

Design of the supporting structure, including preparation of detailed drawings and bill of materials.

14.20.4 **Supply including packing and transportation to site**

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

Frame (s) for pre-stressing of spring elements.

Suitable hydraulic jacks system including electric pumps, high pressure tubes etc. required or the installation, alignment etc. of the spring units, two extra hydraulic jacks, one hand operated pump and spares for the hydraulic jack system as required.

14.20.5 **Erection and Commissioning**

Complete erection and commissioning of the vibration isolation system including:

Pre-stressing of spring elements, placing of spring elements in position, checking clearances on the shuttering of the R. C. C. top deck, construction of the supporting structure and the R.C. C. top deck, releasing to pre-stress in spring elements and making final adjustments and alignments after machine installation etc.

The Scope of work shall be deemed to include all activities which may not have been explicitly mentioned but are reasonably implies for the successful completion of the work for which these specifications are intended.

This part of the specifications is for vibration isolation system.For the construction of the supporting structure for the crusher and the top deck, the relevant parts of the specifications should be referred to.

14.20.6 **Documentation**

Submission of detailed design calculation, analysis (Static and dynamic) and drawings for Employer's acceptance and approval.

Furnishing methodology of providing shuttering and its removal as well as concreting of deck slab, installation of springs and the sequence of operation.

Furnishing installation and maintenance manual indicating equipment, procedure etc., necessary for installation, maintenance of vibration isolation system.

Furnishing a check list for confirming the readiness of the civil fronts for the installation of vibration isolation system and equipment required at each stage installation.

Bill of materials of various elements such as springs, visco-dampers, with their rating, stiffness etc., included in supply.

Detailed specifications of the vibration isolation system and various items included in the supply and the standard (local or international) to which they conform.

Proposed erection strategy of the entire system.

14.20.7 **Design Requirements for Crusher (Ring Granulator) Foundation**

Dynamic Analysis

Detailed dynamic analysis shall be done for the top deck together with springs and dampers and the natural frequencies and amplitudes of vibration shall be determined. A mathematical model of the top deck shall be formulated with three – dimensional beam / plate finite elements for the purpose of analysis with spring idealized with vertical and horizontal stiffness's. The mass of the machine together with that of the top deck shall be considered for the analysis.

Natural frequencies upto at least 10% above the operating speed shall be determined and these frequencies shall be checked against the design criteria.

Forced response dynamic analysis shall be carried out for the operating condition unbalance forces using a sinusoidal forcing function. Unbalance forces as given by this specifications shall be used for his purpose. The amplitudes shall be checked against the design criteria. The dynamic forces from this analysis shall be used for structural design with a suitable fatigue factor.

Isolation Efficiency

The vibration isolation system shall be designed for about 90% isolation efficiency.

De-coupling

A ratio of the least 10 (ten) shall be ensured between the stiffness of the supporting structure and the stiffness of the spring system in the vertical direction to achieve de-coupling between the two (the stiffness to the spring system being lower). This ensures that dynamic analysis of the supporting structure need not be carried out.

Frequency Criteria

The frequency criterion has already been laid down implicitly by the isolation efficiency criteria and de-coupling required.

The first bending mode frequency of the top deck shall be at least 20% above the operation speed.

Unbalance Forces

Unbalance forces arising out of all the following cases shall be considered for checking the design and amplitudes.

Balance quality grade Q40 as per VDI 2060-1966.

One hammer broken condition. The missing hammer shall be assumed to be closest to the crusher non – drive end of the crusher.

Three hammers broken condition. All the three hammers broken shall be assumed to be the same suspension bar and located at the non – drive end of the crusher.

The calculated amplitudes (mean to peak values) shall not exceed following limits under the specified conditions.

1) Operating Speed of 750 RPM

    150 microns for an unbalance force arising out of balance quality grade Q 40 as per VDI 2060 - 1966.

    300 microns in case of one hammer broken condition.

    Amplitudes need not be checked for a three hammer broken condition.

2) Operation Speed of 450 RPM

    200 microns for an imbalance force arising out of balance quality grade Q40 as per VDI-2060-1966.

    400 microns in case of a one hammers broken condition.

Amplitude need not be checked for a three hammer broken condition.

For intermediate operation speed between 450 to 750 RPM the amplitude can be linearly interpolated.

The amplitude limits mentioned above are in both vertical and horizontal directions. The amplitudes shall be calculated at critical pins on the top surface of the RCC deck. The amplitudes shall be checked for the most unfavorable super position of modes in any direction. However, phase difference between the maximum amplitude occurring in different directions due to the rotating vetor may be considered while superimposing the modes.

Transient Resonance

Transient resonance, which may occur during the start - up or coasting down condition of the crusher, shall be checked, and the amplitudes in such a condition should not exceed one - and - half times those at operating speed for each design condition.

Strength Criteria

The following criteria shall apply for the design of top deck :

a) Dead loads, live loads, Seismic loads and dynamic loads shall be considered for the design. The most unfavorable combination shall considered for design.

b) Seismic loads shall be assumed to act together with dynamic loads for a one millimeter eccentricity in the rotor. However, seismic loads and dynamic loads arising out of hammer breakage need not be considered together

c) Fatigue shall be considered while designing for dynamic forces. A fatigue factor of 2.0 shall be used on all dynamic forces to arrive at the equivalent static force for the purpose of design.

d) Working stress method shall be used for the design of R. C. C. deck. In survival condition, 10 % overstressing may be permitted.

e) The R. C. C. top deck shall be at least of M25 grade of concrete as per IS : 456 - 1978.

f) Fatigue need not be considered for the three hammer broken condition.

g) For calculating unbalance forces, the heaviest hammer (plain or toothed) shall be considered.

CHAPTER – 15

ASH HANDLING SYSTEM

15.1 SPECIFICATION FOR CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS SHALL BE REFERRED

Ash handling system shall comprise of bottom ash, coarse ash, fly ash handling systems, ash slurry pump house and ash compressor house, ash water pump house, ash pipe supports including culverts, coarse ash tank, ash water sump bridges etc. upto the existing Ash Dyke.

Works shall include bottom ash hopper supports, bottom ash pipe supports, ash slurry pipe supports from ash slurry pump house, dry fly ash & bottom ash pipe supports, supporting structure for buffer hopper, buffer hoppers, fly ash silos, development of silo area (including paving, fencing, access roads), pump and equipment foundations, ash compressor house, MCC room, RCC thrust blocks, vaccum pump house and other buildings, supporting structure facilities required to complete the system.

Structural arrangement, pile foundation system, if required, cladding interior and exterior finishes, area paving etc., shall be as per total plant building design and finish schedule furnished elsewhere in the specification.

Pipelines shall be supported on steel structures supported on RCC pedestals and foundations, if required. The top level of the pipe pedestals shall be 300mm above the formation level. Pipes shall be suitable anchored with RCC pedestals to resist lateral and vertical movements. For crossing of the pipe lines and maintenance road with nallahs, canals etc. and / or for road / rail crossings, pipes shall be laid through RCC box culverts / bridges. Road leading to silos shall have minimum width of 8.0m with both sides berms 1m and drains.

The compressors and their associated equipments shall be housed in RCC building along with requisite MCC room. Crane / monorail of adequate capacity shall also be provided in all pump / compressor house.

15.2 Following facilities shall be provided near the silo as per Vol. III of specification.

i) Ash slurry sump with pump house.

ii) Ash water sump with pump house.

iii) Vaccum Pump house.

iv) Complete Ash Water recirculation systems.

v) Ash conveying Blower room.

vi) MCC Room / Control room.

vii) Pipe Rack / trenches etc. in the plant area.

viii) RCC paving in Silo area

ix) Silo utility building including Blower room

x) Dry ash storage silo shall be located in existing silo area.

xi) The following densities shall be considered for design of silos:

(a) For volume calculation of bottom ash silo	:	850 kg/cum
(b) For volume calculation of fly ash silo	:	750 kg/cum
(c) For load calculation of both types of silos	:	1600 kg/cum

xii) The concrete 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 concrete wall. Temperature of ash shall be taken as 150ºC.

15.3 ASH PIPE SUPPORTING STRUCTURE

Ash pipe from plant area to Ash Dyke will be supported on existing pedestal. Modification and strengthening of existing pedestals (wherever required) is in the scope of Bidder. If required, new pedestal to support ash pipe will also be constructed by the Bidder.

Suitable arrangement including constructions of bridges/ culverts to cross the existing roads / drains in entire route of ash pipe is also in the scope of Bidder. Modification / strengthening of existing culverts in ash pipe route will be done by Bidder. Bidder has to perform all the activities complete in all respects including labour, material or any other requirements to the satisfaction of Engineer.

CHAPTER – 16

RAW WATER PRE-TREATMENT AND DM PLANT SYSTEM

16.1 Raw water pre-treatment for CW and DM plant generally consist of the following facilities/buildings. However, the bidder may add/delete/club facilities as per approved system:

- Chlorination buildings
- Aerator
- Stilling chamber and inlet channels and measuring flumes
- Clarifiers
- Chemical house
- Sludge pit

  Rapid gravity filters
- Filtered water reservoir and pump house
- Raw water pump house
- DM Plant
- Sludge thickener
- CPU regeneration area

16.2 The stilling chamber and aerator shall be of RCC structure. The chambers and water channels shall be watertight structures.

16.3 The clarifier shall be of RCC construction. The watertight circular RCC structures shall have continuous platform with handrail along periphery at the top. At least 3 nos. ladder shall be provided at the outside and vertical rungs shall be provided inside for maintenance.

16.4 The sludge sump shall be an underground RCC pit, part of the pit shall be cover with RCC slab for supporting the vertical sludge pumps. The sludge pumps shall be housed in a pump house with RCC roof supported on RCC columns and beams. There will be hoist and monorail of required capacity for handling of pumps. Capacity of sludge sump is indicated in Vol. III & Composite Water Scheme.

16.5 Rapid gravity filters shall be installed at inlet of filter water reservoir.

16.6 Filter water reservoir shall be of water tight RCC construction covered with RCC roof. Vent pipes shall be provided at roof. Filter water reservoir including RCC roof shall be designed as uncracked structure as per IS:3370. The filter water pump house structure shall be of RCC framed construction with RCC flat roof. Side cladding shall be of brick masonry. Monorail or gantry shall be provided for handling pumps. The building shall be complete with doors, windows and rolling shutter. Floor and other finishes shall comply with architectural specification. Capacity of the Filter water reservoir is indicated in Vol. III & Composite Water Scheme.

16.7 Pretreatment chemical house shall be a two storied concrete RCC framed building. Clear height of 5.5m (minimum) shall be provided in each floor. The building shall be complete with brick work, plastering, doors, windows, rolling shutters, flooring, plaster, painting, roofing etc. and all other items necessary for satisfactory performance of the building. The building shall have toilets and the scope shall include supply and fixing W.C.'s urinals, showers and all plumbing sanitary and other work required for satisfactory completion of the above building. The tanks and parts of floor slabs shall be lined with acid / alkali proof tile lining. Monorails of adequate capacities shall be provided as per functional requirements. The building shall be provided with adequate toilet facilities.

16.8 Near the chemical house there will be a single storeyed RCC framed building housing the chlorination plant. Hoists with monorail shall be provided for normal plant operation and for handling of equipment during erection / maintenance. The building shall be complete with brick work, plastering, doors, windows, rolling shutters, flooring and painting, roofing etc. and all other items necessary for safety and satisfactory performance of the building. Brick masonry wall with suitable windows and doors will be provided in accordance with architectural specification.

16.9 The DM plant building will be RCC framed building having brickwork cladding on all four sides. Ground floor shall house MCC and control room. Control Room which shall have false ceiling and shall be air-conditioned. Central chemical laboratory and office rooms etc. shall be at first floor level, which will also have false ceiling and air condition provision. Equipment foundations & trenches in ground floor slab shall be of reinforced cement concrete. Ground floor shall have ironite flooring except at locations, which may come in contact with acid/ alkali where acid / alkali resistant tile lining with epoxy mortar shall be provided. Effluent drain trenches shall also have acid proof lining at inside surfaces of drain as well as soffit of pre-cast removable covers. The building shall be provided with adequate toilet facilities.

16.10 Floor where acid / alkali spillage are expected shall be isolated with RCC kerb. Neutralizing pit shall be of watertight RCC construction. Internal surfaces shall be lined with acid / alkali proof lining with matching epoxy mortar. Neutralization pit shall be designed as uncracked section. Ceiling as well as floor, supporting pumps shall be given epoxy lining.

16.11 Acid /alkali/hypochlorite storage tanks shall be resting on RCC saddles on elevated RCC platform. The platform shall be supported on RCC beams, columns with RCC foundations. The saddles along with platforms shall be lined with acid/alkali proof tiles.

16.12 Acid / alkali storage and handling area shall also be lined with acid / alkali resistant tiles.

16.13 The DM storage tanks shall rest on thoroughly compacted fill of gravel, coarse sand or other stable material topped with minimum 75 mm thick compacted crushed stone, screenings, fine gravel, clean sand or similar material mixed in hot asphalt (8 to 10 percent by volume) and rolled or compacted. This filling shall be confined within a RCC ring wall with foundation. The tank shall have complete bearing with the foundation fill. All backfilling within tank foundation shall be done by compacted sand. Degasser shall be supported on RCC framed structure. Minimum 2.5m wide RCC pavements shall be provided around each outdoor equipment.

CHAPTER – 17

ARCHITECTURE

17.1 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 & 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 and materials may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

d) Overall colour scheme and finish schedule of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into an account the mass and void of buildings, its façade, 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 coordination with other agencies can be taken up at appropriate time.

17.2 ARCHITECTURAL DESIGN

i) Natural light shall be used to the maximum extent especially in the form of north light / sky light. For adequate light & ventilation, National Building code recommendations shall be followed.

ii) Entrance canopies, chajja (projections, recesses) over openable windows and door openings on exterior facades shall be provided.

iii) All the buildings shall be architecturally designed to meet the National Building Code (SP: 7) norms and local building bye laws, wherever applicable.

iv) Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect. Statutory requirements 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 same/similar kind of works. The consultant shall evolve the design philosophy based on Employer's guidelines and shall present it in the form of presentation drawings, Prospective views, 3-D Models & detail drawings.

v) Minimum 1000mm high (from floor / roof level) hand railing shall be provided around all floor / roof openings, projections / balconies, walkways, platforms, steel stairs, etc., All handrails and ladder pipes (except at operating floors) shall be 50mm nominal bore MS pipes (medium class) conforming to IS: 1161 and shall be galvanized as per IS: 4736 treated with primer and finished with suitable paint. All rungs and ladders shall also be galvanized. Minimum weight of galvanizing shall be 610 g/sqm.

All stairs and around all floor openings at operating floors, 1000mm high hand railing with 32 NB (polished) stainless steel pipe shall be provided.

vi) All stairs shall have a maximum riser height of 180mm and a minimum tread width of 250mm. Minimum clear width of stair shall be 1200mm unless specified otherwise.

vii) All buildings having metal cladding shall be provided with a 150mm high RCC toe curb at the edge of the floor along the metal cladding. 900mm high hand railing shall be provided on this RCC curb, wherever required from the safety point of view.

viii) In all buildings, structures, suitable arrangement for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting, etc., shall be provided for each floor. All the drains shall be suitably covered with grating or pre-cast RCC panels.

ix) RCC staircase shall be provided for all RCC construction buildings and structural steel staircase for all structural steel buildings.

x) Parapet, Chajja over window and door heads, architectural facias, projections, etc., shall be provided with drip course in cement sand mortar 1:3.

xi) All fire exits shall be painted with P.O red/signal red colour shade which shall not be used anywhere except to indicate emergency or safety measure. Fire safety norms shall be followed as per National Building Codes and fire safety requirements for providing fire exits, escape stairs and firefighting equipment. In detailing of all buildings, fire safety requirements conforming to IS: 1641 and IS: 1642 shall be followed.

17.3 **INTERIOR DESIGN**

A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving power plant technology, and architectural and civil engineering for a smooth control hierarchy and man machine inter face. All the design aspects such as flooring, false ceiling, furniture, colour scheme, equipment design and layout, illumination, fire fighting, acoustics and ergonomics requirements shall be detailed out so as to present an overall unified aesthetic spatial appearance. The areas to be undertaken for this interior design process shall be control room complex including common control room, computer room, conference rooms and office areas in the main plant building and the following aspects shall be reviewed and evaluated for design. Furniture to be supplied by Bidder for the control room complex shall be as specified under C&I specification.

a) Layout, keeping in view the man-machine interface and suitable ergonomic practices.

b) Integration of civil engineering with architecture and interior design.

c) Illumination levels, noise levels, electromagnetic interference levels, taking into account the equipment and furniture.

d) Comfort and safety requirements such as air conditioning, fire fighting, fire escapes etc.

e) Microprocessors based control system to control the functional requirements.

