Clause No.	CIVIL WORKS
1.00.00	**GENERAL**
1.01.00	This specification covers design, preparation of general arrangement drawings, construction and fabrication drawings, supply of labour, materials and construction of all civil, structural and architectural works. Description of various items of work under this specification and nature of work in detail are given hereinafter. The complete work under this scope is referred to as Civil Works. Various buildings, structures, plant and systems, facilities, etc., covered under the scope are given in Volume-III, Section-VI, Part-A. Irrespective of what is stated in this document, all civil works required to complete the entire scope of work specified elsewhere within the battery limits (terminal points) of this bid document shall be deemed to be in the scope of this contract. The work to be performed under this specification consists of design, engineering and providing all labour, materials, consumables, equipment, temporary works, temporary storage sheds, temporary colony for labour and staff, temporary site offices, constructional plants, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for the completion and proper functioning of the plant, all in strict accordance with the specifications including revisions and amendments thereto as may be required during the execution of work. All materials including cement, reinforcement steel and structural steel, etc., shall be provided by the Bidder. The scope shall also include setting up by the Bidder a complete testing laboratory in the field to carry out all relevant tests required for the Civil Works. The work shall be carried out according to the design/ drawings to be developed by the Bidder and approved by the Employer. For all buildings, facilities, systems, structures, etc., necessary layout and details are to be developed by the Bidder keeping in view the statutory and functional requirements and providing enough space and access for operation, use and maintenance. The Bidder's work shall cover complete requirements as per IS codes, fire safety norms, requirements of various statutory bodies, International Standards, best prevailing practices and to the complete satisfaction of the Employer. The Bidder shall do all works related to site clearance including levelling, grading and finishing. The formation levels of different areas are as indicated in general layout plan drawing enclosed with this specification. All survey and other related works shall be done by the Bidder as specified in scope of works. The bidder shall carry out detailed survey and soil investigation work as required for the entire plant area. The soil investigation report shall be prepared with detailed recommendations regarding type of foundations and other soil parameters. The report shall be submitted for Employer's approval prior to commencement of

design of foundations.

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

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

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

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

2.00.00 **SUBMISSIONS**

2.01.00 Commencement of fabrication and erection and construction shall be done after approval of the relevant documents and drawings. All drawings shall be of standard sizes (Metric System) and shall be made on AutoCAD. All documents shall be made using MS office. Bidder shall submit copies of all documents and drawings on CDs alongwith hard copies as specified elsewhere.

In addition to the requirements specified elsewhere in the specification 3D/2D structural frame analysis and design for the plant structures shall also be submitted by the bidder for Employer's review and approval.

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

a) Plant 'General Layout Plan' drawing with coordinates of roads, boundary wall, buildings and facilities, piping/cable corridors, green belt, etc.

b) Drawings showing underground facilities with co-ordinates and invert levels of the facilities like buried pipes, buried cables, trenches, ducts, sewers, drains, sumps, pits, culverts, manholes, foundations, etc. Existing structures, below & above ground shall also be incorporated to the extent they are relevant.

c) Architectural floor plans, including conceptual interior/ equipment and

furniture arrangement, elevations, cross-sections and perspective view in colour of all buildings i.e. for GT, ST, common control room, facility building, administrative building etc. including provision of sufficient natural light for GT & ST buildings. Bidder shall submit two different schemes along with a report elaborating the underlying philosophy of the proposed architectural concepts.

d) Survey drawings at mutually agreed grid size indicating spot levels for the required areas and L-section along pipe corridors.

e) Project design intent document giving the basis of design, which shall cover all the aspects, parameters, assumptions, references, structural idealisation/ mathematical model, loading cases, load combinations, analysis and design of all buildings, facilities, systems and structures etc. shall be furnished and got approved before commencement of detailed engineering.

f) Structural analysis, design calculations and drawings of substructure and super structures for all buildings, structures, facilities, and systems including cooling water ducts/ pipes.

g) Analysis, design calculations and drawings for all services like roads, culverts, bridges, road/ rail crossings, drainage pump houses, drains, sewers, sewage pump house, water supply, water tank, cable trestles, trenches, ducts, etc.

h) Design calculations including dynamic analysis and drawings for all foundations subjected to dynamic loads like foundation for TG, etc.

i) All architectural drawings required for execution of construction work such as detail floor plans, detail elevations, detail sections and other miscellaneous architectural details such as finish schedule, colour scheme (both internal and external), doors and windows, flooring including provision of north/ sky light in the roof of turbine bay, false flooring, false ceiling, etc., architectural facia and projections, miscellaneous architectural details, coping, flashing, khurras, water proofing, fillet, roof decking, wall cladding, surface drains, rain water down comers, sanitary, plumbing, etc.

j) Design calculations and drawings for interconnecting structure at reservoir outlet, raw water, firewater PH structure.

k) Design calculations and drawings for switchyard structures, transformer yard & oil separator pit etc.

l) Design calculations & drawings for CW pump house, sumps, channels, forebay, stop logs, trash racks, lifting arrangement etc.

m) Design calculations and drawings for civil structures/ work associated with Fuel Gas system.

n) Write-up on various statutory requirements and their compliance for various buildings, facilities, structures and systems, etc.

o) All reports of tests/ studies/ investigations including model studies carried out by the Bidder.

p) Shop drawings/ fabrication drawings of all structural steel works (only for reference) and design calculations for important joints/ connections.

q) Construction and erection procedure for all major structures such as GT & ST buildings, STG foundation, other machine foundations, HRSG stack, Bypass stack, C.W. PH, Cooling Towers and Clarifiers, etc. covered under the Bidder's scope.

r) Scheme for Geotechnical investigation, and detailed Geo-technical report.

s) In case of piling, scheme for initial pile load tests in vertical, lateral and uplift modes along with supporting design calculations, and methodology for installation of working piles.

t) In case of piling, the design of piles in terms of type, rated capacity, length, diameter and termination criteria to locate the founding level.

u) Marking scheme identifying the equipment lay-down areas, with distinctive colour scheme.

v) All other design details/drawings or any other submission as indicated elsewhere in this specification and as required by the Employer.

w) Details of corrosion protection measures for all structures.

x) All construction drawings shall include total quantity of concrete (grade wise), reinforcement steel (grade wise) and structural steel (section wise).

y) Specifications, design & drawings for profiled roof metal deckings and metal claddings.

z) Design calculations and drawings for HRSG supporting structures.

aa) Detailed hydraulic calculations, design & drawings for CW system, effluent treatment plant, water treatment plant, etc.

bb) Material test certificates.

cc) As built drawings with quantities of various items of work system wise,

building wise, structure wise, etc. duly certified by Site after execution of work for information/ record.

dd) The bidder has the option to use mild steel as per IS:2062 or medium/ high tensile steel conforming to IS:8500 for structural steel works in various buildings/ structures. He shall submit detailed fabrication and welding procedure along with his design/scheme drawings.

ee) A detailed basis of design, general arrangement drawings, detailed analysis, design calculation, detailed engineering drawings, bill of materials, detailed catalogue/ information of all direct supplied items pertaining to stacks.

ff) One complete set of applicable standards, references, specifications, code of practice, other than BIS(Bureau of Indian Standards), etc., to the Engineer for use at site.

gg) Analysis of proportioning of major foundations to minimise differential settlement.

hh) Wherever applicable, scheme for dewatering, shoring, strutting/ sheet piling and scheme for blasting (including controlled blasting) of hard rock.