The above design philosophy put into practice shall be detailed out through presentation drawings, perspective views, scale models, detail drawing etc.

17.4 **ROOF DRAINAGE AND WATER PROOFING**

a) Roof drainage system shall be provided for quick and efficient draining of rainwater from roof to avoid seepage and damage to roof. The runoff gradient for the roof shall not be less than 1 in 100. Roof drainage system shall consist of roof drain heads, rain water down corners and fixtures. System shall be designed to handle design rainfall for the specific site and shall be in accordance to stipulations of IS: 1742 and IS: 2527. The down comer pipes shall be suitably concealed with masonry work, cement concrete or sheeting to match with the exterior finish.

b) Multiple drains (minimum 2) shall be provided for all roof areas. Any roof more than 8 m above grade shall have access from within the building for cleaning of roof drains.

c) Rain water down comers shall be of M.S pipe conforming to IS: 1239.

d) All roofs shall be provided with water proofing treatment using high solid content liquid applied elastomeric water proofing membrane with separate wearing course as per ASTM C-898. Thickness of the membrane shall be a minimum of 1.5mm. The treatment includes application of polymerized mortar over sloped roof to achieve a smooth surface and a primer coat. Wearing course shall be 40mm screed of 1:2:4 concrete as above cast in panels of 1.2m x 1.2m and reinforced with 0.56mm dia galvanised chicken wire mesh and joints sealed using sealing compound. Chequred tiles of 25mm thickness over 15 thick cement mortar (1:3) bed shall be provided over water proofed area to a width of 1000 mm where movement of personnel is anticipated to approach roof extractor, AC/Ventilation equipment.

17.5 MASTER KEY SYSTEM

An appropriate serviceable and functional master key system for the whole plant shall be installed. The elaboration of the system itself shall be made in close co-ordination with the Purchaser / Consultant and only after obtaining the Purchaser's / Consultant's approval in writing shall the order of production be placed.

The following requirements shall be met:

- The general master key shall operate all locks
- The main key shall open all locks of one building
- The single key shall open the lock of a single room.

Necessary attention shall be paid to later extensions of the master key system, which shall be suitable for the entire plant including all final stages.

The keys shall be made of material approved by the Purchaser / Consultant and shall have an engraved indication of the applicable key system and the building or door number.

Keys shall be supplied in the following numbers:

General Master Key	10	nos
Main keys	10	nos. per each building
Single keys	3	nos. per each door

17.6 LAND SCAPING

17.6.1 General

This specification covers broadly the requirements for Landscaping within the Plant Area. Landscaping shall be carried out after all the underground utilities and drainage systems are in place. The entire work of Landscaping shall be carried out to the satisfaction of the Engineer / Consultant and in a manner to have a beautiful appearance after completion of the work.

The Landscaping plan should be prepared by the Contractor with the help of an expert Horticulturist with due considerations for Fauna & Flora grown in the adjacent area and which can sustain in the area climate.
The area to be landscaped shall be clearly demarcated at site and got approved by the Engineer and the work shall be divided into following sub-items.

17.6.2 Preparing Lawn

For this purpose, within the area where lawn is to be grown, about 0.3 metres of earth shall be removed. This shall be replaced by fresh garden soil and manure in 2:1 proportions spread evenly. Fresh garden soil & manure shall be mixed thoroughly, well watered and left overnight. The next morning, the variety of lawn, as per approved plan and as directed by the Engineer, shall be planted. This grass shall be maintained till well established by watering, weeding, clipping, rolling etc.

17.6.3 **Preparing Clipped Hedges**

Hedges made of Casuarinas or other shrubs as directed by the Engineer shall form borders between footpath and the Lawns. The shrubs shall be planted at spacing not more than 25 cms.

17.6.4 **Planting Shrubs**

Shrubs with coloured leaves like Crotons, Acalyphia, Oleander and Bougainvillea, Hibiscus etc. which are perennial shall be planted in clusters or over a large area at locations and in the manner as per approved layout. These shrubs shall be planted at spacing of not more than 25 cms.

17.6.4.1 **Planting Trees**

Trees of different category and height shall be planted as per prior approval from Owner.
In addition to above, Bidder has to develop Green belt by planting around 80,000 of trees in approximate 32 hectares of land ,location as approved by Engineer in charge. Green belt area as mentioned above is approximate. Actual area to be decided as/MoEF&CC guidelines.

17.6.5 **Installation of Watering System**

Contractor shall prepare and submit watering System for the Plants. Drip Irrigation and Spray System consisting of complete PVC pipe with all necessary bends, Tees, Elbows etc., valves, stop cocks, Spray nozzles, sufficient lengths of Flexible PVC pipes to reach all area of Landscaping shall be included in the watering system. Only after approval of the Engineer, the Contractor shall commence the work.

17.7 **ARCHITECTURAL FINISHES**

17.7.1 **Plastering**

a.) The plastering work including the application of cement punning (Neru) or plaster of Paris treatment on brick or concrete faces with architectural features shall be executed as per in accordance with the following latest IS codes: POP shall be used only on inside surfaces of ceiling and walls for aesthetic and architectural requirement.

IS:1542	: Sand for plastering
IS:1661	: Code of practice for application of cement and cement lime plaster finishes.
IS:2333	: Plaster of Paris
IS:2402	: Code of practice for external rendered finishes
IS:2394	: Code of practice for application of lime plaster finishes.

b.) Mortar for plastering shall be mixed in the proportion in a dry state and then wetted and mixed thoroughly to obtain the required consistency. The mortar shall be mixed in an approved manner including machine mixing in batches for its consumption within half an hour of mixing. Any mortar for partially set plaster shall be rejected and removed from site. The mix for plastering shall be as follows:

i) Outside plaster on masonary wall: Plastering is required on outside of masonary wall.

ii) Inside plaster on masonary wall: 12 mm thick (1 cement : 3 sand)
iii) Concrete ceiling: Plaster : 6 mm thick (1 cement : 3 sand)

c.) Before application of plaster, the surface shall be prepared as per IS:1661. In all plaster work, mortar shall be applied in an uniform layer slightly more than the required thickness and well pressed into the joint and in the surface and rubbed & levelled with a flat wooden rule to give required thickness.

Plaster, when more than 15 mm thick, shall be applied in two coats, base coat followed by the finishing coat. Thickness of base coat shall be just sufficient to fillup all unevenness in the surface; no single coat, however, shall exceed 12 mm in thickness. The under-coat shall be thicker than the upper coat. The overall thickness of the plaster shall not be less than the minimum thickness shown on the drawings.

The undercoat shall be allowed to dry and shrink before applying the second coat of plaster.

The undercoat shall be scratched or roughened before it is fully hardened to form a mechanical key. The method of application shall be" thrown on" rather than "applied by trowel". The finished surface shall be true to line & plumb; and the contractor shall make up any irregularity in the masonry/concrete work with plaster. The mortar shall adhere to the surface intimately when set; and there should be no hollow sound when struck.

All vertical edges of pillars, door jambs etc. shall be chamfered or rounded off. All corners must be finished to their true angles or rounded. Any plastering damaged shall be repaired and left in good condition at the completion of the job.

d.) All plastered surfaces after laying and sufficiently hardened shall be cured for a minimum period of seven days and shall be protected from excessive heat and sunlight by suitable approved means.

e.) Plaster of Paris Finish: The plaster of Paris shall be calcium sulphate hemi-hydrate variety. Its initial setting shall be less than 13 minutes. The material shall be mixed with water to workable consistency. Plaster of Paris shall be applied to the surface in the uniform layer slightly more than 2 mm thick and shall be finished to an even and smooth surface with a steel trowel. Thickness of finish shall not be less than 2 mm. All corners, arises, angle and junctions shall be carefully and neatly finished.

17.7.2 **Wall Cladding**

Permanent colour coated sandwiched insulated metal cladding system

a.) Permanent colour coated sandwiched (insulated) M.S. / High tensile steel metal cladding of approved colour combination shall be provided for main plant building and all buildings having structural steel framework and any other building with metal cladding where thermal insulation is required as per thermal requirements.

b.) Troughed galvanized M.S. sheet having 0.6 mm minimum thickness with minimum rate of galvanization of 275 gm./sq.m. or high tensile steel sheet having minimum yield strength of 350 MPa of 0.5 mm minimum thickness and coated with zinc aluminium alloy (zincalume) at the rate of 150 gms./sq.m shall be used on external face (outer face) of cladding system. The outer side (exposed face) of the sheet shall be permanently colour coated with silicon modified polyster coating of Dry Film Thickness (DFT) 20 microns (minimum) over primer. Inner face of the sheet shall be provided with suitable pre-coating of minimum 7 microns.

c.) Galvanised M.S sheets of minimum 0.6 mm thickness withminimum rate of galvanization of 275 gms/sq.m or high tensile steel, having minimum yield strength of 350 MPa of 0.5 mm minimum thickness, coated with zinc aluminium alloy at the rate of 180 gm/sq.m shall be used as inner liner (internal face) of cladding system. The exposed face shall be permanently colour coated with silicon modified polyester paint of DFT 20 microns (minimum) over primer. Inner face of sheet shall be provided with suitable pre-coating of minimum 7 microns.

d.) The permanent colour coated sheet shall meet the general requirements of IS:14246 and shall conform to class 3 for the durability.

e.) The insulation shall be of bonded mineral wool of minimum thickness 50 mm conforming to IS:8183, having a density of 32 kg/cu.m for glass wool, 48 kg/cu.m for rock wool or 40-45 kg./cu.m for polyurethane foam (fire retardants and nontoxic) conforming to IS:12436

f.) The sheets shall be fixed by means of concealed fixing system or any other compatible method approved by the Engineer. The fasteners shall be of high quality corrosion resistant grade of self tapping / self drilling type provided with suitable cap.

g.) Inner sheet shall fixed directly to side runner and Z spacers made of at least 2 mm thick galvanized sheet of grade 375 as per IS:277. Inner sheet shall be fixed at the rate not more than 1.50m centre top centre to hold the insulation and external sheeting.

h.) All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same materials and coating specification as mentioned above for the outer face of the sandwiched by manufacturer.

17.7.3 **Permanent colour coated non-insulated metal cladding system**

a.) Permanent colour coated (non-insulated) M.S./High tensile steel metal cladding of approved colour combination shall be provided for boiler roof/canopy, TP's conveyor galleries, and cladding over parapet walls of buildings where metal cladding is specified.

b.) Troughed galvanized M.S sheets having 0.6 mm minimum thickness with minimum rate of galvanization of 275 gms/sqm (or High tensile steel sheet coated with zinc aluminium alloy @ 150 gms/sq.m. of 0.5 mm minimum thickness and having minimum yield strength of 350 MPa) shall be used for the cladding system. The outer side (exposed face) shall be permanently colour coated with silicon modified polyster paint of minimum DFT 20 microns over primer and the inner side (internal face) shall be coated with same paint of minimum DFT 20 microns over primer. These shall be fixed with concealed fixing system or any other compatible method approved by the Engineer. The sheets shall meet the general requirements of IS:14246 and shall conform to class 3 for the durability. For roof sheeting the specification remains same as that of side cladding except the thickness and galvanization. The minimum thickness of roof sheeting shall be 0.8mm with galvanization rate of 275 gm/sqm.

c.) All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same materials and coating specification as mentioned above for the outer face of the sandwiched by manufacturer.

17.7.4 **Roof Decking And Suspended Ceiling**

a.) The roof decking includes furnishing of cold rolled formed troughed profile sheets manufactured from tested quality CR rolls conforming to IS:513 including fixing. The profile sheet section shall be obtained from feeding strips of uniform coil thickness through successive pairs of shaped rollers, each pair of rollers progressively forming the sheet until finished section is obtained

In general the troughed profile shall have minimum depth of valley 44mm and center to center of valley about 130mm. The thickness of sheet shall be 0.8 mm (minimum). To suit the spacing of purlin, the length of sheet may vary between 1.50 to 2.00 m. The overall minimum width of sheet shall be 824.20mm and covering width as 780mm i.e. side overlap shall be 22.10 mm.

b.) Pre-Treatment & Phosphating: The pre-treatment process shall conform to medium class–B conforming to IS:3618. Next operation of rust removal shall be done by dipping in a tank containing highly diluted hydrochloric acid (HCL); and traces of HCL shall be removed by double rinsing in a water tank for about 5 minutes each. Subsequently sufficient conditioning shall be done by dipping in the next tank containing surface conditioner. Hot phosphating shall be accomplished in the next tank followed by water rinsing and finally passivated by heat process in the passivation tank. Thereafter traces of moisture shall be removed by hot compressed air before application of primer and final paint coating as required. In general the pre- treatment stages shall be as under:

Sl. No.	Stages	Chemicals	Processing Temp.	Processing Time
1.	Degreasing	Cleaner	55 to 75° C	3 to 10 minutes
2.	Water Rinsing	-	Room Temp	-

Sl. No.	Stages	Chemicals	Processing Temp.	Processing Time
3.	Derusting	Rust remover	R. Temp to 60^0C	1 to 10 Mts
4.	Water Rinsing	-	Room Temp	-
5.	Surface conditioning	Surface conditioner	Room Temp	15to 30 sec.
6.	Phosphating Solution	Phosphating	50 to 55° C	3 to 5 Minutes
7.	Water Rinsing	-	Room Temp	-
8.	Passivation Solution	Passivation	Room Temp.	15 to 30 sec
9.	Defonised water	-	Room Temp	-
10.	Drying			
	After pre-treatment, the sheet shall be painted with a coat of zinc chromate red oxide primer on both faces.			

17.7.5 **Flooring**

The nominal total thickness of floor finish shall be 50 mm including under bed and topping. The flooring shall be laid on already matured concrete base. The under bed for floors shall consist of cement concrete 1:2:4 with stone chips 12.5 mm down graded as coarse aggregates. The under bed shall be provided with appropriate slope towards catch pit for floor drainage.

a) **False Flooring System**

Removable type false flooring system shall be provided in computer rooms and control rooms as required. RCC floor slab shall be sunk to a depth 800 mm which shall be height of the false floor system. The flooring shall consist of fire resistant phenol formaldehyde bonded particle board panels 600x600x35mm size, mounted on steel pedestals of adjustable height and supporting steel grid system to provide under floor space. 2 mm thick flexible anti-static pvc topping on top and pvc strip edging on sides of each panel shall be provided.

b) **PVC Floor Finish**

Two mm thick PVC as per IS:3462 laid as per IS:5318 over concrete under bed of 48 mm .

c) **Carborandum Tiles**

Polished heavy duty cement concrete tiles (carborandum) of 300x300x22 mm thick manufactured as per IS:1237 using colouring pigment and hard chips like carborandum, quartz etc shall be laid as per IS:1443 over concrete under bed to result in overall thickness of 50 mm.

d) **Terrazzo Tiles**

Tiles shall generally be of size 250 x 250 x 20 mm laid over concrete bedding to result in an overall thickness of 50 mm.

e) **Granolithic flooring**

i. Granolithic flooring (cement concrete flooring in 1:1:2) with non metallic floor hardener topping 12 mm thick with a total thickness of 50 mm shall be provided in maintenance and unloading area of Station building, Mill and bunker bay, Workshop floors, operating floor of pump house, permanent stores and other plant building areas where heavy duty flooring is required.

ii. Granolithic flooring without floor hardener shall be provided in all MCC and switch gear rooms which are not air-conditioned.

iii. Granolithic flooring shall also be provided in areas which are not provided with any special finish. Areas which are likely to be subjected to oil spillage shall be provided with two coats of oil resistant painting over Granolithic flooring.

f) **Ceramic Tiles**

Heavy duty anti skid ceramic tiles with matt finish shall be used in toilets, pantry, dining hall of canteen, locker rooms etc. The tiles shall be 300 x 300 x 10 mm of approved colour / shade and brand. Dado in toilets and pantry, locker rooms etc shall also be of similar finish
Ceramic tiles shall be of first class quality, uniform size, even surface, sharp, parallel, non-crumbling edges, free from soluble salt, and other detrimental constituents; free from cracks and blisters, serrated edges, chipped corners and other imperfections or flaws affecting their quality, appearance and strength; rear and side surface capable of bonding effectively for placing, laying and jointing. All ceramic tiles shall be of approved make and bear the identification mark of the manufacturer on the lower face in either positive or negative embossment

g) **Acid / Alkali resisting Tiles**

Battery rooms, and other areas coming into contact with acid / alkali vapors or fumes shall be given acid / alkali resistant tiles 25 mm thick, jointed with acid / alkali resistant cement slurry. Bedding shall comprise of potassium silicate mortar conforming to IS:4832 (Part-I) and resin based mortar like epoxy for jointing. Total thickness of flooring shall be 50 mm. Ceramic unglazed vitreous tiles conforming to IS:4457 with minimum thickness of 20 mm may also be used as acid / alkali resistant tile. The above specification do not apply to D.M. Plant.

h) **Integral floor finish**

For cable vaults room, floors of wagon tripler shed, reclaim hopper shed, crusher house, junction towers, pent house shall be provided with floor finish integral to the concrete base shall be provided as per IS:2571.

i) **Cast-in-situ Terrazzo**

Cast in situ terrazzo flooring shall be laid as per IS:2114, using white cement or cement with colouring pigment. Chequered finish shall be provided for treads. Total thickness of the finish shall be 25 mm.

j) **Glazed vitrified tiles**

Polished vitrified tiles shall be of 600 mm x 600 mm x 10 mm in size and shall be approved shade , brand and colour and shall be laid with CM 1:3. These are proposed in the following areas:

Operating floor, Control room area including control room ,computer room, control equipment room, SWAS Room and Conference room, senior executive room – The floor shall has vitrified tiles of size 2 feet X 2 feet applicable for industrial use.

17.7.6 **Acid / Alkali resistant Tiling / Brick lining in D.M Plant**

a Bitumen primer followed by 12 mm thick bitumastic layer, 6 mm thick potassium silicate mortar bedding and 38 mm thick alkali / acid resistant bricks as per IS:4860 shall be provided for CPU regeneration area, Chemical house floor, effluent drains, floors around equipment & chemical handling vessels, chemical storage area for the floor, curbs andsumps, all as per the acid / alkali proofing specialist Contractor's requirement.

b For floor of neutralizing pit the finish shall be as follows. Bitumen primer followed by 18 mm thick bitumastic layer, 6 mm thick potassium silicate mortar bedding and 75 mm thick acid / alkali resistant brick as per IS:4860.

c For walls of neutralizing pit, the same specification as 1.10.2 shall apply except that thickness of the brickwork shall be 115 mm with suitable pilasters at 2000 mm c/c.

d Special instruction to be followed for acid resistant lining in neutralizing pit shall be as follows.

i) The structures shall be tested for water t ightness.

ii) Surface on which lining is to be applied shall be prepared as per IS:2395.

iii) Joints between acid resistant bricks / tiles shall be filled with resin type mortar conforming to IS:4832 (Part II). Seal coat of ready made epoxy paint shall be provided at the joints to cover up any porosity.

iv) Acid resistant bricks shall be laid with 6 mm wide and 20 mm deep pointing. Pointing shall be with epoxy / furnace / CNSL as per the requirement of the agency guaranteeing the performance of lining.

v) Under side of all precast slabs / steel covers over effluent drains shall be given two coats of epoxy coating, 150 microns thick.

vi) Acid / alkali resistant treatment shall extend at least 1 meter on all sides from the outermost periphery of pedestals / saddles for indoor installations and 2 meters all round for outdoor installations.

17.7.7 **Skirting / Dado**

a 150 mm skirting matching with floor finish shall be provided in all areas unless specified otherwise elsewhere.

b Toilets & locker rooms shall be provided with dado up to ceiling level .

c For main Control room and control equipment room minimum 5 mm thick decorative coloured ceramic tiles shall be provided upto false ceiling level.

d For battery room and other areas coming in contact with acid / alkali spillage/ fume, dado of acid / alkali resistant tiling as per IS:4457 shall be provided to a height of 2100 mm set in potassium silicate mortar and joints pointed with resin bonded mortar.

e Staircase wall shall be given dado of cast in situ terrazzo to a height of 2100mm. If Entrance lobby and lift area in Service building and Admin building shall be provided with granite tile dado to a height upto false ceiling level.

17.7.8 **Doors, Windows, Ventilators, Louvers Etc.**

Unless specified all doors, windows and ventilators of air conditioned areas, entrance lobby of all buildings and windows/ventilators provided on the outer face of all buildings shall have, electro colour coated (anodized) aluminum framework with glazing. All doors of office areas shall be of factory made pre-laminated particle board (MDF exterior grade). All other doors (unless otherwise specified) shall be of steel.
Buildings under coal handling system (like crusher house, pent house, transfer house, junction house etc) shall be provided with steel glazed windows. Doors for all air-conditioned areas, entrance doors to switchyard control building, service building and all non-plant building shall be of fully glazed anodised aluminium type.

Main entrance of the control room and control equipment room shall be provided with air-locked lobby with provision of double doors / glazed panels of aluminum frame work with toughened safety double glass glazing confirming to IS 2553 hermitically sealed and separated by 12 mm thick cup for thermal insulation. Doors shall be of double swing type or sliding type.

For common control building, double glazed wall panels with aluminum frame shall be provided between air-conditioned and non air- conditioned areas and on the side of control room and control equipment room(s) facing the operating floor to have a clear view.

Single glazed panels with aluminum frame work shall be provided as partition between two air-conditioned areas wherever clear view is necessary.

Coal conveyor galleries shall have steel windows/ventilators shall be as per IS1038

All steel doors shall consist of double plate flush door shutters. The door shutter shall be 45 mm thick with two outer sheets of 18 G rigidly connected with continuous vertical 20 G stiffeners at the rate of 150 mm centre to centre. Side, top and bottom edges of shutters shall be reinforced by continuous pressed steel channel with minimum 18 G. The door shall be sound deadened by filling the inside void with mineral wool. Doors shall be complete with all hardware and fixtures like door closer, tower bolts, handles, stoppers, aldrops, etc.

Steel windows and ventilators for coal conveyor gallery shall be as per IS:1361 and for all other areas as per IS:1038. Windows of coal galleries shall be provided with wire mesh.

Wherever functionally required rolling shutters with suitable operating arrangement Manual / Electric shall be provided to facilitate smooth operations. Rolling shutters shall conform to IS:6248.

All windows and ventilators on ground floor of all buildings located in isolated areas shall be provided with suitable anodized aluminum grill.

All Switchgear and cable spreader rooms shall be provided with minimum two fire proof steel doors to satisfy statutory requirement. Fire proof doors with panic devices shall be provided at all fire exit points as per the recommendations of Tariff Advisory Committee (TAC). These doors shall generally be as per IS:3614 (Part I and Part II). Fire rating of the doors shall be as per TAC requirements. However minimum rating shall be 2 hours. These doors shall be double cover plated type with mineral wool insulation..

Hollow extruded section of minimum 3 mm wall thickness as manufactured by INDAL or equivalent shall be used for all aluminum doors, windows and ventilators.

All door sizes shall be decided carefully, keeping in view the size of the machinery/panels to be erected inside the building. In any case opening height shall not be less than maximum height of machinery/panel installed inside the building.

Weather strip shall be provided to all external doors as well as in all air conditioned area.

Specially fabricated sliding or double leaf side hung steel door shall be provided in mono rail location.

Main entrance to control room of TG building shall be provided with air locked lobby with automatic closing sliding glass doors. Lobby shall be formed of anodized aluminium framing with toughened sheet glass 6 mm thick. Partition between control room and adjoining rooms shall be of glazed aluminium partition with 300 mm high brick wall at bottom for toe protection. All the doors in control room area shall be single leaf glazed aluminium doors. For movements of panels suitably sized double leaf aluminium glazed doors shall be provided.

Battery room shall be provided with doors with louver at bottom. For airwasher room steel doors will be used which shall be made airtight. No window shall be provided in Air washer room.
All accessible ventilators and windows of all building shall be provided with min. 4 mm thick float glass, plain or tinted for preventing solar radiations, unless otherwise specified.
All inaccessible (where regular maintenance is not feasible) ventilators or windows of all buildings shall be provided with 6 mm thick Multiwall

Polycarbonate plain or tinted sheet for preventing solar radiations. The Multiwall Polycarbonate sheets shall be fire and u/v resistant, and suitable for continuous use up to a temperature of 100oC. Suitable aluminium beading shall be used. The open ends of the sheet shall be sealed as per manufacturer's recommendations.

The sky light/north light shall have Multiwall Polycarbonate sheet fixed with anodized aluminium frame of approved colour & same shall be made leak proof.

False ceiling shall consist of regular edge light weight mineral fibre tiles of size of 600 x 600 or 600 x 1200 or as per architecture design with minimum tile thickness of 15 mm and shall be of standard make. Exposed surface shall be semiperforated (fine fissured) with nominal depth of
perforation as 4 mm. The material shall be humid resistance upto 95% RH with fire performance of class 0/class 1 (as per BS 476) and shall not sag for 10 years under 95% RH. Metal suspension system shall conform to ASTM C-635 and shall be not dipped MS galvanised (grade 180 as per IS: 277). Nominal size of Tsection shall be 24 x 38 mm or 24 x 25 mm cross runners. 24 mm wide exposed flange surface shall be permanently colour coated. Suspension system shall be as per manufacturer's specification.
.
Gypsum plaster board under for false ceiling, shall be minimum 12 mm thick conforming to IS: 2095. Gypboard false ceiling system shall consist of concealed aluminium 600 x 600 grid framing with main aluminium member of 38x25x1.5 mm , cross tie of 25x25x1.5 mm and aluminium angle of 25x25x1.5 mm suspended by 6 mm diameter galvanised steel rods from main ceiling. Glass reinforced gypsum plaster boards shall be fixed to the aluminium frame with screws. All frame work shall be concealed behind the gypsum board and the surface shall be provided with smooth wall putty finish and two coats of approved acrylic emulsion paint over one coat of primer

IS Codes

Following are some of the important IS codes (latest edition) applicable to this section:

IS:204 (Part-II)	:	Tower bolts non ferrous metals
IS:208	:	Door handles
IS:2002 (Part-I)	:	Flywood face panels
IS:1341	:	Steel butt hinges
IS:1868	:	Anodic coatings on aluminum and its alloys
IS:3564	:	Door closers (hydraulically regulated)
IS:5187	:	Flush bolts
IS:6315	:	Floor springs (hydraulically regulated) for heavy doors
IS:7195	:	Hold fast
IS:7452	:	Hot rolled steel sections for doors, windows and ventilators
IS:10019	:	Mild steel stays and fasteners
IS:1038	:	Steel doors, windows and ventilators
IS:1361	:	Steel windows for industrial ventilators
IS:1948	:	Aluminum doors, windows and ventilators
IS:1949	:	Aluminum windows for industrial buildings
IS:4351	:	Steel door frames
IS:3614 (Part-I)	:	Fire check doors

IS:10451	:	Steel sliding shutters (top hung type)
IS:4021	:	Timber door, window and ventilator frames
IS:1003 (Part-I)	:	Timber paneled and glazed shutters – door shutters.

17.7.9 Wall paneling

All the exposed structural steel i.e. wall, columns, bracings in STG control room and air-conditioning areas shall be provided with wooden wall paneling. The wall panel shall consist of teak wood batten grid of size 600x600 mm or as per site requirement. The size of batten shall be 2 inch x 1 inch. BWP grade plywood conforming to IS:710 shall be fixed on this grid. The Venner of approved quality and shade shall be fixed on the plywood as exterior finish with suitable adhesive. The entire work shall be carried out to the satisfaction of engineer.

17.7.10 Glass and Glazing

All ventilators and windows on external face of turbine building, conveyor gallery, pump house, compressor house, DG set building, transfer points, workshop building, fire escape staircase and those buildings located in fire prone areas shall be provided with wired glass of minimum 6 mm thickness conforming IS:5437.

Glazing in control room between AC and Non AC areas shall be double glazing consisting of two 6 mm thick clear toughened safety glass conforming to IS:2553, hermetically sealed and separated by 12 mm thick gap for thermal insulation.

For single glazed aluminum partitions and doors, Float glass or flat transparent sheet glass of minimum 6 mm thickness shall be used.

Ground glass / frosted glass of minimum 4 mm thickness shall be used for all windows / ventilators in toilets.

Unless specified otherwise in this specification minimum thickness of plain sheet glass used for windows/ventilators shall be 4 mm.

Float glass or flat transparent sheet glass shall conform to IS:2835. All glazing work shall conform to IS:1083 and IS:3548

17.7.11 False Ceiling and Under Deck Insulation

All air conditioned areas shall be provided with the suspended false ceiling system. Under deck insulation system shall be provided on the under side of the roof / floor slab of the air conditioned areas based on the functional requirement. Ceiling of air washer room shall also be provided with under deck insulation.

Aluminum false ceiling system shall comprise of 84 mm wide 12.5 mm deep closed type plain panels of approved colour, roll formed out of 0.5 mm thick corrosion resistant aluminum alloy AA 5050 fixed on roll formed carriers. Additional hangers and height adjustment clips shall be provided for return air grills, supply air diffusers, light fixtures, AC ducts etc.

Suitable M.S channel (minimum ISMC100) grid shall be provided above false ceiling for movement of personnel to facilitate maintenance of lighting fixtures, AC ducts etc.

CONTRACTOR shall prepare a layout of the false ceiling system incorporating light fixtures, supply air diffuser, return air grills, fire protection sprinklers etc. such that the ceiling looks aesthetically pleasing. Work shall commence only after the OWNER approves the layout.

Under deck insulation(under side of roof slab and under side of floor slab of air conditioned area) shall comprise of 50 thick PUF material of density 36 kg/cubic meter . This mat shall be backed with 0.05 mm thick aluminum foil and 24 Gx25 mm wire mesh netting. They shall be fixed to ceiling or wall as the case may be with 100x50x6mm slotted mild steel plate welded to M.S. plate inserts embedded at the soffit of the slab at 600 mm c/c and 14 G steel wire drawn through slots and fixed to wire netting.

17.7.12 **Painting**

Details furnished here in below are the minimum acceptable standard for painting. Superior finish if any required by CONTRACTOR to enhance overall appearance will be permitted if such finish meet with the technical requirements.

Water proof cement based paint as per IS:5410 shall be provided on external faces of walls, sunshades, etc.

Inside surfaces shall be provided with Acrylic washable distemper for all areas as per IS:428 except for Control room, Control equipment rooms, all air conditioned areas for which Acrylic emulsion paint shall be provided as per IS:5411.

Inside surfaces shall be provided with Acrylic distemper as per IS:428 for plant buildings like Workshop, Permanent stores, D.G. house, Compressor house, pump houses, Ash handling pump house etc.

Walls in D.M.Plant shall be provided with chlorinated rubber based paint as per IS : 9862 over walls. Walls above Dado in battery rooms shall also be provided with similar painting.

All plastered ceilings shall be provided with acryclic washable white distemper as per IS:42. Wall and ceiling above false ceiling shall be white washed above cement plaster.

Oil resistant paint as per IS:161 shall be provided for oil canal and oil equipment room.

All wood work shall be provided with fire resistant transparent paint as per IS : 162 over french polish as per IS:348 or flat oil paint as per IS : 137.

Painting for structural steel have been specified else where in this document. Following general instruction for painting shall be followed.

i) For painting on concrete, masonry and plastered surfaces IS:2395 parts I and II shall be followed.

ii) For painting on wood work IS:2338 part I & II shall be followed.

iii) All paints shall be of brand (Asian,Burger,Nerolac or equivalent) and make to the approval of OWNER.

iv) A minimum of two finishing coats of paint over a primer shall be provided to give a smooth uniform finish for the painted surface.

v) All painting on masonry or concrete surfaces shall preferably be applied by rollers.

vii) Thinner shall not be used with textured paint (sandtex matt etc) finish.

viii) All fire exits shall be painted in Post office red colour shade which shall not be used any where except to indicate emergency or safety measure.

viii) Wall and ceiling above false ceiling shall be white washed above cement plaster.