3.00.00 DESIGN CRITERIA

3.01.00 **General**

3.01.01 The design criteria given herein is applicable for all structures and buildings including GT & ST buildings, Common Control building, Facility building, Administrative building, Trestles, Culverts, Bridges, Pump Houses, C.W. ducts, Water retaining/ carrying structures, Water System, Control Room, HRSG supporting structures, HRSG stack & stack supporting structures, By pass stack & stack supporting structures, compressor house, DG set building, switchyard structures, switch gear and other miscellaneous buildings, Roads, Drains, Sewers, Cables, pipe trestles etc. and various other works included in the scope of the bidder.

3.01.02 **Load Combinations:**

Structures shall be analysed and designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, piping loads (static, friction and dynamic), wind loads, seismic loads and temperature loads. In addition, Erection loads, loads and forces developed due to differential settlement shall also be considered.

Load combinations for Natural Draught Cooling Tower:

Following minimum load combinations shall be considered for analysis and design

A. DL +WL + SL

B. DL + SeL

C. DL+TL

D. DL+WL+TL+SL

E. DL+SeL+TL+SL

F. 1.0DL +1.5WL

Where DL = Dead Load

WL = Wind Load

SL = Settlement Load

SeL =Seismic Load

TL = Theremal Load

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

Load Combination for Induced Draught Cooling Tower

i) Static Analysis and Design

The following load conditions shall be considered for the design of the Fan supporting structure along with other load combinations as per IS:875.

Machine Load.

Load case 1 + unbalance load for the balance of the fan corresponding to Q 16 as per VDI 2056.

Load case 1 + unbalance load corresponding to one blade failure load condition.

The strength design of the Fan supporting structure shall be done for worst loading combinations as stated above.

ii) Dynamic analysis

a) Free vibration analysis

A free vibration analysis of the fan supporting structure including the intermediate supporting structure for motor, gear box and pillow block (if applicable) shall be carried out to calculate the natural frequency of the fan supporting structure and its fundamental natural frequency shall be at least +20% away from the operating speed of the fan and motor.

b) Forced Vibration Analysis

Forced response analysis shall be carried out for the fan supporting structure including the intermediate structure supporting the motor, gear box and pillow block to calculate the vibration amplitudes for the following unbalance condition.

1. For unbalance load corresponding to Q 16 balance grade of the fan as per VDI 2060.

2. For unbalance load corresponding to one blade failure condition.

The amplitude so calculated shall be within the permissible valuesas specified by the fan manufacturer or IS-2974, whichever is more stringent.

iii) Mid Bearing supporting structure

The intermediate supporting structure for motor, gearbox and pillow block shall be so arranged that it does not cause any torsional moments on the beams/pedestals on which the intermediate support rests. The intermediate supporting structure shall be orthogonal to the grid of beams on which it rests. The motor shall be supported on a base frame.

3.02.00 **Loading**

3.02.01 **Dead loads**

Dead loads shall include the weight of structure complete with finishes, fixtures and partitions, false-ceiling and shall be taken as per IS: 875. Dead loads for cooling towers shall include self weight of structure, weight of fill material, weight due to algae growth, weight of falling water, weight of hot water pipe, weight of water in hot water channel and distribution system including the self weight of channel and distribution system, weight of drift eliminators, etc.

3.02.02 **Imposed loads**

a) 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 and as supplied by the equipment supplier), pipe loads (static, friction and dynamic), cable/ducts loads are not included in the imposed loads furnished below and shall be considered in addition to imposed loads.

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

Sl.No.	Location	Minimum specified Imposed Loads (T/Sq.m.)
A)	**STG Building**	
i)	Ground floor	1.50
ii)	Operating floor	
a)	General	1.50*
b)	Equipment lay-down area	2.50
c)	Mezzanine floor	1.00*

* Additional load of minimum 0.5 t/m2 shall be considered for piping/ cabling loads.

B)	**GTG Building**	
i)	Ground floor	1.50
ii)	Air inlet duct filter and exhaust Duct support floor	0.50 or as required by filter and equipment supplier, which ever is higher

In addition to the above a load of minimum 0.50 t/m along column line of GT building shall be considered at 6m above ground floor towards cabling, piping, ducting etc.

C)	Common Control building (except toilet, stairs & walkways) and Battery	1.00 or as required by equipment supplier

room, Switchgear room, AHU, Air washer room, Cable vault areas — whichever is higher.

In addition a load of 250 kg/m2 shall be considered for cabling, ducting, false ceiling etc.

D) BFP / Deaerator Building

i)	Ground floor	1.50
ii)	Intermediate floor	1.00
iii)	Deaerator level floor	1.00

In addition a uniform load of 0.25 t/m2 will be considered for cabling, ducting, false ceiling etc. below intermediate & deaerator floor.

Pump Houses

Operating floor — 1.50

F) Underground Structures such as Channels, Sumps, Underground Pump House, Tanks, Trenches, Reservoirs, C.W. ducts etc.

In addition to earth pressure and ground water pressure, the surcharge load of 2T/sq.m. shall also be considered for design of all underground structures.

G) Road Culverts/ Bridges and its allied structures including RCC Pipe Crossings and Road Crossing of Trenches.

Design for class 'AA' loading (wheeled and tracked both) and checked for class 'A' loading as per IRC Standard.

H) Covers for Channels/ trenches

(i)	General	0.40 or imposed Load of adjoining area whichever is higher
(ii)	At road crossings for vehicular traffic	As per IRC Standard

I)	**Railway Supporting Structures, Rail Culverts**	As per 'Railway Bridge Rules
J)	**HRSG Support Structures**	0.50

K) ID Cooling Tower

i)	Roof/ fan deck	0.50
ii)	RCC floors	0.50
iii)	Chequered/ grating floor	0.50
iv)	Basin, sump, duct & underground pipe	Besides earth pressure under dry and wet condition, an additional surcharge of 2.0 t/m2 shall be taken
v)	Covers for Hot Water channels/ HW distribution basin	0.40
vi)	Walkway inside CT distributing basin	0.50

vii) Construction Loading

The Bidder shall decide the method of construction and type of formwork to be used in advance. Temporary loadings likely to be imposed during construction shall also be considered in the design of cooling tower structures. Temporary loadings may include the following depending upon the method of construction:-

a) Handling of concrete.

b) Scaffolding of formwork.

c) Correcting shutter alignment

d) Hoist fixing

e) Storage of materials on scaffolding

f) Temporary access

g) Work temporarily omitted for access purposes

viii) Load on Fin Supporting Structure 0.25 plus self weight of fins

L) 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
vii)	Walkways (General)		0.50
viii)	Floor of control room of GIS building		1.00
ix)	Cable/ pipe /duct supports		0.40 for walkway plus friction loads as applicable

Note: Additional load for cable, piping/ducting, in cable & pipe trestles shall be considered as applicable.