17.7.13 **Chemical Resistant Treatment Battery Room**

a.) Battery room floors and other surfaces as required shall be provided with acid/alkali resistant tiles and treated suitably as detailed below by supplying & furnishing of all labour, materials & equipment in accordance with the following latest codes:

IS : 3384	:	Specification for bitumen primer for use in water proofing & damp proofing
IS:4443	:	Code of practice for use or resin type chemical resistant mortars
IS:4457	:	Specification for ceramic unglazed vitreous acid resistant tiles.
IS:4832	:	Specification for chemical resistant mortars (Part I to III).
IS:4971	:	Recommendation for selection of Industrial floor finishes.

b.) The surfaces to be treated against acid shall be levelled smooth, dry & clean. The entire surface shall be tapped by wooden hammer to determine hollows if any. In case hollows are found, they shall be suitably sealed with concrete or other approved materials.

c.) The unsatisfactory surfaces shall be replaced by new concrete or other suitable material after ensuring proper bond between the new and old surface. Surface to be prepared shall be wetted for 24 hours; use of epoxy resins for bonding fresh concrete during repairs shall be permitted with Engineer's subject to its execution as per Manufacturer's instructions. All patched areas shall be properly cured by sprinkling water for a period of not less than 10 days.

17.7.14 **Acid/Alkali Resistant Tiles on Floors & Walls**

a.) The surface after preparation shall be applied with a coat of bitumen primer conforming to IS: 3384 (latest). The primed surface shall be subsequently applied with a uniform coat of bitumen conforming to IS:1580.

b.) For bedding of tiles, potassium silicate based cement mortar [15 mm thick] as per IS:4832 shall be used spreading on the back & two adjacent sides of the tile. The tile shall be pressed on the floor or wall & push against floor or wall until the joint in each case of 6 mm thick & 6 mm width is maintained with spacers. Before the bedding mortar sets completely, the jointing material shall be removed to a depth of 20 mm. After the bedding mortar is properly set, the joints shall be cured with resin type mortar filling up the entire length of the joint. The excess mortar shall be trimmed off to make the joints smooth & place. Seal coat shall then be applied over the epoxy mortar to cover up porosity that may be left in mortar. Acid resistant tiles shall be provided for a height of at least upto lintel level on all the walls of battery room. The rest of the battery room walls & ceiling shall be provided with 2 coats chlorinated rubber paint. The tiles used for flooring & walls shall be 20 mm thick conforming to IS 4457. Tiles of approved quality and shade shall be used.

Acid curing shall be carried out as per manufacturer’s directions using the safety precautions normally used when handling acids. The mortar joints shall be cured with 20 to 25 percent hydrochloric acid or with 30 to 40 percent sulphuric acid no sooner than 2 days and not later than 6 days after the masonry units are bonded with the mortar. The curing time shall be at least 60 minutes.

Performance guarantee: The contractor shall be responsible for the safety, suitability & efficient functioning of all the acid resistant treatment. He should guarantee for efficient performance of the treatment for a period of five years time from the date of the completion. During the guarantee period, if at any stage, it is found that any of such treatments has given way or has not been functioning satisfactorily, the same shall be made good by the contractor at his own cost.

17.7.15 **Finishing Schedule**

The minimum quality of finishes used for various building areas are furnished in Table-1 in this section. The Bidder is at liberty to use superior finishes provided all specific requirements for the finish specified in this specification.

TABLE 1 : FINISHING SCHEDULE

Building / Area	Wall (Internal)	Floor Finish	Ceiling	Roof Treatment	Wall (External)
STG Building					
Ground Floor: Maintenance Bay & Unloading Areas	Acrylic washable distemper	Granolithic with non-metallic hardner	Acrylic distemper	--	Water proof cement based paint
Ground floor general area	Acrylic washable distemper	Granolithic Flooring	Acrylic distemper	--	
Cable Room	Acrylic distemper	Granolithic with non-metallic floor hardener	Acrylic Distemper	--	
Electrical Room	Acrylic distemper	Granolithic with non-metallic floor hardener	Acrylic Distemper		
Mezzanine Floor	Acrylic washable distemper	Granolithic flooring	Acrylic Distemper	--	
Operating Floor Operating Area, laydown area	Acrylic washer distemper	Polished Kota Stone	Acrylic Distemper	--	
Central Control Room	Acrylic emulsion paint	Glazed Vitrified tiles Double Charge	Aluminum False Ceiling		
Electronic cubicle room & Computer room	Acrylic emulsion paint	Heavy duty ceramic tiles	Aluminum False Ceiling	--	
Conference room, senior executive room	Acrylic emulsion paint	Glazed Vitrified tiles Double Charge	Aluminum False Ceiling	--	
Switchgear room	Acrylic washable distemper	Granolithic with non-metallic floor hardener	Acrylic Distemper	--	
Battery Room	Acid & alkali tile dado for 2100 mm high + Chlorinated rubber based paint	Acid / alkali resistant tiles	Acid Resistant Paint	--	
SWAS room	Acrylic washable distemper	Glazed Vitrified tiles Double Charge	Acrylic Distemper	--	--
General circulation and movement areas	Acrylic washable distemper	Polished Kota Stone	Acrylic Distemper	--	
Heater area	Acrylic washable distemper	Heavy duty cement concrete tiles (Carborandum)	Acrylic Distemper	--	
Office Area	Acrylic emulsion paint	Glazed Vitrified tiles Double Charge	Acrylic Distemper	--	

Building / Area	**Wall (Internal)**	**Floor Finish**	**Ceiling**	**Roof Treatment**	**Wall (External)**
Pantry	Dado for 2100 mm high + Acrylic distemper	Heavy duty matt finish ceramic tiles	Acrylic Distemper	--	--
Toilet	Dadoing up to ceiling lvl + Acrylic distemper	Heavy duty matt finish ceramic tiles	Acrylic Distemper	--	
Roof	--	--	--	Elastomeric water proofing treatment	--
Other Buildings					
Bunker Building	Acrylic washable distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Cooling Water Pump House	Acrylic washable distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Raw Water Pump House	Acrylic washable distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Filter Water Pump House	Acrylic washable distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Chemical House	Acid/Alkali resistant tiles on wall up to 1500mm height & chemical resistant paint above.	Acid/Alkali resistant Tiles	Chemical resistant paint	Elastomeric water proofing treatment	Water proof cement based paint
DM Plant	Chlorinated rubber based paint	Acid/Alkali Resistant Tiles	Chlorinated rubber based paint	Elastomeric water proofing treatment	Water proof cement based paint
Chlorination Building	Acid / Alkali resistant tiles	Acid / Alkali resistant tiles	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
CPU Regeneration Building	Acrylic washable distemper	Granolithic Flooring	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Control Rooms	Acrylic emulsion paint	Glazed Vitrified tiles Double Charge	Aluminum False Ceiling	--	Water proof cement based paint

Building / Area	**Wall (Internal)**	**Floor Finish**	**Ceiling**	**Roof Treatment**	**Wall (External)**
MCC Switchgear Room	Acrylic washable distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	--	Water proof cement based paint
Cable Vaults	Acrylic Distemper	Granolithic floor with non metallic floor hardener	Acrylic Distemper	--	Water proof cement based paint
Workshop	Acrylic washable Distemper in workshop area & Acrylic emulsion paint in office area	Granolithic floor with non metallic floor hardener in workshop area and Vitrified Tiles in office area	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Canteen **:** General Area Kitchen	Dado for 2100mm high & Acrylic Distemper above.	Heavy Duty Ceramic Tiles	Acrylic Distemper	Elastomeric water proofing treatment	Granular finish
Fire Station Building	Acrylic washable distemper	Glazed Vitrified tiles Double Charge in office,dormitory area & granolithic flooring with non metallic floor hardener in parking & equipment store area.	Acrylic Distemper	Elastomeric water proofing treatment	Water proof cement based paint
Service building: Ent. Lobby, Reception, Portico & Lift Area Office Area	Acrylic emulsion paint	20 mm thick polished granite stone Glazed Vitrified tiles Double Charge	Aluminum False Ceiling	Elastomeric water proofing treatment	Granular finish (Vineratex)

CHAPTER – 18

PILING

18.1 The detailed design, preparation of construction drawings, installation and testing of piles forming foundations to buildings and structures are detailed below conforming to the latest IS:2911 – Code of Practice for Design and Construction of Pile Foundations : Part I Concrete Piles and IS:2911 Part : IV Load test on piles and to this Specification. The contractor shall be responsible for all aspects of the pile performance installed including demonstration of the adequacy of his design by testing. During detailed design the contractor shall submit the proposed firm to undertake piling work with details piling system, method of installation, summary of design basis, number, type and size of construction plant items to be employed for the work including crane, piling equipment, concreting equipment and proposal for installation & testing of trial piles and tests on work piles.

18.2 Prior to installation of trial piles, the contractor shall submit final details of the trial piling installation including specifications, detailed design calculations and construction drawings for the trial piling together with associated equipment to be provided for construction and testing of the same.Design report discussing the overall results of the tests on trial piles and concluding with and justifying the proposed definition of reference piles; specification, with fully detailed construction drawings, supporting calculations for the final design of the working piles, and the field control procedures the contractor intends to use to verify that pile installation satisfies the requirements of his design should also be submitted.

18.3 **DESIGN CRITERIA**

The following shall be the design criteria for the working piles :

a. Piles shall be designed in line with approved soil investigation report as single vertical piles acting under a design load as deemed fit.

b. The pile foundations shall be RCC bored cast-in-situ piles and piling shall be as per IS: 2911 (relevant part). Boring shall be done by using conventional or rotary hydraulic rig. Flushing of pile bore shall be ensured by air lift technique duly approved by OWNER. The construction methodology to be adopted shall be suitable to ensure proper termination of pile in the strata and to ensure pile bore free from spoils.

c. Only RCC piles shall be provided. ·

d. Diameters of pile shall be 450mm, 600 mm and 750mm. The uplift and lateral load capacities shall be restricted to 20% and 5% respectively of the allowable load capacity in vertical compression. However, the pile capacities to be adopted shall be the least of the estimated design values and that obtained from the pile load tests.

e. The piles shall be designed for a minimum factor of safety of 2.5 against failure under the design load specified.

f. Piles shall be designed for a limiting settlement of a single pile under vertical design load of 8 mm at the head and lateral deflection as 5mm.

g. Piles shall be designed to resist a maximum force due to critical load combination in any direction applied to the head of the pile at cut-off level. For this design condition it shall be assumed that the pile head is effectively as a fixed-end by the pile-cap.

h. Only Straight piles shall be used. (U.N.O.)

i. CONTRACTOR shall furnish the design of piles (in terms of rated capacity, length, diameter, termination strata and criterion to locate the founding level for construction of pile, reinforcement for job as well as test piles etc.), construction methodology/ specifications for construction of piles and scheme and locations of initial pile load tests in vertical, lateral and uplift, and the details of equipment for OWNER"s approval. ·

j. Regular QA checks for density of circulation mud, contaminated mud and samples from pile bore bottom, slump of concrete, pile concrete integrity test on all piles etc. shall be done by the CONTRACTOR. ·

k. Wherever pile foundations are adopted, a minimum of two pile group shall be provided below every column /foundation

18.4 TOLERANCE

Setting out shall be carried out from the main grid lines of the proposed structure. Immediately before installation of the pile, the pile position shall be marked with suitable identifiable pins or markers. For a pile head cut-off, at or above ground level, the maximum permitted deviation of the pile head cut off center from the center point, shown on the setting out drawing shall be 75 mm in any direction. For a pile head cut-off below ground level, an additional tolerance will be permitted as below on the assumption that the pile head would have been within tolerance if the cut-off had been at ground level. The maximum permitted deviation of the finished pile from the vertical is 1 in 75. Forcible corrections to concrete piles shall not be made.

18.5 The contractor shall carry out the work to minimize noise and disturbance.
<u>If during the execution of the work, damage is likely to be, caused to mains, services or adjacent structures, the contractor shall submit proposal for repair or avoidance of such damage. The contractor shall ensure that damage does not occur to completed piles. All damages to be repair by contractor with out any cost implication to owner.</u>

18.6 RECORDS

The contractor shall keep records as below of the installation of each pile and shall submit record to the Engineer.

Table 1.0

a)	Piles reference number (location)	*
b)	Piles cut off level	*
c)	Pile type	*

d)	Nominal cross-sectional dimensions or diameter	*
e)	Pile design capacity	*
f)	Standing groundwater level	*
g)	Date and time of driving, red riving or boring	*
h)	Date of concreting	*
i)	Ground level at commencement of installation of piles	*
j)	Working level	*
k)	Depth from working level to pile toe	*
l)	Toe level	*
m)	Depth from working level to pile head level	*
n)	Length of temporary / permanent casing	*
o)	Type weight, drop and mechanical condition of hammer	*
p)	Number of type of packings used and type and condition of	*
q)	Record of blows per 300 mm over complete drive	*
r)	Set of pile or pile tube in mm per 10 blows or number of	*
s)	Temporary compression of ground and pile from time of marked increase in driving resistance until pile reaches	*
t)	Length and details of reinforcement	*
u)	Grade and slump of Concrete mix and control test	*
v)	Volume of concrete installed in pile	*
w)	Method of placing concrete	*
x)	Number of blows to form bulb where appropriate	*
y)	Level of water or drilling fluid at commencement of placing concrete	*
z)	All information regarding obstructions delays and other interruptions to the sequence of work	*

18.7 BORE CAST-IN-SITU PILES

The following specification deals with the requirements of materials, workmanship and installation of Bore Cast-in-situ reinforced concrete piles.

The materials and workmanship shall conform with the provision of the latest IS:456, IS:2911 (Part I, Section 2) & IS:2911 (Part 4).

Care shall be taken while boring piles so that no existing foundations / sub-structures are disturbed by providing suitable arrangements like shoring etc.

a. Sequence of Piling

The sequence of piles installed shall be such that the adjacent piles already installed are not disturbed nor their carrying capacity reduced by subsequent boring operation. In a group the installation of the piles shall normally proceed from the center of the group towards the periphery.

b. Control of Alignment

Piles shall be installed as accurately as possible as per the designs and drawings either vertically or to the specified batter. Great care should be

exercised in respect of installation of piles in two pile group. For vertical piles a deviation of 1.5 percent should not normally be exceeded. Piles should not deviate more than 75 mm or D/10 whichever is more in case of piles having diameter more than 600 mm from their designed positions at the working level of the piling rig.
For piles carried to substantial depth, the design should provide for the worst combination of the above tolerance in position and inclination. In case of piles deviating beyond these limits and to such an extent that the resulting eccentricity cannot be taken care of by a redesign of the pile cap and ties, the piles shall be replaced or supplemented by one or more additional piles, as directed by the Engineer, at no extra cost.

Any deviation from the designed location, alignment or load capacity of any piles shall be noted and brought to the attention of the Engineer and rectification and supplemental works carried out to the satisfaction of the Engineer at no extra cost.

A minimum length of one meter of temporary casing shall be inserted in each bored pile unless otherwise specifically desired. Additional length of temporary casing may be used depending on the condition of the strata etc.

Drilling mud of suitable consistency may also be used instead of temporary casings for stabilizing sides of the holes.

In case, a bored pile is stabilized by drilling mud the bottom of the hole shall be cleaned very carefully before concreting work is taken upon. The cleaning of the hole shall be ensured by careful operation of boring tool and / or flushing of the drilling mud thorugh the bottom of the hole. Flushing of bore holes before concreting with fresh drilling fluid/ mud is preferred.

In case a holes is bored by use of drilling mud, the specific gravity of the mud suspension near about the bottom of the hole shall, wherever practicable, be determined by suitable interval of piles and recorded. Consistency of the drilling mud suspension shall be controlled throughout the boring as well as concreting operations in order to keep the hole stabilized as well as to avoid concrete getting mixed up with the thicker suspension of the mud.

The concreting operatings should not be taken up when the specific gravity of bottom slurry is more than 1.2. Concreting shall be done by tremie method in all such cases.

The top of concrete in a pile shall be brought above the cut-off level as per cl. 7.8 of IS: 2911 (Part 1/sec.2).

In case, defective piles are formed, they shall be removed or left in place, if so directed by the Engineer, if these do not affect the performance of the adjacent piles or the cap as a whole. Additional piles shall be provided to replace them as directed by the Engineer.

Any deviation from the designed location alignment or load capacity of any pile shall be noted and adequate measures taken well before the concreting, of the pile cap and plinth beam if the deviations are beyond the permissible limit.

During chipping of the pile top manual chipping may be permitted after three days of pile casting, pneumatic tools for chipping shall not be used before seven days after pile casting.

After concreting the actual quantity of concrete shall be compared with the average obtained from observations actually made in the case of a few piles initially cast. If the actual quantity is found to be considerably less, special investigations shall be conducted and appropriate measures taken.