3.02.03 **Equipment, piping and associated loads**

Loads of all equipments like Deaerator, Heater, Feed water Tank, Cooling Equipment, Motors, fan drive pulleys, Pumps, Monorails, Ventilation duct, air inlet & exhaust duct, Electrical control and relay panels, Cable load, Pipe load (static and dynamic), Tanks, AHU, Batteries, Air Washer, etc. shall be considered over and above the imposed loads. Equipment loads shall be considered as given by equipment supplier. Equipment loads which are of permanent nature shall be treated as dead loads.

3.02.04 **Crane load**

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

3.02.05 **Seismic load**

Seismic forces shall be considered as per the criteria specified in Project Information attached in this specification. Response spectrum method shall be used for the seismic analysis using at least five modes of vibration.

Seismic forces for Natural Draught Cooling Towers:

The seismic analysis shall be carried out in accordance with IS:1893 by modal analysis for the hyperbolic cooling towers or any other method as approved by the owner. The earthquake analysis of the shell and its support columns including the foundations shall be carried out by response spectrum method. For the fill supporting structures (RCC frames) response spectrum method is permitted. The modules of elasticity for concrete shall be obtained from IS:456 WITH AN AGE FACTOR OF 1.0. All the analysis shall be carried out as per theory of elasticity.

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

3.02.06 **Wind load**

Wind loads shall be taken as per the criteria specified in Project Information attached in this specification.

Wind Pressure on Natural Draught Cooling Tower

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

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

For conducting model tests, bidders should survey the whole terrain and make their own assessment of likely critical wind forces and 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 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 tests shall also include all adjacent topographical features, buildings and other structures which are likely to influence the wind load pattern on the lower significantly. The model test shall be carried out in a well reputed institute/testing laboratory after obtaining prior approval from the owner. The testing agency selected by the bidder shall have requisite experience and should have successfully carried out tests in the past for atleast one cooling tower of similar capacity. The model tests shall be duly witnessed

and approved by the Engineer. The model test results shall be made available before final approval of the design.

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

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. The 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 coeffecient(p) shall be computed as p=1.43(p1), where (p1) is the wind pressure coefficient as per IS:11504.

The 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)]. For details, reference shall be made to "Criteria for Wind Resistant Design of Structures and Equipments" placed under Project Information and as given below.

The wind pressure at a given height [P(z)] shall be computed as per the stipulations of IS:875. For computing the design wind pressure at a given height the basic wind (Vb) shall be taken as Vb=47 m/sec at 10.0 meters height above mean ground level. For computing design wind speed (Vz) at a height z,. the risk coefficient K1=1.2 shall be considered. For coefficient K2, Terrain category 2 and class 'c' as per table 2 of IS-875 shall be considered. Coefficient K3 shall be determined by taking into account of various features of the plant site and topography. The wind direction for design purposes shall be the one which induce worst load conditions. Howerver, coefficient K3 shall not be less than one under any circumstances. The wind pressure at a given height shall be computed theoretically in accordance to the IS Codal position given as under:

$Pz= 0.6\ Vz^2\ N/mm^2$

The bidder shall also compute the wind pressure (pz) along the wind direction by Gust Factor (GF) or Gust effective factor method (GEF). Method for estimating the wind load on the tower and other elements, shall be based on IS:875. While calculating the gust factor, the term 'b' shall be taken as the diameter of the throat in Fig. 10 of IS:875.

Design of the tower shall satisfy quasi-static method & GEF method.

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

In case the bidder proposes to adopt aerodynamic rough surface such as provision of meridional ribs in the cooling tower shell, the pressure coefficients as given in the VGB-BTR KUHLTUMRE GERMAN SPECIFICATIONS (latest) (structural design of cooling towers) shall be permitted. The provisions of BTR may be adopted for choosing the value of circumfererntial wind pressure coefficient (p1) only. The wind pressure coefficient (p1) as obtained from BTR after accounting for internal suction, shall be multiplied by a factor 1:43 to arrive at the net design pressure coefficient (p). The bidder shall furnish authorized English Translation of VGB-BTR KUHLTURME GERMAN SPECIFICATIONS (latest) for the review of the Employer. All other stipulations as specified in these specifications shall be met with.

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

3.02.07 **Temperature load**

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

Temperature load for Natural Draught Cooling Tower:

Temperature effects due to solar radiation shall also be considered in addition to above.

The cooling tower shell shall be designed for stress due to axi-symmetric temperature

distribution corresponding to external ambient temperature variation from 3 degree centigrade to 50 cegree centigrade. 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 ase the operational philosophy so demands. The analysis for the stresses resulting from non-symmetric temperature loading, the calculation shall be based upon the operating specification. Besides, the shell shall be designed for one sided solar radiation effect also. Neverthless an effective temperature difference of at least 25 degree centigrade across the shell thickness constant over the height and follow a sine functions along half the circumference shall be considered.

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

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.

3.02.08 **Construction Load**

For Cooling Tower design, construction loading depending on methodology of construction shall be considered. Temporary loadings likely to be imposed are due to handling of concrete, formwork, hoist fixing, storage of materials, temporary access etc. Loads due to foundation settlement shall also be considered.

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

a. Barrowing of concrete

b. Scaffolding and formwork

c. Loads produced by anchoring devices of climbing scaffolds

d. Hoist fixings

e. Storage of materials on scaffolding

f. Temporary access

g. Tower crane fixing

h. Works temporary omitted for access purpose.

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

3.03.00 **Design Concepts**

3.03.01 i) All buildings shall have framed super structure.

ii) The GT & ST building, Common Control Room building, Deaerator supporting structures and facility building shall have structural steel framed super structure, with metal cladding on exterior face.

iii) a) Facility building, if provided as combined building with control building shall have structural steel framed super structure.

b) Facility building, if provided as seperate building adjacent to control building with interconnecting corridor at operating floor level, shall have RCC framework.

iv) All other buildings except pump houses may have either RCC or structural steel framework. However, pump houses shall have structural steel super structure with metal deck roofing. Walls for pump houses shall be with hollow concrete block masonry/brick masonry. For brick masonary, bricks with crushing strength not less than 75 kg/cm2 shall be used.

v) All buildings having RCC framing shall have masonry cladding of minimum one masonry unit thickness (not less than 200 mm.) on exterior face.

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

3.03.03 Different load combinations shall be taken as per IS:875 and other relevant IS Codes.

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

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

c) 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.

d) In case more than one crane is provided and tandem operation is envisaged for some bays, then the load shall be taken as both the cranes fully loaded and standing side by 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.

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

f) For the design of pipe/ cable supporting structure, the soil weight shall be considered as backfilled upto grade level for the condition of pipe running full/ cables in position.

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

h) Paving in crane corridor shall be designed for the maximum load due to movement of crane.

i) In ST/ GT buildings at crane rail level, walkway of chequered plate with handrails shall be provided for entire column sectional depth for full length of the building. In addition, it shall be ensured that through walkway (without hindrance) of required width is available to the nearest part of the crane structure from the face of the columns on all four sides of the buildings.