The bentonite suspension used for piling work shall satisfy the following requirements:

i. The liquid limit of bentonite when tested in accordance with IS:2720 (Part V) shall be more than 300 percent and less than 450 percent.

ii. The sand content of the bentonite powder shall not be greater than 7 percent.

iii. Bentonite solution should be made by mixing it with fresh water using pump for circulation. The density of the freshly prepared Bentonite solution should be between 1.034 and 1.10 gm/ml depending upon pile dimensions and type of soil in which the pile is to be installed. However, the density of bentonite solution after mixing with deleterious materials in the pile bore may be up to 1.25 gm/ml.

iv. The marsh velocity when tested by a Marsh cone should be about 37 seconds.

v. The differential free swell shall be more than 540 percent.

vi. The PH value of the bentonite suspension shall be between 9 & 11.5.

c.) The main longitudinal reinforcing bars in piles shall be in one continuous length. In long piles, joints shall be permitted in main longitudinal bars but these shall be kept to a minimum. Joints in adjacent bars shall be staggered at least 1 meter part along the length of the pile. Joints in reinforcement shall be such that the full strength of the bar is effective across the joint.

Longitudinal reinforcement shall be provided for the full length of the pile extending above pile cut off level to provide adequate bond length into the pile cap. The minimum area of longitudinal reinforcement within the pile shaft shall be 0.4 percent of cross-sectional area of the pile on the basis of the nominal casing diameter. Longitudinal reinforcement shall be formed into a rigid cage to resist deformation during handling and installation by the use of links or helical reinforcement. The minimum diameter of links and helical reinforcement shall be 6 mm spaced at 150 mm and not more than 300 mm. The longitudinal reinforcement shall project 52 times its diameter; above the cut off level of the pile to ensure adequate bond length inside the pipe cap. Minimum 6 Nos. of longitudinal reinforcement shall be provided. Reinforcement provided in pile shall be symmetrical about any axis on the pile cross section. The diameter of longitudinal reinforcement shall not be less than 12 mm. Lap or splice joints shall be provided with sufficient link bars to resist eccentric forces. Minimum cover to main reinforcement in the pile shall be 75mm.

d.) The method of placing and the workability of the concrete shall be such that continuous monolithic concrete shaft of the full cross-section is formed. Mechanical vibrators shall not be used to compact concrete. Concrete in piles shall be of design- mix with minimum grade M25 with minimum cement of 400 kg/cum water cement ratio within 0.45 to 0.55 using super plasticized Sikament 170 or equivalent. Generally the slump of the concrete shall be within the range 100 to 150 mm. The contractor shall ensure the minimum specified strength in accordance with IS:456, IS:10262 & SP. 23 shall be followed as guidance for mix design. Compaction of test cubes shall be done under same condition as followed for concreting of piles.

Irrespective of the specified pile cut-off level, concrete shall be poured into the pile bore until all the contaminated concrete at the top of the bore overflows the top of the pile bore and neat concrete appears continuously as overflow. Concreting shall then be terminated after permission of the ENGINEER.

e.) **Concrete Level – finishing of pile head**

The cut-off level shall be as shown on the construction drawings. Concrete shall be cast to minimum of 500 mm above the cut-off level, or local ground water level, whichever is higher. Withdrawal of temporary casing shall be carried out in stages during the concrete placing operation with utmost care maintaining an adequate head of concrete above the bottom of casing at each stage of withdrawal so as to prevent the inflow of soil and water into the bore. Section of empty hole remaining above the head of the pile shall be temporarily backfilled with sand or other approved material prior to excavation for pile cap construction.

f.) **Trimming of pile heads**

Following excavation subsequently for pile cap construction, the contractor shall carefully remove excess concrete above specified cut-off level, without damaging the remainder of the pile including the projection reinforcement. Any cracked or defective concrete occurring below specified cut-off level shall be cut away and made good with new concrete properly bonded to the old. Piles that are defective shall be pulled out or left in place as judged by Engineer without affecting performance of adjacent piles. Also the contractor shall be bound to install additional piles to substitute the defective ones as per the directions of the Engineer.

Manual breaking of piles shall not be permitted. All pile cut-offs to specified levels shall be done using percussion tools or specified devised methods.

On completing pile cut-off for any pile, all exposed reinforcement surface shall be coated with cement wash at no extra cost to the Owner.

g.) The dynamic cone penetration tests shall be carried out for a depth of at least 2 meters from the termination depth. The number of such tests shall be as follows :

a. One number dynamic cone penetration test for each pile group consisting of more than four piles.

b. For TG and Chimney pile groups the number of dynamic cone penetration tests shall be one per cent of the total number of piles.

18.8 TERMINATION CRITERIA

a) **SOIL**

Standard penetration test(SPT) in Pile Bore

The contractor shall carry out SPT in pile bore. The depth of SPT shall be at 1 meter interval, starting from 3.0mt prior to termination levels, in the piles selected by the engineer. SPT rods shall be lowered through 100mm dia casing pipes. Casing pipes shall extend upto 150mm above SPT Depth.For conducting the test, the bottom of bore hole shall be cleaned properly, and the the spoon shall be properly and centrally seated in position in bore hole.it is necessary to ensure that drive hammer is of specified weight and has a specified free fall as/IS-2131. It shall be ensured that energy of falling weight is not reduced by friction between drive weight and guides or between rope and winch drum. Only BIS recommended standard connecting rods shall be used for the test. The pile shall be terminated if three consecutive SPT values are equivalent or higher than designed SPT values.

b) **ROCK**

The Piles found in rocky strata shall be terminated after socketing the desired length of pile inside the rock.actual length of pile shall in no case be less than the design length. A socketing length of three (3) times the diameter of the pile into rock with core recovery greater than 20% shall be ensured in deciding the minimum length of pile.

18.9 LOAD TESTS ON PILES

a) Load test shall be in accordance with IS:2911 Part IV (latest revision) Initial load tests on "Trial Piles" shall be executed in advance of works pile construction and shall comprise vertical load tests at locations as directed. Load test on trial piles shall also include lateral load test and uplift load tests as directed by the Engineer. 9 number of trial piles shall be tested for each dia and rated capacity of the pile. Out of the nine (9) nos. of piles to be tested for three (3) nos. of each dia and rated capacity shall be tested for vertical load, three (3) nos. for lateral load and three (3) nos. for uplift load.
Routine load tests on "Works Piles" shall be vertical load test and lateral load tests on piles as directed by the Engineer. Number of routine tests to be conducted on work piles for each diameter and rated capacity shall be equal to one and half (1.5) percent of the total number of piles used in the work for vertical load tests as well as lateral load tests subject to the minimum of one.

b) Load tests shall not normally be undertaken by the contractor within 28 days after the installation of the piles in position. However, the contractor may be allowed by the Engineer to use rapid hardening cement or add necessary admixtures to enable him to conduct the tests within a lesser period. Before any load test is done, the proposed arrangement for carrying out the load tests including the preparation of the structure to receive the loads and the type of loading to be adopted shall be furnished by the contractor.

c) **Vertical Load Test on Trial Piles**

Load tests to verify the contractor's design shall be carried out on piles of different diameter and rated capacities proposed to be used. The contractor shall commence testing as early as possible after installing the piles. The test shall be carried out by applying series of loads on RC cap over single pile. The load shall be applied by means of standard hydraulic jack reacting against a loaded platform which shall be preloaded platform which shall be preloaded to three times the estimated safe load carrying capacity of the pile. Reading of settlement and rebound shall be recorded with Linear Variable Differential Transducers (LVDT) or four dial gauges of 0.01 mm sensitively and resting on diametrically opposite ends of the pile cap The dial gauge shall be fixed to a datum bar whose ends rest-upon non-movable supports. The supports for datum bar with reference to which the settlement of the pile is measured shall be at least 5 times diameter of pile away from the pile.

The test shall be conducted by the cyclic loading method. The test load shall be applied in equal increments of about one-fifth of the estimated safe load. Each stage of loading or unloading shall be maintained till the rate of movement of the pile cap is not more than 0.02 mm per hour. However, load shall be maintained for longer periods at 1 to 1.5 times the assumed safe capacity, and at final loads as directed by Engineer. The safe load on pile shall be the least of the following :

i Two third of the final load at which the total settlement attains the value of 12 mm.

ii Two third of the final load at which the net settlement attains a value of 6 mm.

iii 50 per cent of the final load at which the total settlement equals one-tenth of the pile diameter.

d) **Lateral Load Test on Trial Piles**

The test pile shall be decided by the Engineer. The test pile shall be cut off at the proper level and provided with a cap with vertical plane sides having an adequate area for proper seating of the jack and dial gauge. The lateral load shall be applied on the pile at or approximately at cut off level and the deflection shall be measured at a point diametrically opposite to the point of load application. The loading shall be applied by the hydraulic jack of adequate capacity, abutting the pile horizontally and reacting against a suitable system. The reaction may be provided by the well of the excavated pit when the test is being conducted below ground level or by a neighbouring pile in which case thrust pieces shall be inserted on either end of the jack to make up the gap. Lateral load applied on the pile shall be measured by a calibrated pressure gauge mounted on the jack, having a least count of 500 kg. Deflection of the pile head shall be measured by Linear Variable Differential Transducers (LVDT) or four dial gauges, fixed to datum bars & having a least count of 0.01 mm. The datum bars shall be provided with rigid supports. Loading shall be applied in increments of 500 kg.Each stage shall be maintained for a period till the rate of movement of the pile head is not more than 0.02 mm/hour or 1 hour whichever is greater .
Loading shall be continued till one of the following occurs :

i. Deflection of pile head exceeds 12 mm.

ii. The applied load on the pile is three times the assumed lateral load capacity of the pile.

The safe load shall be smaller of the following :

i. Half the final load for which the total deflection is 12 mm.

ii. Load at which the total displacement corresponds to 5 mm.

e) **Pull-out Test**

The test piles shall be decided by the Engineer. The test pile shall be built upto the proper length and the head provided with suitable arrangements for anchoring the load applying system. Loads shall be applied using a approved reaction system, uplift forces on the pile shall be applied directly to the test pile or through a lever system. The reaction shall be provided by neighbouring piles or blocks may be constructed for the purpose. Hydraulic jacks shall be used for load application. Load applied by the hydraulic jack shall be measured by a calibrated gauge with a least count of 100 Kg. Movement of the pile shall be measured by Linear Variable Differential Transducers (LVDT) or dial gauges, fixed to datum bar and having a least count of 0.01 mm. Four dial gauges placed diametrically opposite shall be used. Datum bars shall be provided with rigid supports. The load shall be applied along the longitudinal axis of the pile using method approved by the Engineer. Loading shall be applied to the pile top in increment of one-fifth of the expected safe capacity. Each stage shall be maintained for a period till the rate of movement of the pile head is not more than 0.02 mm per hour or four hours whichever is greater. Loading shall be continued till one of the following occurs :

i. Yield of soil pile system occurs causing progressive movement of pile exceeding 12 mm.

ii. The loading on the pile top equals three times the estimated safe load or as specified in the case of separate test pile.

The safe capacity of the pile should be least of the following :

i. Two third of the load at which the total displacement is 12 mm or the load corresponding to a specified permissible uplift, and

ii Half of the load at which the load displacement curve shows a clear break (downward trend)

f) **Routine Test on Working Piles**

These tests shall be carried out on working piles upto one and half times the design load and the maximum settlement of test loading in position being not exceeding 12 mm as per IS:2911 (Part IV). In case a pile fails under or during the load test, the Engineer shall select two additional piles in lieu of each of such failed pile and the contractor shall carryout load tests on such additional piles.
The routine test on piles shall be conducted by direct loading method. The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

A report on the pile load tests shall be submitted for OWNER"s approval. 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 contractor shall install additional pile (s) as required and accordingly, pile cap design should be reviewed and modified if required at no extra cost to the owner

Low Strain Pile Integrity test shall be conducted on all test piles and selected job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM and it shall be pulse eco method

18.10 CODES AND STANDARDS

The following Indian Codes and Standards (Latest) shall be used for design of the structural elements:

IS:456: Code of Practice for plain and Reinforced concrete

IS:875: Code of Practice for Design loads (other than earthquake) for Buildings and structures.

IS:2911: Code of Practice for Design and Construction of Pile Foundations – Bored Cast-in-situ Piles (Part 1/sec. 2)

IS:2911 : Code of Practice for Design and Construction of Pile Foundation – Load Test on Piles (Part 4)

IS:1786 : Code of Practice for HYSD bars

IS:2751 : Code of Practice for welding of mild steel bars used for reinforced concrete construction

IS:2062 : Steel for general structural purposes

SP:16 : Design Aids for Reinforced Concrete to IS:456.

CHAPTER – 19

SURVEYING WORKS

19.1 TOPOGRAPHICAL SURVEY

Topographical survey shall be carried out to establish the ground levels and to determine any existing structures, roads etc. The survey shall be carried out before the commencement of the work and if required during the progress of the work. The Topographical survey shall be carried out at a grid spacing of 5-10 meters and at every change of level of the existing ground to produce contour drawings at 0.25 meter intervals. Scale of the contour drawings shall be as directed by the Consultant. A specialized firm approved by the Consultant shall carry out the Topographical survey.

A single grid pillar will be given by the client with coordinates in plant area. Necessary grids shall be made by EPC contractor including demarcating the structures, buildings and jungle clearance including Cutting, uprooting and removing of trees and dispose the same away from the site etc.

Survey points (reference points and bench marks) : The contractor shall construct adequate number of reference points and bench marks for marking the setting out lines and levels. The reference points shall consist of suitable metal plates set in 400 mm x 400 mm x 500 mm precast concrete plinth (grid pillars) and inscribed with the exact level. All levels of the benchmarks shall be related to the agreed datum. The exposed numbers, locations, co-ordinates and level of the reference points and bench marks shall be plotted on drawings and approved by the consultant prior to the commencement of the work. Survey points in solid walls shall be stainless steel plates or cast iron, fixed firmly and sufficiently deep in the walls.

<u>Safeguard of survey points:</u> The survey points shall not be removed from their position without the permission of the Consultant. If any of the survey points are damaged or lost due to any work carried out near their location, the contractor shall be responsible for replacing such survey points.

<u>Surveying during the progress of work</u> : The contractor shall assist the consultant at any time when checking survey points, setting out, checking construction items and erection parts. The contractor shall provide and arrange the following:

i.) Provision and maintenance of survey instruments and accessories.

ii.) Provision of skilled personnel, supply of all material required for the survey exposing covered survey points.

iii.) Shifting of any machinery used for construction out of the sight lines.

iv.) Stopping all drilling, blasting, driving and any other works.

v.) Causing soil vibrations and stopping during instrument observations

vi.) Removing all obstructive accumulation of water

vii.) Taking all necessary safety precautions viii.) Furnishing any marking material requested by the Consultant in connection with control surveys

ix.) Providing additional survey points in accordance with the consultant's instruction.

CONTRACTOR shall furnish softcopy of survey drawing in one CD along with six hard copies of all survey drawings to the OWNER for his reference.

19.2 HYDROGEOLOGICAL SURVEY

Hydro geological survey is to be carried out mainly to find out the availability of ground water for extraction through tube wells in any area and infiltration gallery / radial collector well in the river bed or by the side of river and also to decide the particular type of dewatering system. The hydro geological survey for any subsurface water source will generally cover any one or more of the following:

a) Geological investigation

b) Auger holes

c) Slug tests and pump tests

The actual investigation may be preceded by a reconnaissance survey of the area by an expert hydrogeologist to decide the type of investigations. For geophysical investigations, direct current electric resistivity method is normally employed. Vertical electrical sounding and horizontal profiling are to be carried out as part of investigations to find out information on the succession of different conducting zones and their thickness. Wherever possible auger holes and slug tests / pump out tests to be carried out to find out properties of the water bearing strata. On the basis of hydrogeological investigations, aquifer characteristics like average thickness of strata, permeability, transmissivity and properties of the material like grain size etc. are arrived at. Based on this data the type of development shall be decided and the yield shall be estimated and furnished to the OWNER in the form of a report for his approval.

19.3 HYDROGRAPHIC SURVEY

Hydrographic survey need to be carried out when intake well / pump house or any other structure is located inside or close to a water body like river, lake etc. This is essentially to find out the topography of the river bed / lake bed through soundings taken from surface of water body usually by employing boats. The hydrographic survey should be carried with proper datum so that topographic details on land outside the water body and the area submerged are linked appropriately.For locating and finalising the details of drawal scheme, in addition to the topography of river bed / lake bed, data on maximum water level / minimum water level will be required. For drawal from river or streams, cross section of the river / stream at a few locations will be needed. For establishing the availability of required quantum of water throughout the year gauge discharge data / flow data for the river / stream has to collect. In case the stream / river is not gauged, the discharge availability has to be established by correlating the data available elsewhere or by correlating with rainfall data.