3.03.04 Design detailing and fabrication of steel structures shall be done as per provisions of IS: 800.

3.03.05 Welding shall be used for fabrication and erection. Site connections shall generally be with welding/bolts. For bolted connection, IS: 4000, IS: 3757, IS: 6623 and IS: 6649 shall be followed. IS: 814, IS: 816, IS: 1024, IS: 4353 and IS: 9595 shall be followed for welding of structures.

3.03.06 All structures close to railway line shall have clearances conforming to Railway norms.

3.03.07
a) Dispersion of load in any direction through soil shall be as per IS: 8009 (relevant part).

b) Dispersion of load through concrete shall be considered at an angle of 45 degrees with horizontal from the edge of contact area.

3.03.08
a) Permissible deflection (unless specified otherwise in this specification) for latticed framework and beams of floors other than drive floor shall be span/325.

b) The allowable deflection for beams directly supporting drive machinery shall be restricted to span/500 unless specified otherwise in this specification.

3.03.09
a) The design and construction of RCC structures shall be carried out as per IS: 456. Working stress method shall be adopted for the design wherever specifically mentioned in this specification.

b) For design and construction of steel-concrete composite members, IS: 11384 shall be followed.

c) For reinforcement detailing, IS: 5525 and SP: 34 shall be followed.

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

3.03.10
a) All RCC liquid retaining/ conveying structure (except water storage tanks) shall be designed in accordance with IS: 3370 by the working stress method, using limited steel stress. However, water storage tanks shall be designed as an uncracked section as per IS: 3370 by working stress method. Grade of concrete for the above structures shall be M-25 as per IS: 456.

b) Water proofing treatment shall be provided for liquid retaining/ carrying structures and basement type structures (requiring dry working condition). Dense and durable concrete with water cement ratio not more than 0.45 shall be used. Plasticiser/ super-plasticiser cum water proofing compound shall be added to the concrete. All the construction/expansion joints shall be properly treated with PVC water bar and/or chemical injection grouting as per IS: 6494. For basement type of structures, internal/external surface shall be provided with acrylic based polymer modified cementitious composite coating system for critical structures. For external application wherever the surface is in contact with the earth, fine silica/quartz sand of 0.6 mm nominal size shall be added in the coating mix for better abrasion resistance and total nominal thickness of such coating shall be minimum 1.5 mm. For non-critical structures minimum two coats of bitumen grade 85/25 as per IS: 702, mixed with 1% of anti-stripping compound meeting the requirement of IS: 6241, shall be applied. The total application of bitumen shall not be less than 1.7 kg/sq.m.

Bidder shall submit a comprehensive scheme for water proofing treatment based on above or any other alternative scheme, internationally accepted for Employer's approval prior to commencement of work.

c) 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.

3.03.11 For design of all underground structures, foundations, C.W. ducts, etc. ground water table shall be assumed at the finished ground level unless specified otherwise.

3.03.12 Earth pressure for all underground structures shall be calculated using coefficient of earth pressure at rest or co-efficient of active earth pressure, whichever is applicable, depending upon the structural configuration. However, for the design of substructure of pump houses, earth pressure at rest shall be considered. Co-efficient of passive earth pressure shall be used only in design of shear keys for stability against sliding.

3.03.13 a) 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.

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

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

iii) 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., shall not be permitted to counter the buoyancy in pump sumps.

iv) Base slab and piers of the pump houses shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum ground water level.

. b) 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.

c) 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.

3.03.14 **Deflection Criteria:**

The max. deflection for various structures shall not exceed and be limited to the following:

S.No.	Description	Max. Value of
1.	For all structures	Span/325 or Height/325 as the case be unless noted otherwise.
2.	For all beams directly supporting equipment	Span/500

3.	For all roof purlins	Span/250
4.	For all grating/chequered plates	Span/250 (However, the min. vertical deflection grating/ chequered plate shall be limited to 6 mm.)
5.	For cladding runners, roofing/ cladding sheets	Span /250

However, the max. vertical deflection of Grating/chequered plate shall be limited to 6mm).

3.03.15 **Equipment Foundations**

Supporting Arrangement : The steam Turbine Generator (TG) and Gas Turbine (GT) shall be supported over RCC deck. The bidder may support the RCC deck for TG/GT on steel helical springs/spring cum viscous dampers which in turn will be supported on RCC sub-structures resting on soil/piles. Alternatively the deck may be directly supported on RCC sub-structure/soil/piles without steel helical springs /spring cum viscous dampers.

Detailed static and dynamic analysis shall be carried out for the foundations of ST & GT etc. The static analysis shall include all operating conditions, load cases and abnormal loads like short circuit, loss of blade unbalance and seismic forces. Unbalance loads for normal operating condition as given by machine manufacturer and/or VDI 2060 whichever is more conservative shall be used for calculating dynamic response. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. Transient analysis shall be carried out for the short circuit condition with an appropriate force function. Frequency separation criteria and amplitude criteria as laid down in IS: 2974 and/or DIN 4024 and/or VDI 2056 and/or as required by the machine manufacturer, whichever is more stringent shall be satisfied. RCC design shall be done by the working stress method for all machine foundations. A fatigue factor of 2.0 shall be considered for dynamic forces. Minimum reinforcement shall be governed by IS: 2974 as well as IS: 456. However minimum reinforcement in bottom face of the foundation raft resting on soil or pile shall not be less than 0.2% of effective cross sectional area of the raft. The minimum grade of concrete for TG & TG foundation shall be M35.

In case steel helical springs are provided, the foundation arrangement shall be such that the spring units are located above the finished floor level by at least

200mm. The isolation efficiency of the foundation system comprising RCC deck and steel helical springs shall be at least 90%. The ratio of actual spring supported weight to the nominal spring capacity shall be at least 0.80. At least 3% to 5% of critical damping shall be provided in the form of viscous dampers.

The special requirements for concreting including grade, type of aggregate, use of admixture, temperature control, ultrasonic testing, etc., shall be as mentioned elsewhere in this specification.

The specification requirements for steel helical springs are specified elsewhere in this specification.

All block foundations supporting rotating equipment resting on soil or piles shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than three times the mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all the modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down in the relevant codes and/or by machine manufacturer, whichever, is more stringent shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456. Minimum Reinforcement in base raft in either direction shall be as follows:

i) At bottom face - 0.2% of gross cross-sectional area

ii) At top face - 0.12% of gross cross-sectional area

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

3.03.16 **CW Ducts**

A) Design of C.W. ducts shall be done for the following conditions.

i) Internal Pressure Condition:

Following cases shall be considered for the design of pipe:

a) Maximum design water pressure

b) Surge or water hammer pressure

c) Pressure, under testing condition

ii) External Pressure Condition:

The pipe shall be designed for external pressure due to soil overburden, surcharge loading, vacuum condition in pipe, ground water, etc., taken together.

iii) Practical Requirements:

Design shall also be checked for handling stresses.

Both stresses and the deflection of pipe shall be within the limits for the above design conditions. Deflection of the pipe under worst loading condition shall be restricted to 2 (two) percent of the pipe diameter.