A report on the studies conducted shall be submitted to the OWNER for his reference.

CHAPTER – 20

EXCAVATION AND FILLING

20.1 The contractor shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and such like and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his tender.

The works to be provided by the bidder in respect of excavation in all types of soils including shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc. relevant to structures and locations shall be as detailed below:

a. Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, equipment, tools and plants, transportation etc. required for the work.

b. Prepare and submit working drawings showing the approaches, slopes, beams, 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 carryout sampling and testing and submit to the Engineer, results of soil compaction tests if required by the Engineer to assess the degree of compaction.

20.2 All works should conform to the requirements of the latest revision of relevant IS.

IS: 3764 : Indian Standard for Safety Code for excavation work.
IS: 1200 (PartI): Indian Standard Methods of Measurement of Building and Civil Engineering work, Part-I: Earthwork.

20.3 The bidder should carry out the work as per the approved drawings. All materials required for the work shall be of best commercial variety. Borrow materials for back- filling shall be excavated from approved locations and shall consist of material, free from roots, vegetation, 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.

20.4 **QUALITY CONTROL**

The bidder shall get approved the field quality plan, for maintaining the quality control for which, he shall establish and maintain quality control lab for the various aspects of the work, method, material 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.

Guide lines for quality control is attached in Vol-II of the specification.

20.5 **EXCAVATION**

a. **Setting out:** The contractor should submit to the Engineer, detailed drawings of the excavation work to be executed by him showing the dimensions as per drawings and specification adding his proposals of slopes, shoring, approaches, dewatering sumps, beams etc. Upon Engineer's approval the contractor should 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 shall be fixed at intervals prescribed by the Engineer. The contractor should proceed with the work after Engineer's approval. It should be noted that this checking by the Engineer prior to start of the work shall 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 necessary, should be carried out by the contractor free of cost to the Purchaser.

b. Clearing and Grubbing etc.: The area to be excavated shall be cleared out of fences, trees, logs, stumps, bush, vegetation, rubbish, slush etc. and leveled 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 up to 600mm below ground level or 150mm below formation level whichever is lower. After the tree is cut and roots taken out, the pit-holes formed shall be filled with good earth in 250 mm layers and consolidated. The trees shall be cut in suitable pieces as instructed by the Engineer.

Before earthwork is started, all the spoils/ unserviceable materials and rubbish shall be burned or removed from the site to approved disposal areas as specified. Useful materials, saleable timber, firewood etc. shall be the property of the Purchaser and shall be stacked properly at the work site in a manner as directed by the Engineer.

c. Excavation in all kinds of soil: The excavation in all kinds of soil including old (from demolished structures) underground RCC / CC / brick masonry 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 workman like manner without endangering the safety of nearby structures/ services or works and without causing hindrances to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work shall be checked by the Engineer thoroughly and the balance work shall be carried out carefully to avoid any over-excavation. If somewhere, and for any reason, excavation are executed beyond the established design level, the contractor shall at this own expenses backfill to engineer's approval, the volume corresponding to over excavation. On completion, the work shall 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.

d. Disposal: The excavated soils shall be disposed of within 8 km crow fly distance from site as directed by the Engineer-in-charge in any or all the following manners:

i) By using it for backfilling straightway.

ii) By stacking it temporarily for use in backfilling at a later date during execution.

iii) By either spreading or spreading and compacting at designated disposal areas.

iv) By selecting the useful material and stacking it nearly in areas designated by the Engineer for use in backfilling by some other agency.

e. Disposal of Surplus: The surplus material from excavation shall be carried away from the excavation site to designated disposal area selected by the Engineer. All goods excavated from the pits and all assorted materials of dismantled structures shall be the property of the Purchaser.

20.6 BACK-FILLING

a. The backfilling material shall consist of materials, 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.

b. Filling and compaction in pits and trenches around structures: As soon as the work in foundations has been accepted and measured, the space 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 the satisfaction of the Engineer. Earth shall be rammed with approved mechanized compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the Engineer. The final surface shall be trimmed and leveled to proper profile as desired by the Engineer. Since the degree of compaction depends on the moisture content of the soil, a close watch should be kept on it and corrections done to optimize the moisture content.

The backfilling shall be carried out at optimum moisture content to achieve density requirements as per standard proctor test as under:-

i) Backfilling of foundations and under grade slabs-95% of proctor's maximum dry density.

ii) Under roadways and packing areas- 95% of proctor’s maximum dry density.
iii) Embankment- 95% of proctor’s maximum dry density

c. Plinth filling: The plinth shall be filled with earth in layers not exceeding 250 mm in loose thickness, watered and compacted 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 slopes intended to be given to the floor.

d. 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 disintegrated rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used for filling. 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.

e. Filling in disposal area: Surplus material from excavation which is not required for backfilling shall be disposed of in designated disposal areas within the lead for disposal as 5 km crow fly distance from the site. 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 shall 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.

20.7 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 plant. Sturdy and elegant fencing shall 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.

20.8 LIGHTING

Full scale area lighting should 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 filling.

20.9 TESTING AND ACCEPTANCE CRITERIA

a. Excavation: On completion of excavation, the dimensions of the pits shall be checked as per the drawings. After the pits are completely dewatered, the work shall 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 M10 proportion and/ or richer and/ or by compacted earth, as directed by the Engineer. Over excavation of the sides shall be made good while carrying out the back-filling. The excavation work shall be accepted after the above requirements are fulfilled and all temporary approaches encroaching inside the required dimension of the excavation have been removed.

e. Back-filling: The degree of compaction required shall be as per IS standards and the actual method of measuring the compaction achieved shall be as decided by the Engineer. The work of back-filling shall be accepted after the Engineer is satisfied with the degree of compaction achieved. <u>One Proctor and three density tests shall be made at every fourth fill layer prior to continuation of filling work. The testing location will be indicated by the Engineer</u>.

20.10 FILL MATERIALS

The fill materials used and source are to be examined and approved.

Excavation materials can be used if they fulfill the requirements.

Select fill:

Select fill shall have the following properties:

Well graded (uniformity index not less than 5), non-cohesive and nearly silt free (silt content not greater than 5%; up to 10% tolerated, except below footings of structures), salt free (content less than 3%), soils free of organic matter (limit 2%). Decomposing or compressible materials shall not be used.

All materials shall be of such nature and character that it can be compacted to the specified densities in a reasonable length of time. It shall be free of highly plastic clays, of all materials subject to decay, decomposition or dissolution, and of cinders or other materials which will corrode piping or other metal.

The intention is to use select fill below plinth, floors, roads, parking areas
Etc.

Ordinary fill:

Ordinary fill shall have the following properties:

i) Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%. For other properties see under 'Select fill'.

ii) Pond Ash.

The intention is to use ordinary fill for non-built areas.

Special fill: Special fill material shall be gravel or crushed rock (for other properties see under 'Select fill'). The intention is to use special fill e.g. as sub-base material for tanks and roads.

Rip-rap/Rock fill:

Rip-rap must be of a size suitable for the place where it is to be used, as determined by the speed of the current, wave height and depth of water. Rip-rap shall be of deformable and yielding construction, using round stones if the intention is to safeguard the underlying ground against scour. If the rock infill is to be used as a foundation for structural components, the aim should be to secure effective bedding of angular stones under water. The stones must be weather and waterproof.

20.11 DEWATERING DURING CONSTRUCTION

20.11.1 General

This division applies to the methods and techniques of ground water control. Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions have to be obtained from the results of the soil investigation and/or information given in writing by the Engineer.

All costs for ground water control for keeping the construction pits dry shall be included in the relevant excavation items of the lump sum except otherwise indicated.

The method and technique shall be based on the IS: 3764.

The scope of supply includes the installation of all equipment, plants, pipes, machinery, etc. and its removal after completion including operation & maintenance of the equipment during the construction period.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and any other works required for the water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that alterations and extensions can be made at any time throughout the operating time, if necessary. Reserve units shall be kept ready for service when failure of any of the installed units occurs.

The contractor has to consider the possibility of a temporary failure of any pump, diesel engine and/or the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the installed unit at the moment of failure. The contractor shall submit to the Engineer, the detailed method of the envisaged pumping system for dewatering, the pump capacity and the standby reserve units. The contractor shall adjust the system if required by the Engineer.

The contractor must ensure that any dewatering works will not cause any interference to his own work and to those of other contractors working elsewhere on site or at structures under construction. Any damage occurring during the above mentioned period shall then be made good by the contractor at his own expense.

During the foundation works, the excavated areas, foundation levels, and pits are to be kept free of water down to at least 0.50 m below the foundation level.

CHAPTER – 21

WATER SUPPLY, DRAINAGE AND SANITATION

21.1 The technical details of surface drainage, storm water drainage, sewerage disposal system, sanitary appliances and water supply required for proper supply, drainage, disposal and completion of buildings are detailed below:

21.2 SURFACE DRAINAGE

a) All the paved and unpaved areas shall be adequately drained. The surface drainage system shall be designed for surface washings and / or rain / fire water as the case may be. Unpaved open areas shall be drained through RCC drains and connected to main storm drains.

b) The paved area shall be sloped towards the drains with a minimum slope of 1 in 100. The maximum drainage travel extent shall be limited to 10 metres.

c) The surface drainage from uncontaminated area shall be connected to nearest open storm water drains through rectangular drains. Contaminated area surface drainage shall be collected through separate network.

d) The interconnecting pipes and rectangular drains shall be sized for carrying the design discharge when running full.

e) The rectangular drains shall be minimum 450 mm wide of RCC construction. The pipes for water drainage system shall be of RCC class NP2 conforming to IS:458 with minimum size of 150 mm NB. However, for road crossings etc., pipe of class NP3 SHALL BE PROVIDED. For rail crossings, pipes conforming to railway loading standards shall be provided. If sufficient clearance cannot be provided between the top of the pipe and road top, the pipes shall be encased in RCC. Minimum clear width of drain shall be 300 mm.

f) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum velocity for self cleansing of 0.6m/sec shall be ensured. Slope of drain shall not be milder than 1 in 1000.

g) Minimum earth cover of 450 mm shall be provided over drainage pipes in paved areas.

h) Garland drains minimum 300mm wide shall be provided allround the building to lead away roof drainage to plant drainage system. Plinth protection in PCC grade 1:2:4 shall be provided between brick wall and drain with appropriate slope.

21.3 STORM WATER DRAINAGE SYSTEM

a) The plant storm water drainage system shall take into account the topography of the plant area, area drainage patterns and intensity of rainfall etc. The drainage system shall be designed for a precipitation intensity equal to hourly rainfall for a return period of 1 in 50 years. However, storm frequency of 100 years return period shall be applied for Coal Storage area. These values shall be based on the recommendations of Indian metrological department (IMD).

b) All storm water drainage shall preferably be through open storm water drains. These shall be provided on both sides of the roads and shall be designed to drain the appropriate catchment area including road surface, open and covered area etc. The drains shall be minimum 300 mm wide at the base.

c) For open trapezoidal drains, brick masonry lining on sides and bottom shall be provided. Bricks shall be laid in cement mortar and joints pointed flush. The thickness of lining shall be minimum 115mm. The lining shall be with fly ash bricks of class designation 150N/sqmm laid in cement sand mortar 1:4 and flush pointed with cement sand mortar 1:2. The side slopes upon which lining has to rest shall be made such that no earth pressure is exerted upon lining in any conditions. However, the side slope shall not be steeper than 2 vertical to 1 horizontal. Alternatively, open drains trapezoidal in cross section may be provided in PCC lining of M15 grade. The thickness of PCC lining shall be minimum 100mm or as per design requirements whichever is higher.

d) All open drains rectangular in cross section shall be in RCC. In the main plant block, rectangular section RCC drains in minimum M25 grade concrete shall be provided. The thickness of side and bottom shall be minimum 125 mm or as per design considerations whichever is higher.

e) The pipes for water drainage system shall be concrete pipes of class NP2 conforming to IS:458. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. Diameter of pipes used for drainage / culverts shall be between 300 mm to 600mm. Beyond 600mm, box drains / culverts shall be provided. Also refer sec. 41.0 of Part B, Vol. VI .

f) Surface drains shall normally have a bed slope not milder than 1 in 1000 along longitudinal direction and RCC pipes shall have such slopes so as to have effective discharge. The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However, minimum velocity for self cleansing of 0.6m/sec shall be ensured at peak flow condition (i.e. 3 times average flow) for pipes flowing at half full.

g) Suitable manholes shall be provided to piped drainage lines at every 30m intervals, at junctions and at change of gradient, alignment and diameter of pipe and shall be of masonry or RCC construction. Minimum size of manholes shall be 1.0m x 1.0m. All manholes shall be designed considering maintenance, inspection and cleaning of pipes. Easy accessibility and safety shall also be given due consideration.

h) The cushion over the pipes for storm culverts shall be minimum 600mm. Where less cushion is available, pipe shall been cased in RCC m-15. Suitable RCC or masonry structures shall be provided at drops / falls to prevent scouring or damage to surface.

i) Invert of drainage pipe / drain shall be decided in such a way that the water can easily be discharged above the high water level in to storm water holding pond.

The storm water drainage for the contaminated area such as coal stack pile, fuel oil area, oil skids, ash silo area etc. shall be designed separately and the discharge shall be led separately for treatment and disposal.

21.4 WASTE WATER TREATMENT AND DRAINAGE SYSTEM

Waste water treatment plant will receive plant waste water and CT blow down. The treated water will be used within the plant.

The cooling tower blow down shall be pumped to CMB/Ash water sump.

All necessary civil / structural works for waste water treatment plant shall be under scope of contractor. The major source of plant waste water are Boiler blow down, coal mill area drainage, PH and boiler area oily effluent drain, F.O. pump house oil drainage, boiler and ESP area floor washing drains, water pre-treatment plant effluent, fly ash silo area effluent, transformer yard waste water etc. <u>Design and construction of all channels / settling pits / sumps / pipe lines / separators shall be done by the Bidder.</u>

The description of some of the major structures / components covered under the waste water system package is given below:

Coal pile area run-off will be led to settling pond. R.C.C settling pond with two (2) compartments will be provided. Top of pond shall be 500 mm above surrounding finished grade level to restrict ingress of storm water from adjacent areas. Capacity of pond shall be determined on the basis of inlet drain invert. At the downstream of pond, RCC overflow weir and sump shall be provided. Design and detailing of pond shall be as per good engineering practice so as to satisfy functional requirement as specified in the specification. Necessary sluice gates with hoisting arrangement shall be provided in inlet drain carrying coal pile area run-off so that one settling pond can be operative while the other one under maintenance.

The Power House and boiler area service water waste shall be collected in a RCC underground oily waste sump pit. Necessary pumps and supporting floor / maintenance area shall be provided. This effluent will finally be treated in TPI (tilted plate interceptor).

Oil storage and handling area run-off will be collected to a conventional baffled oil water separator. This oil water separator will be an underground RCC structure having RCC baffle wall and overflow sump for collecting water at outlet end. An oil collection pit shall be provided on sidewall of oil water separator. This structure shall be designed as un-cracked section as per IS:3370. The structure shall project at least 300 mm above finished grade sddlevel. Handrail shall also be provided around the pit. The overflow sump shall be covered at top over which pumps will be installed.

RCC sump for collecting boiler blow down and ESP area floor washing is included in scope of bidder. Civil work for outlet of this effluent shall also be under scope of this package.

RCC sump for collecting boiler blow down and ESP area floor washing **for unit-I & II and ash silo washing** is also covered under the scope of bidder

The Waste of DM plant and CPU will go to CMB, through neutralization pit. The waste water shall be treated in ETP and reused. Refer VOL-III for ETP.

The partial list of Civil Structures in the waste water treatment (ETP) shall include the following.(Any other structure those required to complete the waste water system, shall also to be in the scope of bidder.)

1) Waste water RCC sumps located all over the plant as described in VOL-III, Chapter 11 of technical specification.

2) RCC central monitering basin (in two compartments) as described in VOL-III, Chapter 11, of technical specification.

3) RCC Clarifier.

4) RCC ETP clarified water sump of capcity as described in VOL-III, Chapter11 of technical specification.

5) RCC Clarified water pump house to house DM feed and clarified water pumps.

6) RO DM Building (RCC) to house RO & DM Plant.

7) RCC Degasser Tower.

8) RCC Coal settling pond as describer in VOL-III, Chapter11 of technical specification.

9) MCC & Control room building.

10) RCC ESP area pre settling pit as described in VOL-III, Chapter11 of technical specification.

21.5 SANITARY SEWERAGE SYSTEM

Sanitary Sewerage System shall be carried out as specified in VOL – III (Mechanical Spec.).

The treated water to be provided with necessary pumps and distribution lines for reutilization for Horticulture / Green belt development.

The sewerage system of foul water from toilet shall include layout and laying of sewers up to a sewage treatment plant together with all fittings and fixture and inclusive of ancillary works such as connections, installation of man-hole and inspection chambers. The construction of a sewage treatment plant of adequate capacity including settling tank, lifting stations, pump house and all other necessary provisions shall be made for treating the sewage water by using the latest CAACO technology developed by M/s. Central Leather Research Institute, Taramani, Chennai.

The domestic effluent from the plant shall be collected and treated in proper STP to meet the prescribed BIS standard before being discharged or reutilized for green belt development.

21.5.1 **Sanitary Sewer Drains**

a) Sanitary sewers shall be designed for a minimum self cleansing velocity of 0.75 m/sec. and the maximum velocity shall not exceed 2.5m/sec.

b) Very hot (over 60^0C) water shall be first cooled down to less than 60^0C in collecting basin by mixing with cold water before connecting to storm drainage system.

c) The maximum temperature, quality, quantity and location of drain water of individual equipment shall be tabulated and furnished to the Owner's representative.

d) All underground piping below concrete slab shall be cast iron of minimum 100mm dia and for outdoors it shall be reinforced concrete pipe of minimum 200mm diameter. In buried piping system manholes shall be placed at junctions and at change of gradient, alignment, direction and diameter of pipe and at every 30M (max.) interval in straight run Suitable clean outs shall be provided for buried piping under floor slab.

e) Following minimum drainage slope shall be provided:

- Pipes of diameter less than 200mm : 1 (vertical) : 100 (horizontal)
- Pipes of diameter 200mm & more: 1 (vertical): 200 (horizontal).

21.6 **SEWERAGE PIPES**

a) **Glazed Stoneware Pipes**

Glazed stoneware pipes of diameter not exceeding 150 mm can be used in localized areas not subjected to any traffic loads. The glazed stoneware pipes with spigot and socket ends shall conform to IS: 651 Grade "A" or "AA" as specified. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipe shall be free from erasing. The pipes shall give a sharp clear note when struck with a light hammer. There shall be no broken blisters. The pipes shall be handled with sufficient care to avoid damage to them.

b) **HDPE soil, waste, vent pipes and fittings**

i) HDPE soil, waste, vent pipes and fittings shall be of "Approved make" conforming to I.S. 4984-1995. The outer and inner surfaces of the pipes and fittings shall be smooth and clean and shall in all respects be free from cracks, pin holes, laps or other imperfections, which may impair the strength and durability of the pipes and fittings. The ends of the pipes shall be reasonably square to their axes.

ii) The clamps for fixing the pipes to the external wall shall be of approved design and shall fit closely round the pipe or accessory directly beneath the socket.

iii) The HDPE. soil, waste and vent pipes shall normally be fixed externally to the wall or in suitably designed shafts as per alignment shown on the drawings or as directed by the Engineer. The pipes shall be fixed and kept in position by means of brackets or holder clamps which shall be securely embedded in the wall. For vertical runs, each pipe shall hang freely on its own brackets fixed just below the socket. For horizontal runs, an additional clamp shall be provided at the centre. The brackets or clamps should be of such a design so as to maintain a minimum distance of 50 mm between the surface of the pipe and the wall.

iv) The soil, waste or vent pipes shall be carried up, above the roof by a least 1.5 m and shall have a cowl of suitable design at the upper end.

c) **RCC Pipes**

i) RCC pipes shall be used below ground level for sewage disposal. Pipes connecting toilet facilities to manholes shall be minimum 100 mm diameter NB. Pipes connecting various manholes shall be minimum 150 mm diameter NB. RCC Hume pipes shall be supplied and laid as required as per latest editions of the following IS codes:

IS : 458	:	Concrete pipes (with and without reinforcement)
IS : 783	:	Code or practice for laying of concrete pipes
IS : 4111(Part-1)	:	Code of practice for ancillary structure in sewerage system

ii) The contractor shall supply the RCC hume pipes [class NP3/NP2] of various diameters along with fittings required for carrying out the work. The contractor should furnish manufacturer's test certificates from recognized authorities. PCC encasement shall also be provided whenever required as per design requirement.

iii) **Alignment, Levels and Grade**

The work shall be carried out in conformance to the alignments, levels and grades specified. The layout and levels shall be made by the contractor from one reference grid and bench mark given by the Engineer with the assistance of instruments, materials and men for checking the detailed layout and levels as and when required. Making of reference layout and level pillars along the pipeline route and maintaining them upto completion of the work shall be the Contractor's responsibility.

iv) **Laying of Pipes**

The laying of RCC pipes shall conform to IS:783. To suit the site conditions, the pipes should be laid as per drawings and instructions of the Engineer. Under the culvert condition, the pipe shall be laid under embankment and may project wholly or partly above the original ground surface.

Under trench condition, the pipe shall be laid in the excavated trench which shall be refilled with thoroughly tamped earth after laying and jointing of pipes in an approved manner. Adequate sand field cushioning shall be provided below pipes. Minimum depth of cushion shall be 600 mm.

Under open condition, the pipe shall laid such that it projects wholly or partly above original ground surface, there being no super imposed over burden on the pipe.

v) **Bedding and Supports**

Under culvert and trench condition, the pipes shall be laid generally on "First Class bedding" as per IS:783. If shown on the drawing or so instructed by the Engineer, the pipes can be laid on concrete cradles, conforming to IS:783. Minimum crushing strength shall be 140 Kg/sqm. Under open condition, the pipes shall be supported over rigid C.C. pedestals constructed at intervals not greater than the length of one individual piece of pipe, as per drawings and instructions of the Engineer.In no case shall the joint between two pieces of pipe shall lie at center of the span between the supports. The pedestal shall be of plain/reinforced concrete with a properly shaped out top to receive the pipe.Manholes shall be provided as per latest IS:4111 (Part-I) for pipe drains at the change of diameter of pipe, alignment and direction at a max. spacing of 30 m c/c upto 900 mm diameter and 45 m c/c for higher diameters of the pipe. Each manhole shall be provided with a heavy duty C.I. cover as per IS:1726.

d) **Jointing**

i) **Glazed Stoneware Pipes**

The cement mortar for jointing shall be 1:3 (1 cement: 3 fine sand) with spun yarn in neat cement. Tarred gasket or hemp/ spun yarn soaked in thick cement slurry shall first be placed round the spigot of each pipe and the spigot shall then be placed well into the socket of the pipe previously laid. Then pipe shall be adjusted and fixed in the correct position and gasket/ spun yarn caulked tightly so as to fill not more than ¼ th of the total depth of the socket.

The remainder of the socket shall be filled with stiff mixture of cement mortar in the proportion of 1:1 (1 cement: 1 fine sand). When the socket is filled, a fillet shall be formed round the joint with a trowel forming an angle of 45 Degree with the barrel of the pipe. After a day's work any extraneous material shall be removed from the inside of the pipe. The newly made joints shall be cured.

ii) **Jointing of RCC pipes**

IS : 783 provisions shall be followed for jointing of pipes; and every possible care shall be taken to ensure that the joints made are leak proof. Curing of joints shall be done for a period of 10 days.

e) **Testing of Joints**

i) **Stone Ware Pipes**

Stone ware pipes used for sewers shall be subjected to test pressure of 1.5M head of water at the highest point of the section under test. The test shall be carried out by suitably plugging the low end of the drain and the ends of the connection 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 vertical pipe jointed to it so as to provide the required test head. Or this 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.

ii) **RCC pipes**

All RCC pipe joints shall be checked for water tightness as per relevant IS code.

21.7 **WATER SUPPLY**

a) All water supply pipes for internal plumbing of buildings shall be of GI pipe of medium class conforming to IS: 1239 of approved make. Galvanizing of pipes shall conform to IS: 4736.

b) The pipes and sockets shall be cleanly finished, well galvanized in and out and free from cracks, surface flaws, laminations and other defects; all screw threads shall be clean and well cut. The ends shall be cut cleanly, and square with the axis of the tube. The thickness and weight of pipes and sockets shall be in accordance with IS: 1239.

All screwed tubes and sockets shall have pipe threads conforming to latest IS: 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

c) The pipe fittings shall be of malleable cast iron or mild steel tubes complying with all the appropriate requirements of clause No.3 or as specified. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended. The fittings shall have screw threads at the ends conforming to IS: 554 (latest edition). Female threads on fittings shall be parallel and male threads (except on running sipples and collars of unions) shall be taper.

d) Cutting, Laying and Jointing -Where the pipes have to be cut or rethreaded, the ends shall be carefully filled out so that no obstruction to bore is offered. The ends of the pipes shall then be threaded conforming to IS: 554 (latest edition) with pipe dies and tapes carefully in such a manner as well not result in slackness of joints when the two pieces are screwed together. The tapes and dies shall be used only for straightening screw threads which have become bent or damaged and shall not be used for turning of the threads so as to make them slack, as the later procedure may not result in a water tight joints. The screw threads of pipes and fittings shall be protected from the damage until they are fitted.

The pipes shall be cleaned and cleared of all foreign matter before being laid. In joining the pipes, the inside of the sockets and the screwed end of the pipes shall be oiled and rubbed over with white lead; and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the sockets, tee etc. with the pipe wrench. Care should be taken that all the pipes and fittings are properly jointed so as to make the joints completely water-tight; and pipes are kept at all times free from dust and dirt during fixing. Bore from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

Any threads exposed after joining shall be painted or in case of under-ground piping thickly coated with approved anticorrosive paint to prevent corrosion.

e) **Fitting**

(i) For internal work, the galvanized pipes fittings shall be done by means of standard pattern holder bat clamps, keeping the pipes about 1.5 cm. clear of the wall. When it is found necessary to conceal the pipes chasing may be adopted or pipes fixed in the ducts or recesses etc. provided there is sufficient space to work on the pipes with the usual tools. The pipes shall not be buried in walls or solid floors,where unavoidable pipes may be buried for short distances provided adequate protection is given against damage and where so required joints are not buried. Where directed by the Engineer, a steel tube sleeve shall be fixed at a place a pipe is passing through a wall or floor for reception of the pipe and to allow freedom for expansion and contraction and other movements. In case the pipe is embedded in wall or floors, it should be painted with anticorrosive bitumastic paint of approved quality. The pipe should not come in contact with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipes shall be laid in layer of sand filling done under concrete floors.

ii) All pipes and fittings shall be fixed truly vertical and horizontal unless unavoidable. The pipes shall be fixed to walls with standard pattern holder bat clamps of required shape and size so as to fit tightly on the pipes when tightened with screw bolts. The clamps shall be embedded in brick work in cement mortar 1:3 (1 cement : 3 coarse sand) and shall be spaced at regular intervals in straight lengths as indicated below :-

Size of pipe (mm)	L E N G T H S	
	Horizontal runs (m)	Verticalruns (m)
15	2	2.5
20	2.5	3
25	2.5	3
32	2.5	3
40	3	3.5
50	3.5	3.5
65	3.5	5
80	3.5	5

The clamps shall be fixed at shorter lengths near the fittings as directed by the Engineer.

iii) For G.I. Pipes 15mm to 25 mm dia, the holes in the walls and floors shall be made by drilling with chisel or jumper and not by dismantling the brick work or concrete. However, for bigger dimension pipes, the holes shall be carefully made of the smallest size as directed by the Engineer. After fixing the pipes, the holes shall be made good with cement mortar 1:3 (1 cement and 3 coarse sand) and properly finished to match the adjacent surface.

21.8 TRENCHES AND OTHER EXCAVATIONS FOR PIPE LAYING

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 handpacking 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.

21.9 a) **Water Closet**

(i) Minimum one number main toilet block for Gents, Ladies & Officers separately, with required facilities shall be provided on each floor of Service building Aministration building and Canteen building. Toilets for physically handicapped shall be provided as mentioned. All other buildings shall have minimum one toilet block each. The facilities to be provided shall be as stipulated in subsequent clause. <u>IS:1172 shall be followed for working out the basic requirements for water supply,</u>

drainage and sanitation. In addition, IS:2064 and IS:2065 shall also be followed.

Each Toilet block shall have the following minimum facilties. Unless specified all the fittings shall be of Chromium plated brass (fancy type)

(ii) The water closet shall be of Orissa pan/European type of approved make, Vitreous China conforming to IS: 2556 Part- III. The closet shall be of size as specified. The flushing rim shall be integral with the pan and shall be Self draining type. The closet shall be provided with a self cleaning trap of the same material as the pan. The trap shall be either a "P" or "S" outlet and with a vent hole. The effective depth of the water Seal shall not be less than 50 mm.

(iii) The pan shall be fixed in position as shown on the drawing. It shall be embedded on a suitably prepared surface rendered smooth with neat cement or cement plaster so that uniform support is provided to the pan. The pan shall normally be at the floor level unless otherwise specified. The WC pan shall be fixed to the trap by means of a cement mortar joint as in the case of SW pipes; and the entire job carried out so that the effective seal is always kept maintained the vent of the trap being connected to Anti siphonage pipe.

(iv) While laying flooring, a section about 1 x 1.5 m or less of the part of the floor where WC is to be fixed shall be left out. This shall be finished only after the pan has been fixed and laid in position. The pan shall be kept suitably protected against all damages. It shall include both pan and trap, as well as fixing materials as needed.

b) **Flushing Cisterns for Water Closets**

The flushing cistern for water closet shall be of PVC low level type of 10 Ltr. capacity (IS 2556 mark) with PVC bend of approved make. The cistern shall be secured on wall or supported on steel brackets which shall be well embedded in the wall. The height of the bottom of the cistern from the top of the pan shall be 30 cm for low level cistern. The cistern shall be provided with brass balcock with ball to IS:1703. It shall include brackets, screw, flush pipes, brass ball cock with ball as needed.

c) The Urinal shall be of first quality, White Glazed Vitreous china flat back conforming to IS 2556 of size as specified and of approved make. The urinal shall be fixed in position by means of four plugs embedded in wall and screws, the top of urinal lip being 65 cm from the floor level. Urinal bring a soil fitment should be connected to soil pipe. Each urinal shall be provided with 25 mm dia B Class GI Waste pipe connected to the pan by suitable joint and shall discharge in to a drain connected to a soil pipe through a trap. The flushing of urinal shall be with all fittings including photovoltaic control flushing system as per IS:2556 (Part-6 Section-1). Provision of stone/granite partitions in between urinals shall be made.

d) The wash basin (oval shape) with all fittings as per IS:2556 made of vitreous China clay to be fixed on a concrete plat form finished with 12 mm thick polished granite stone. The basin shall be provided with single tap connection. The washbasin shall have an integral soap holder recess or recesses which shall drain into the bowl.

Each Wash Basin shall be provided with :

i) 32 mm ø CP brass waste fitting with CP brass chain and 32 mm dia plug.

ii) 25 mm ø galvanized waste pipe "B" class discharging into a drain suitably connected to waste fitting by means of brass check nuts.

iii) 15 mm ø CP pillar taps of superior quality to IS-8994 of approved make.

e) All toilets shall have at least one No. of exhaust fan. The No. of exhaust fan shall be decided as per ventilation requirements to maintain the high hygienic conditions in the toilet.

f) One number looking mirror 600 x 900 x 6mm, edge mounted with teak beading and minimum 12mm thick plywood backing, one number stainless towel rail 600 x 20mm, one number liquid soap dispenser.

g) One toilet with required facilities shall be provided for physically challenged persons as per National Code requirements in GRIHA rated buildings.

h) In addition to the facilities stipulated elsewhere Bathroom with rotating type chromium plated shower including all fitting and fixtures shall also be provided in toilet at ground and operating floor of main plant and any other building as per functional requirement.

j) Janitor Space & Space for drinking water cooler.

j) Electric operated hand dryer with photo voltaic control.

k) The pantry shall consist of one number stainless steel pantry sink, as per IS:13983, of size 610 x 510mm, bowl depth 200mm with drain board of at least 450mm length with trap, hot and cold water mixer, one number geyser of 25 liters capacity, with inlet and outlet connections, one number HDPE loft type / over head water storage tank, as per IS:12701 and of 500 liters capacity, complete with float valve, overflow drainage pipe arrangement, GI concealed water supply pipe of minimum 12mm dia of medium class, cast iron sanitary pipe (with lead joints) of minimum 75mm diameter, floor trap with Stainless.