For the concrete encased pipe, the design of pipe shall also be checked under concreting condition during construction.

Moreover, temporary bracing shall be provided inside the pipe to limit the deflection within 2% of diameter of pipe during construction.

iv) Top of C.W. duct shall be minimum 1.5m below grade/ formation level.

B) The design of C.W. steel pipe liners with concrete encasement shall be as per "Design and Construction of Buried Thin Walled Pipes" CIRIA (Construction Industry Research and Information Association, London) report and also as per American Water Works Association (AWWA) Manual.

Steel lined C.W. duct shall be designed ignoring the internal lining (if any) and external coating/ encasement. Corrosion allowance of minimum 2mm shall be kept over and above the designed thickness. Ready manufactured RCC pipes with 3mm (min.) thick steel liner shall be designed as per AWSI/AWWA C 300-89 or equivalent unless noted otherwise. Steel Hume pipes shall be designed as per AWWA manual.

3.03.17 All roads shall be of flexible pavements unless otherwise specified. Design of flexible pavement shall be carried out as per IRC-37. The minimum requirements as specified in IRC-37 w.r.t. surfacing base and sub base, shall be followed. The design traffic load shall be a minimum 4 million cumulative standard axle. All roads shall be designed for class 'E' of traffic, i.e, traffic intensity of 450-1500 per day (heavy vehicles exceeding 3 tonnes laden weight) as per IRC-37. The road shall be designed for 30 years of life and considering a minimum traffic growth of 1% per annum. In case of concrete pavement the design shall be carried out as per IRC-58.

3.03.18

a) No cable/pipe trench is envisaged in outdoor areas of the plant.

b) All pipes and cable shall generally be routed above ground on structural steel trestles having minimum clear height of 3.0m.

c) A minimum clearance (clear headroom) of 8 m shall be kept for all over-ground pipe/cable trestles for all road/rail crossings. For other areas, the requirement of trestle height is specified elsewhere in the specifications. All trestles shall be provided with continuous walkway of minimum 750mm width with handrails and toe-guards all along the length of the trestle along with approach ladders near roads, passageways, etc. Before and after the road/rail crossings, a barrier of suitable height shall be constructed so as to prevent the approach of cranes (having height more than 8 m) etc, upto the pipe/cable trestles.

d) Within Main plant area, generally grating shall be provided for Mezzanine floor except for valve room area, cable spreader floor, etc. where the floor shall be of RCC. Oil equipment room shall also have RCC floor below the grating floor.

3.03.19 Plant storm water drainage shall be designed taking into account the finished grade levels of the plant area, drainage pattern, intensity of rainfall, etc. The storm water drainage shall cater to storm water run off resulting from one hour rainfall intensity, with a return period of 100 years. These values shall be based on the recommendations of the Indian Meteorological Department (IMD). The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8 m/sec. respectively. However, minimum velocity of 0.6m/sec. for self-cleansing shall be ensured. Bed slope not milder than 1 in 1000 shall be provided. The open drains shall be open rectangular drains of RCC unless required otherwise due to functional requirement. Pipe or box culverts shall be provided at rail, road or other crossings.

3.03.20 Sewers shall be designed for a minimum self-cleansing velocity of 0.75m/sec and the maximum velocity shall not exceed 2.4m/sec. and shall be connected by gravity or by pumping, to the sewage treatment plant to be constructed by bidder.

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

3.03.21 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. In case composite action is considered in the design, suitable shear studs shall be provided as per BS: 5950.

3.03.22 Plant effluents shall be handled in separate drains/ pipes. The plant effluent drain shall not be mixed with storm water drain or sewer lines.

3.03.23. Switchyard Structures

(a) Switchyard structure shall be designed for the worst combination of dead loads, wind load conditions as per IS : 802, seismic loads, loads due to deviation of conductor, loads due to unabalanced tension in conductor, torsional loads due to unbalanced vertical and horizantal forces, erection loads, short circuit forces including snaps in case of bundled conductors, etc. 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.The terminal/line take off gantries shall be checked for ± 30 deg. deviation of conductor in both horizontal and verticalplanes. The distance between terminal and dead end gantry shall be taken as 200 meters. Foundation shall be designed for a factor of safety of 2.2 for normal and braken wire condition and 1.65 for combined short circuit and broken wire condition. Design of foundation shall be carried out as per IS :4091.

(b) Supporting structure for equipment may either comprise of glavanised pipe supports (ERW pipe of grade YST 21 or higher) or lattice structural steel supports as per equirement. The pipe supports shall be designed as per IS :806 and IS: 1161. The lattice steel supports shall be designed as per IS:802.

(c) The fabrication and erecion of the switchyard works shall be carried out generaly in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanised.

(d) Diagnal wind condition shall be considered for the design of lightning mast.

(e) Lightning mast shall be provided with a structural steel ladder with protection rings. Where the plateforms are provided on lightning mast for mounting of lighting fixtures, these shall have protection railings. The plateforms shall be of steel grating.

(f) Lightning mast shall be provided with minimum two numbers of plateforms with one at top level and an internal ladder (with cage) for climbing purpose upto top level. Top of plateform shall be covered with grating. Plateforms shall be provided with MS pipe hand railing and toe guard plate suitable painted.

g) All steel work used in construction of gantry structure shuold be galvanised and minimum section thickness should not be less than 4 mm. Weight of zinc coating shall be at least 0.610 kg/m2 and foundation bolts shall have heavier zinc coating at least 0.80 kg/m2.

3.03.24 Foundation for all steel tanks shall be designed as per IS: 803.

3.03.25 Footings shall be so propoetioned to as to minimise the differntial settlement.

3.03.26 Design Criteria for foundations and some other facilities/areas are covered seperatery in this psecification.

3.03.27 Plinth level of all buildings shall be kept at least 500 mm above the finished grade/formation level.

3.03.28 **HRSG Structures**

a) HRSG support structures shall be designed for:

i) Live/ Imposed loads

ii) Dead loads

iii) Static and dynamic loads of piping, movable equipment, maintenance parts and possible future additions.

iv) Loads due to platforms, walkways & stairways etc.

v) Seismic and wind loads are as specified in Project Information attached in this specification.

vi) The loads listed above indicate the minimum requirements.

b) HRSG supporting structures shall be so configured that the temperature of steel does no exceeds 60 deg. C unless specified otherwise and the structure shall be designed for temperature variation of 25^0C from atmospheric temperature.

c) The bracings in HRSG structure shall be provided such that under no circumstances normal/convenient access to all points in the HRSG is blocked or obstructed.

d) HRSG Support structures shall be checked for differential settlement of foundation, which shall be restricted to 1 in 1000 of span or 8mm whichever is less.

e) In design of HRSG support structures, dynamic piping loads need not be considered acting simultaneously with wind or seismic loads, increase in permissible stresses shall be allowed in load combinations where dynamic piping loads are considered and shall be as permitted under seismic load conditions.

f) Design Criteria for foundations and some other facilities/areas are covered separately in this specification.