Steel grating, inlet and outlet connections for supply and drainage, with all bends, tees, junctions, sockets, etc., as are necessary for the commissioning and efficient functioning of the pantry (all sanitary fittings shall be heavy duty chrome plated brass, unless noted otherwise)

l) Laboratory sink shall be of white vitreous china of size 600x400x200mm conforming to IS:2556 (Part-5)

m) In addition, adequate number of portable toilet units with adequate plumbing and sanitary arrangement, shall be provided during construction state.

CHAPTER – 22

SWITCHYARD CIVIL WORKS

22.1 CIVIL WORKS FOR SWITCHYARD INCLUDES

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

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

c. Switchyard Control room building, foundation for AC Kiosks etc.

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

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

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

g. Cable trenches in switchyard and inside control room building including civil works for panel fixing etc.

h. For prevention of vegetation, the graded ground shall be covered with Fly Ash Brick pavement over 300mm as filling in the switchyard area.
Each fly ash layer shall be compacted / consolidated by using half tone roller with 4 to 5 passes and suitable water sprinkling.

22.2 DESIGN CRITERIA

22.2.1 Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to Grade IS:2062 or IS:8500 and duly galvanized conforming to IS: 2629 and IS: 4759. All joints shall be bolted connections. All bolts for connections shall be of 16mm dia conforming to IS: 12427 and of property class 5.6 as per IS:1367 (Part 3). Nuts shall conform to IS:1363 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624 and property class shall be 4.6 as per IS:1367 (Part-3). Butt splice shall be used for splicing the main members and splice shall be located away from the node point. IS: 802 "Code of practice for use of structural steel in overhead transmission line towers" shall be followed for design of structures. Height & type of towers shall be established based on electrical requirements. A provision of ± 30 degree angle of deviation of line in horizontal plane and ± 20 degree deviation in vertical plane is considered and the resulting worst combination of forces shall be considered for design. For all outgoing and incoming feeders, the conductor span shall be taken as 200m for design purpose.

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

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

2) Live loads,

3) Wind loads

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

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

4) Seismic loads,

5) Temperature load,

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

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

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

9) Erection loads,

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

Note:

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

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

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

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

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

22.2.3 **Factor of safety:**

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

Design of foundation shall be carriedout as per IS Code 4091.

Design consideration for switchyard equipment support:

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

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

The supporting structure for CT, CSE & Wave Trap equipment shall be comprised of lattice structural steel conforming to IS 2026 and shall be designed as per IS: 802. Common raft foundation shall be provided for each pole of isolator.

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

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

The Switchyard Control Room building shall have RCC framed super structure with one brick thick wall cladding on exterior face. The Control room building shall consist of rooms/facilities/ equipments/ monorail as per system requirement. An open space of one meter width (minimum) shall be provided on the periphery of the panel rows and equipment to allow easy operator movement and access for maintenance purposes. The design of RCC structures shall generally be carried out using limit state method of design as per IS: 456. The minimum grade of concrete shall be of RCC M25 as per IS: 456.

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

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

22.2.7 All structural steel members including stub members, bolts, nuts, spring washers, etc., shall be hot dip galvanized. After fabrication Minimum section thickness should not be less than 4 mm. The Weight of zinc coating shall be at least 0.910 kg/m^2. Zinc required for galvanizing shall be 99.5% as per IS:209. All burrs and irregular edges shall be ground smooth before galvanizing.

The galvanized steel member shall withstand in copper suplphate solution as per IS:2633. When the steel section is removed from the galvanizing kettle, excess spelter shall be removed. The process known as 'wiping' or scrapping' shall not be used for this purpose. Spring washers shall be electro-galvanized.

The design of foundation should take care of sub soil water pressure as per relevant IS Codes.

22.2.8 **Cable Trenches**

Cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 300 mm above the finished formation level so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. <u>The downstream end of cable trenches shall be connected to sump pits and the sump pits be provided with dewatering system through permanently fixed submersible pumps</u>. The precast covers shall not be more than 300mm in width and shall not be more than 65 kg. Lifting hooks shall be provided in the precast covers. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of corners of concrete is expected. All cable trenches shall be provided with suitable insert plates for fixing support angles of cable trays.

All internal cable trenches shall have minimum 6mm thick (o / p) chequered plate covers while external cable trenches shall have pre - cast RCC covers. However, the portion of the cable trench behind and sides of control panel / MCC shall be provided with suitable chequered plate covers as directed by the Engineer. Cable trenches inside switchyard, having depth more than 500mm, shall have wall thickness of minimum 150mm with two layer reinforcement. The design of trenches to take care of sub soil water pressure as per relevant IS Codes.

22.2.9 **Gravel Filling:**

Gravel filling shall be provided as specified elsewhere in the specifications.. Each layer shall be compacted by using 1/2 tonne roller with 4-5 passes and suitable water sprinkling. Before laying the gravel fill, the top layer of the soil shall be treated for anti-weed considering the types of weeds found in the vicinity. The anti-weed/soil sterlization chemical shall be procured from reputed manufacturer. The Bidder shall submit necessary details pertaining to the types of weeds found in the vicinity, anti-weed/soil sterlization such as manufacturer's name, their specification, test certificate, etc., for Employer's approval. Any modification, if required in the proposed anti-weed treatment chemicals, shall have to be done by the Bidder at no extra cost to the Employer. The Bidder shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall commence from the date of completion of work or date of handing over, whichever is later.

22.2.10 **Transformer/reactor foundations**

Foundations of transformers/reactors shall be designed for seismic and wind loads. Block foundations shall be provided for the main transformer block. The oil soak pit, if provided, shall be filled with gravel of size 40mm. The volume of the soak pit shall be sufficient to store complete oil of the transformer/reactor along with 10 minutes of fire water considering only 40% of the volume as available voids between gravel filling. However, in case a separate oil collection tank is provided for the transformer/reactor, oil soak pit of volume equivalent to one-third (1/3) the oil volume of transformer/reactor shall be provided around transformer/reactor. The oil collection tank, in such cases, shall be designed for an effective capacity of complete oil of the transformer along with 10 minutes of fire water. The oil soak pit shall also be provided with a sump at the corner to allow drainage of water/oil from the soak pit and the sump be provided with dewatering system through permanently fixed submersible pumps. Arrangement for moving the transformer into place using rail cum road, jacking pads and pulling blocks including inserts, as required, shall be provided along with the transformer/reactor foundations. RCC Firewall shall also be provided between the transformers wherever required. 300 mm thick PCC M20 encasement all around the Pylon supports inside soak pit for fire fighting system shall be provided up to top of gravel filling. Coarse aggregate filling inside the transformer oil soak pit shall be carried out only after construction/erection of Pylon supports and PCC encasement.

CHAPTER – 23

CONCRETE ROAD AND RIGID PAVEMENT

23.1 PLANT ROADS

Access within the plant site shall be provided by a system of roadways.

All building shall be approached by access road, which shall either be single or double lane road depending upon the functional requirement. Access roads shall also be provided to areas such as transformer areas, steam generator area and other equipment area shown in the plot plan, where access is necessary for inspection, operation and maintenance.

Roads shall be three types: Type I, Type II and Type III. All the roads inside the plant area shall be of reinforced cement concrete of minimum 25 cm thick.

Type I roads shall consist of 8.0 metres wide RCC paved carriageway with 1.5m wide hard shoulders with drain on either side. The main plant access road and a portion of the main plant complex circumferential road shall be Type I.

Type II roads shall consist of one 4.5 metre wide RCC paved carriageway with 1.5m wide hard shoulders with drains on either side. A turning area at blind ends shall be provided. Plant areas where infrequent access is needed shall be served by Type II roads. Examples of Type II roads are the lay-down area roads.

Type III roads shall be of R.C.C & 3.75m wide with 1.0m wide hard shoulders on either side. Type III roads shall be provided along the plant boundary for access for security and maintenance.

All the roads shall be constructed before start of construction activities for power house and shall again be repaired / made good after completion of construction of activities i.e at the time of handover / project.

Road leading to main gate of power house shall be double lane road with suitable berm. Minimum thickness of road shall be 25 cm and width of 7.5m each.

All Type I roads shall have a minimum turning radius of 10 meters and for Type II and Type III roads shall have a minimum turning radius of 7 meter.

Bollards shall be provided along side of all type of roads near equipment which requires protection. Spare duct bank shall be provided under all type roads spaced at 100m intervals and at change points of minimum diameter 300mm.

Signs shall be provided for vehicle management and shall meet the Indian standards. All signs shall be dual worded in both English and the local Indian language. Finished top (crest) of roads shall be as per CEA guide lines. Geometric design of road shall be in accordance with IRC:73. The ruling gradient for roads in longitudinal direction shall not exceed 1 in 25.

The shoulder shall be laid with slope of 1 in 30.

Top level of parking area shall be flushed with crown connecting roads with cross slow. Parking area shall be provided rigid pavements & shall be provided with anti skid tiles.

On either side of type I and type II roads and on one side of type III roads, open drains shall be provided. Minimum clear width of drains shall be 600mm. The drains shall be designed and built using RCC. Drainage lines and other underground services shall be located at least 1m clear from the edge of the roads. All service and utility lines crossing the roads shall be taken through NP3 class RCC pipe designed for impact loading. All culverts carrying storm water shall be cast in place RCC box culverts.

No underground service piping except for drainage and sewage system shall run directly below the road (including upto 1 m. from edge of road) along its longitudinal direction.

Surface drainage of roads shall be provided by giving proper longitudinal slopes and cross falls.

The Roads must be designed for the heaviest equipment of the plant and before designing the CBR test to be carried out. Road shall be designed as per IRC & MOST standards. (MORTH)

The Cross section for road shall be as follows:

i The Sub-grade shall be 250 mm thick Granulated Sub-base compacted to 95% dry density.

ii 250 mm thick metal finish.

iii 100mm thick dry lean concrete

iv A separation membrane shall be used between concrete slab and the sub base. Membrane shall be impermeable plastic sheeting of 125 microns thick laid flat without creases

v Pavement 250 mm thick M30 mix, with single mat reinforcement of 12 dia @ 300 c/c both ways.

vi The drainage system shall be designed for precipitation intensity of 80mm per hour.

The specified is minimum and indicative and the contractor has to provide roads as per functional requirements.

The detailed specification may be prepared including construction and Expansion Joint

24.0 RAW WATER RESERVOIR (OPTIONAL)

24.1 Intent and Scope of the work

It is intended to cover general description and design criteria for Raw Water Reservoir.

A new Raw Water Reservoir shall be constructed having the storage capacity of minimum seven days of consumptive water requirement of 800MW unit. The above capacity will be generated partially by excavating the area to a specified bottom level of the Reservoir and partially by the formation of embankment with CI/CL type of soil obtained from excavation or from the borrow pit out side the plant area. A RCC partition wall shall be constructed to divide it into two compartments for cleaning of accumulated silt. Each compartment of the Reservoir will be fed separately.

Reservoir shall be lined with H.D.P.E liners and protective plain cement concrete layer of grade M-15 throughout and shall be provided in panel over a cement sand plaster in 1 : 6 to avoid damage of the liner.

Free board of 1000mm minimum shall be maintained. The maximum level of Reservoir shall 250mm below the invert level of raw water intake channel (leading to existing raw water reservoir).

Road of 3.75 m with one metre wide shoulder on both side of the road and around the embankment as well as a walkway on the RCC partition wall to facilitate inspection shall be provided. Road shall be designed as per IRC 37 and IRC 19. Expanded metal fencing as per IS specification 1.5 m high on the inner side of the shoulder and suitable railing on both side of walk way on partition wall shalll be provided.

24.2 Codes and standards

1S: 456	:	Codes of Practice for Plain and Reinforced Concrete.
1S: 1200	:	Method of measurement of building and civil (Part-I) Engineering work.
1S: 2720	:	Determination of moisture content (Part-II).
1S: 3370	:	Codes of practice for concrete structure for storage of liquids.
1S: 3764	:	Safety code for excavation work.
1S: 4558	:	Under drainage of lined canal.
1S: 10635	:	Free board requirement in embankment dams guidelines.

24.3 Hydro static effect on lining

The lining is intended to stop loss of water into the ground water table because the homogenous earthen dam with CI/CL soil will allow seepage of water to raise the ground water table in the surrounding area and hence the loss of water and buoyancy effect will be developed when ground water table in the adjoining area reaches the formation level and if the inside water level falls below the outside water table.

Due to the length of the reservoir, waves may be set up by wind blowing over it. According to IS: 10635 a wave height of 1.0 m may be obtained hence the free board shall be kept as 1.0m. Hence the top of embankment is kept 500 mm above the finished floor level of Main Power House building.

On the basis of area available for development of the reservoir and the required storage, the storage depth can be worked out. The bottom level of the reservoir shall be decided considering 300 mm as the allowance for deposition of silt in the interval for dredging of the silt and invert level of existing RCC water intake channel.

The observed highest flood level in the vicinity shall be considerd for setting out the above parameters. As a precautionary measure Pressure relief valve are to be provided which will start working even with 15 cm difference in water level between outside and inside the reservoir.

24.4 Design and details of Reservoir

The side slope shall be 1(vertical): 2(horizontal). Sides of the reservoir shalll also be lined with HPDE film and protective plain cement concrete layer of grade M-15 over a cement sand plaster in 1 : 6 to avoid damage of the liner.

One end of the film shall be anchored in toe wall and other end to be anchored at the top of the embankment.

A trench 300 mm wide and 300 mm deep is to be excavated at top of the embankment for anchoring HDPE film. A toe wall of concrete block set in cement sand mortar shall be constructed at the top of the embankment.

Overflow spill way will be provided in each compartment. These will be located near the pump house so that, if any overflow takes place, it will come to the notice of the operator of the pump house who can intimate the operator at the canal pump house. The over flow will led to the storm water drain. Over flow rate will be same as that of inflow rate.

For cleaning of accumulated silt, each compartment shall be emptied by turn. Emptying shall be done by portable pumps. A sump of 2 m x 2 m x 1.5 m deep sump shall be provided in each compartment for final emptying of the reservoir by portable pumps. These sump pits shall also be located away from pump house.

24.5 Pressure relief valves

The Pressure relief valves start operating as soon as there is a head difference of 15 cm.

The uplift pressure can generate only when out side water level is 15 cm above the invert level of the lining and reservoir is at minimum water level.

Considering the highest water level in the area and as per specifications under IS : 4558 and manufacturer's recommendations, the size, spacing and pattern of PRV shall be decided.

The pressure relief valves shall be tested at manufacturer's installation as well as at site.

24.6 H.D.P.E lining

Thickness of the HDPE lining shall be be provided considering its durability and operation against forces during installation etc. Thickness of H.D.P.E lining shall be minimum 1 mm with density 0.954 gms/cc yield strength 28 N/mm2 and width 6m/7m. Installation of H.D.P.E film shall be as per specification/Guidelines of approved applicator. Field test procedure and Manufacturer's test results shall be produced for verification of materials.

Laying of HDPE lining on the floor of the reservoir would require dry condition for construction.

24.7 Inlet water channel

Water inlet in proposed Raw water reservoir shall be through RCC covered channel. This new RCC Channel shall be connected to existing RCC Channel. Length of new RCC Channel shall be as per plot plan/Site condition.

Invert level. of the proposed New raw water reservoir shall be fixed considering the invert level of existing RCC Raw water intake channel.

All modification work of existing intake RCC channel to connect to proposed RCC channel is in the scope of bidder.

Bidder to ensure that raw water supply to existing raw water reservoir is not affected while carrying out the modification work in Existing RCC inlet channel.

24.8 Bidder shall note the following while submitting the price for New raw water reservoir.

a) Proposed raw water pump house as mentioned in clause 2.6(18) Chapter 2 shall be relocated from existing raw water reservoir to proposed raw water reservoir with all specified equipments.

b) Access road to this raw water pump house from nearest existing road shall be included in scope of work of bidder.

c) Desilting of existing raw water reservoir as mentioned in Chapter 2 of this specification will not be applicable.

d) Additional Cost towards increase in pumps/motors with associated electrical works, raw water pump discharge piping and AHP make up pumps piping shall be included.