3.03.29 **Joints/Connections in steel structures:**

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

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

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

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

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

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

c) Shear connections shall be designed for 60% of section strength for rolled sections and 80% of section strength for built up section or rolled section with cover plates. However, if load is more than above, the connection shall be designed for actual load.

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

e) All butt welds shall be full penetration butt welds.

f) The connection between top flange and web of crane girder shall be full penetration butt weld. Bottom flange, connection with web can be fillet weld or butt weld as directed by Engineer.

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

h) Splicing: All splicing work shall be of full strength. Field splicing shall be done with web and flange cover plates for full strength. Shop splicing for all sections other than rolled shall be carried out by full penetration butt welds with no cover plates. Splicing for all rolled sections shall be carried out using web and flange cover plate.

3.03.30 **Stacks**

a) The design of Bypass and HRSG stacks shall in general conform to the relevant Indian Standards. For design provisions not contained in the Indian Standards, reference shall be made to the relevant American and British Standards, CICIND model codes and other relevant international standards.

b) External and internal corrosion allowances, where applicable, for the stack and it's components, shall be suitably selected in line with the relevant standards for the design operating conditions and the service life of plant.

c) Insulation for stack shall be as per the design criteria specified elsewhere in the specification. Maximum and minimum operating temperatures shall be considered while selecting materials for the stack.

d) The stack shall be designed for vertical loading, along wind loading, cross wind loading, seismic loading, circumferential wind loading , thermal stresses, fatigue and for effects of solar gain, local loadings, rotation of the stack base, moments of second order, and other forces not specifically mentioned but pertinent for the safe design of the structure. The stack shall be designed to resist the most onerous forces resulting from all the possible combinations of various loadings.

e) The stacks, particularly Bypass stack, which carries gases at high temperatures, should be so configured/detailed to avoid buildup of thermal stresses. This may be achieved by allowing thermal expansion between the various components through suitable expansion joints.

f) Adequate measures should also be taken to minimise/prevent buildup of thermal stresses due to differential temperatures between the various inter connecting stack components.

g) The cut-outs/openings in the stack shall be sized and stiffened/reinforced in accordance with the relevant standards.

h) For dynamic response of the stack for seismic and wind loading at least the first five modes of vibration shall be used in the computations.

i) Seismic forces, on the stack, shall be computed by the response

spectrum method using the site-specific acceleration spectra as given in Project Information attached in this specification.

j) The along wind loading shall be computed by the peak wind method and the gust factor method of IS: 875 (Part - 3) and by the method outlined in IS: 6533, and the governing case shall be adopted for design. For wind velocity and other parameters, Project Information attached in this specifications shall be referred.

k) The cross wind analysis of the stacks shall be carried out irrespective of the value of the Scruton Number for the stack and other empirical consideration which suggest structural immunity to cross wind oscillations. To ensure that a particular vibration mode is not excited, the critical wind velocity for the structure for that mode should be at least 20% higher than the maximum wind velocity possible at the site, The strouhal Number shall be taken as 0.2.

l) While estimating the loadings resulting from either along wind or cross wind effects, the proximity of the other stacks shall be considered. Amplification factors on account of aerodynamic interference shall be suitably estimated and included in the analysis.

m) Along wind and cross wind moments shall be taken separately, and as a combined action, in the loading combinations to be considered.

n) Irrespective of the magnitude of the cross wind forces, strakes, shall be provided as three start helices, at least over the top one third height of the stack or one pitch height which ever is greater, with a helix pitch of five times the effective diameter of the stack, Radial depth of strakes shall not be less than one tenth the effective diameter of the stack. The effective diameter is usually the average diameter of the top one-third height of the stack; Strakes shall be structurally designed to withstand three times the design wind pressure at the top of stack. A drag coefficient of 1.4 for the straked region and 1.12 for the unstraked region shall be considered in the analysis & design.

o) Local moments acting on horizontal cross-section of the stack shall be considered together with forces due to the load combination of vertical and co-existing lateral loads and temerature effects.

p) Local moments acting on vertical cross-section of the stack shall be

included together with moment forces from solar gain and /or ovalisation.

q) Since wind is principal loading on the stack, no increase in permissible stress shall be allowed for any part of the structure, foundation and soil bearing stresses/pile forces for the loading combinations with wind loading.

r) The Stack foundation shall be designed for the most critical forces resulting from all the possible combinations of the various loadings from the stack system during all stages of construction. The effect of water table shall he considered and the foundation shall be checked for overturning for minimum and maximum vertical loads. There shall be no uplift under any portion of the foundation for any loading condition.

s) All the loading specifications, design parameters, structural detailing detailing, structural and other materials, coatings and painting, quality, testing, workmanship, construction and safety requirements etc. Shall be in line with this specification and the relevant Indian standards. For provisions not contained in the Indian standards, reference shall be made to the American/ British standards, CICIND model codes and ASCE code on steel chimney liners.

t) The supporting structure for the stack shall extend atleast upto 2/3rd the height of the stack. The stack could be either top hung or bottom supported from the supporting structure. In case it is designed to be supported from bottom, the support location shall be kept as low as possible, however, in either cases of supporting, the stack shall be restrained horizontally atleast at two levels distribute uniformly along the height.

3.03.31 **Architectural Concepts and Design**

A) Architectural Concepts

a) Layout of the plant area shall have definite hierarchy of road network depending upon its usage, aesthetic, visual sensibilities for creating road vistas, focal points, building back drops, building frames. General layout shall be evolved taking over the basis of landform and local climate and due consideration shall be given to orientation and wind direction. The resulting built mass shall present a definite image width in distinct vocabulary in the form of landmarks, nodes and skyline.

b) Main Plant building shall be architecturally treated in such a way that it retains a monumental scale, yet presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses. The overall impact of the building shall be one of aesthetically unified architectural composition having a comprehendible scale, blending tonal values with the surroundings and taking full consideration of the climatic conditions, the building orientation and the existing structures nearby.

c) All other buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the main plant, surrounding structures and environment. Local architectural characters and materials may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale and form.

d) Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipment, 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 finalised in totality including that of equipment so that the proper coordination with other agencies can be taken up at appropriate time.

B) Architectural Design

a) Natural light shall be used to the maximum extent, especially in the form of north light/sky light. For adequate light and ventilation, National Building code recommendations shall be followed.

b) Entrance canopies, chajjas (projections, recesses) over openable windows and door openings on exterior facades shall be provided.

c) All the buildings shall be architecturally designed to meet the National Building Code (SP: 7) norms and local building bye laws, wherever applicable.

d) Architectural design and detailing aspects of all the buildings shall be rendered through professional services of an Architect. Statutory requirements may be required to be met with, wherever essential. The Architect Consultant shall be of National/ International repute having experience in 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 and detail drawings.

4.00.00 STEEL HELICAL SPRINGS AND VISCOUS DAMPERS

4.01.00 **General Requirement**

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

4.01.03 The information about the entire range of spring units, damper units and spring-cum-damper units manufactured by sub vendor shall be furnished to owner along with appropriate type of spring units for different machines. The information to be furnished should include the load carrying capacity, stiffness (vertical & horizontal), damping resistance, dimensions of spring and damper units.

4.02.00 **Material (Design & Supply)**

4.02.01 Steel helical springs and viscous dampers 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.

4.02.02 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.

4.02.03 The dampers 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. Damper Units shall have damping resistance ranging from 40 KN Sec / M to 750 KN Sec./M.

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

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

4.03.00 **Manufacturing & Testing**

4.03.01 Complete manufacturing and testing of the steel helical springs and viscous dampers shall be done at the manufacturing shop of the approved sub vendor/ supplier. For this purpose the contractor/sub vendor shall submit the detail programme for approval of engineer and take up the manufacturing/testing after approval of such programme. The programme 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 (data sheet) of various elements such as spring units, viscous dampers, with their rating, stiffness etc. included in the supply.

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

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

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

4.04.00 **Transportation**

4.04.01 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.

4.04.02 The contractor shall be responsible for any loss or damage during transportation, handling and storage.

4.05.00 **Erection and Commissioning**

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

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

4.05.03 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".

4.06.00 **Supervision**

The spervision 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.

4.07.00 **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.

4.08.00 **Acceptance Criteria**

Stiffness values shall be checked. The permissible deviations shall be as per DIN 2096.

Following acceptance criteria shall be followed:

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

(b) Tolerances are within the specified limit.

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

(d) Bought out material is from the approved manufacturer/vendor.

(e) Bought out material is matching with the approved sample.

4.09.00 **Codes and Standards**

Some of the relevant 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 : 3096	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.

5.00.00 FOUNDATION SYSTEM AND SOIL DATA

5.01.00 **Soil Data**

5.01.01 Employer has carried out Preliminary GEOTECHNICAL INVESTIGATION in plant area. The preliminary Geotechnical report comprising of boreholes, standard penetration test (SPT), static cone penetration tests (SCPT), laboratory tests and chemical analysis etc. of subsoil strata prevailing at site are enclosed with this specification. The onus of correct assessment/interpretation and understanding of the existing sub-soil conditions/data is on the Bidder.

5.01.02 The detail surveying and detailed Geotechnical investigation along with reports thereof will be conducted by the Bidder. Related technical specifications for the same along with the tests to be conducted is to be submitted by the Bidder on the detailed plot plan for approval by the Employer before start of the work. Detailed surveying, leveling, grading etc. are also included in the scope of work. It is envisaged that the Bidder is to check the actual site topography for filling, grading, leveling purposes. Bidder shall carryout detailed soil investigation as per the scheme given at Annexure-I.

5.01.03 No time extension shall be given on account of soil investigation carried out by the bidder.

5.01.04 If there are changes, during detailed engineering due to any reason, in the location of important structures/equipment like GT, ST, Stack, HRSG, Cooling Towers, etc., then the Bidder shall carryout the soil investigation work at the new location of foundations for determining the soil properties. No time shall be given on account of additional soil investigation carried out by the bidder or variation of data so obtained.

5.01.05 The Bidder should note that nothing extra whatsoever on account of variation between soil data collected by the Employer and that found by the Bidder during soil investigation or during execution of works, shall be payable.

5.02.00 **Foundation System**

5.02.01 **General Requirements**

(a) All equipment/structures shall be supported either on suitable open foundations or on pile foundations as required.

(b) The roads, ground floor slabs, trenches, channels and other lightly loaded structures with foundation intensities less than 5.0 t/sq.m may be supported on open/shallow foundation resting on virgin/controlled compacted filled up soil/improved ground. All foundations shall be designed in accordance with provisions of the relevant parts of the latest revisions of Indian Standards.

(c) No major foundation shall rest in the filled up ground/soil.

(d) A combination of open and pile foundations shall not be permitted under the same equipment/structure/building.

(e) Foundations shall be designed to resist all loads, including those due to wind or seismic, construction loads, and any other load as applicable and as specified elsewhere in the specification.

(f) Foundation shall be designed for worst combination of loads as described elsewhere in the specification.

(g) For identifying the subsoil for founding purposes, the Bidder shall depute/post an experienced qualified geologist/geotechnical engineer so that the specified strata as conceived in the design is reached.

5.02.02 **Open Foundations**

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

(a) Minimum width of foundation shall be 1.0 m.

(b) Minimum depth of foundation shall be 1.0 m below NGL.

(c) It shall be ensured that all foundations of a particular structure/ buildings facility shall rest on one bearing stratum.

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

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

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

(i)	All facilities in Main Plant area, ducts, equipment foundation	-	25 mm
(ii)	All foundations in switchyard, control room building including, isolated/strip Continuous/raft foundation	-	40 mm
(iii)	Other footings of width upto 6m	-	40 mm
(iv)	Other footings of width greater than 6.0m (raft)	-	75 mm
(v)	Footings on rock	-	12 mm

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

5.02.03

Pile Foundations

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

(a) The piles foundation shall be of RCC, Cast in situ bored piles as per IS: 2911. Pile shall be installed by using rotary hydraulie rig. Three stage & lushing of pile bore shall be ensured by air lift technique.

(b) The minimum diameter of pile shall be 600mm. The uplift and lateral load capacity shall be respectively restricted to 20% and 5% 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 initial pile load tests.

(c) Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.

(d) The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter like SPT & SCPT value, reinforcement for job as well as test piles, etc.) for Employer's approval.

(e) The piling work shall be carried out in accordance with IS: 2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Bidder for Owner's approval.

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

Vertical
Lateral Minimum of 3 No. in each mode.
Uplift

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

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

(i) Vertical - 0.5% of the total number of piles provided.

(ii) Lateral - 0.5% of the total number of piles provided.

The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. The Employer shall approve piles for routine load tests. Routine load tests may be done by conventional method as per IS:2911 (Part-4) or by means of high strain dynamic pile load testing method as per ASTM D4945. If high strain dynamic pile load testing is adopted, site specific correlation vis-à-vis conventional test shall be established as approved by Employer.

In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Bidder shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required, without additional cost to the Employer.

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

(j) Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the piles for routine load test.

5.02.04 **Ground Improvement**

(a) Employer has carried out site-specific seismic study for the project. All structures shall be designed for seismic forces adopting the site-specific seismic information provided elsewhere in this specification.

(b) Employer has also carried out site-specific study for evaluation of liquefaction resistance of soils. Hence, the following is to be adopted for avoiding liquefaction susceptibility at the site for entire project area.

(i) Soil up to a depth of 0.5 m below the existing ground level shall be stripped. Sub base shall be leveled and compacted by mechanical roller. Thereafter soil shall be compacted in layers (each layer shall not be more than 250mm thick) up to 95% of maximum dry density (MDD) at optimum moisture content

(OMC). The soil shall be made free from grass, large roots, lumps, concrete or any other foreign substances.

(ii) A 1.0 m thick soil compacted in layers not more than 250 mm thick to achieve 95% of MDD at OMC shall be placed above the existing ground level. The soil borrowed from existing site can also be used for filling.

(iii) The material to be used for filling shall be earth, sand or any other inorganic materials except clay / fly ash and shall have a unit weight of 18.5 kN/m3.

(c) The bidder shall furnish following details for employer's approval regarding improvement/treatment of ground from the consideration of liquefaction.

(i) Drawings furnishing details of treatment with all computation & back up data and construction/execution procedure of the ground treatment/improvement.

(ii) Scheme of soil investigation to establish initial soil conditions by suitable field & laboratory tests.

(iii) Procedure to carryout field (initial) trials of treatment & their evaluation. The number of field trials of treatment shall be proposed by the bidder for employer's approval.

(iv) Post-treatment soil investigation Scheme by suitable field & laboratory tests both at initial trial area as well as at the actual job site.

(v) Field instrumentation proposed.

(vi) System of quality control checks / methods in respect of ground improvement / treatment

(d) Subsequent to treatment, any depth of soil remaining un-compacted below the surface shall be compacted by rolling/tamping or by suitable means to satisfy above-mentioned densification criteria.

5.02.05 **Other Requirements**

(i) In case of high ground water table, for excavations comprehensive

dewatering arrangement shall be required. Scheme for dewatering and design with all computations and back-up data of dewatering and sheet pilling shall be submitted for Owner's information.

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

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

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

(v) Excess/surplus excavated material shall be disposed off by the Bidder as per the instructions of the Employer. Shifting of excess/surplus earth with in the plant is in the scope of the bidder as per requirment.

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

(vii) The storage tanks shall rest on flexible tank pad resting on an open/ shallow foundation or pile foundation. The tank pad shall be made of two layers. The first layer shall be thoroughly compacted fill of gravel, coarse sand or other suitable material topped with minimum 75mm thick compacted crushed stone, screenings, fine gravel, clean sand or similar material mixed in hot asphalt (80 / 100 bitumen or equivalent 8 to 10% by volume), rolled and compacted. The second layer shall be with minimum 25 thick premix carpet with 12 mm and down broken stone chips and 80/100 grade hot bitumen. The tank pad shall be laid by an expert agency having wide experience in execution of similar works. The tank pad shall be made up from founding level to the required level by controlled compaction in layers of 200 mm to achieve a relative density of 85% using suitable compaction equipment approved by the Employer.

In addition to the above, in case of an open/shallow foundation, a ring wall shall be provided adjacent to the tank wall for retaining the fill below tank. The foundation system shall be designed as per the provisions of IS: 803. The tank shall have a flexible bottom plate, which will establish complete bearing with the foundation fill.

After the tanks have been erected, hydro testing shall be done. Subsequent upon hydro testing of tank, the differential settlement between any two consecutive points on the periphery shall be less than d/400 (where 'd' is the distance between the points), with the tank periphery being divided into 8 or more equal segments depending upon the size of the tank as decided by the Employer. The procedure for carrying out hydro testing shall be submitted for the Employer's approval prior to testing.

The founding level to be adopted including the allowable bearing capacities, measures to be adopted as mentioned in the specification shall be submitted to the Employer for approval.

6.00.00 CORROSION PROTECTION MEASURES

a) Structural Steel

i) All steel members of buildings and structures shall be provided with suitable protective coating. Steel structures shall have synthetic enamel paint except for corrosive area as specified elsewhere.

ii) All mild steel parts coming in contact with water or water vapour shall be hot dip galvanised. The minimum coating of zinc shall be 610 gm/sq.m for galvanised structures and shall comply with IS:4759 and other relevant codes. Galvanising shall be checked and tested in accordance with IS:2629.

b) RCC Members (Superstructure)

i) The protection for concrete sub-structure shall be provided based on aggressiveness of soil, chemical analysis of soil/sub-soil water and presence of harmful chemical.

ii) The protection to super structure shall depend on exposure condition and degree of atmospheric corrosion.

This shall require use of dense nad durable concrete, control of water cement ratio, increase in clear cover, use of special type of cement and reinforcement, coating of concrete surface etc.

iii) Bidder shall furnish the details of corrosion protection measures.

iv) The following preventive measures are required to be adopted by the bidder as minimum requirement.

For Indoor RCC Members

Dense and durable concrete is to be used.

Water cement ratio shall generally be restricted to 0.45. Plasticizer, if required, may be used.

For Outdoor (or Exposed) RCC Members

Dense and durable concrete is to be used.

Water/cement ratio shall generally be restricted to 0.45. Plasticizer, if required, may be used.

Clear cover to reinforcement shall be increased by minimum 10mm over and above the values specified for normal conditions in relevant IS codes.

c) RCC Members (Underground Sub-soil condition)

Corrosion protective measures for underground facilities/structures shall be on the basis of results of detailed chemical analysis of sub-soil and underground water. This analysis has to be carried out by the bidder by a reputed laboratory/agency to be approved by the owner. The type of corrosion protection measures for concrete; reinforcement steel and structural steel for underground structures/facilities shall necessarily have protective coating.

One such protective coating system for bidder's guidance is given in Table-D on Page 125 of 146 of Section-VI, Part-B Volume-IV of technical specifications. The coating system consisting of zinc or fusion bonded epoxy conforming to relevant IS Codes can also be used based upon the resuls of chemical analysis of sub-soil and water.

7.00.00 GENERAL LAYOUT PLAN

7.01.00 The general layout plan proposed for the project is shown in tender drawing. It shall form the basis for further elaboration by the Bidder for the plant facilities, which are in his scope.

7.02.00 While preparing the detailed general layout, planning the facilities in the Bidder's scope and deciding upon the transportation and construction / erection strategy, and functional requirements the Bidder shall ensure the following aspects.

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

b) Face of the buildings and facilities be located in such a way so as to have an offset of minimum 20m with respect to centre line of double lane road and 15 metre with respect to centre line of single lane road.

c) The entire construction activity shall take into account the commissioning of the units in phases matching with the phased commissioning of the plant.

d) The interface requirements with the plant construction/erection activities of other contracting agencies engaged by the Employer. These agencies engaged may be working parallely with the Bidder within the plant premises.

e) The area for construction/ erection facilities like lay-down, pre-assembly, offices and stores is to be managed by the Bidder. Bidder may have to share these areas with other contracting agencies engaged by the Employer. The final location and extent of area allocated to each Bidder shall be as directed by the Employer.

f) Transportation of all equipment and materials shall be by road as envisaged. Any other mode envisaged by the bidder may be proposed. However the same may be adopted subject to approval of the Employer.

g) No damage shall be caused to existing buildings, facilities and plantation, etc. However, if some structures are to be removed/ relocated, the same may be carried out by the bidder subject to Employer's approval or as specified in this tender document with any cost implication to the Employer.

h) All the buildings and facilities shall be approachable by fire tenders.

7.03.00 Bidder shall visit the project site and physically study the entire area. Entire construction and erection facilities to be deployed including the civil design and construction techniques shall be subject to the Employer's approval. Deep excavations near the existing structures shall be carried out with sheet piling.

8.00.00 SITE LEVELLING

8.01.00 Earth to be used for filling purpose shall be sand, or other inorganic materials and they shall be clean and free from shingle, salts, organic, large roots and excessive amount of sod, lumps, concrete or any other foreign substances. All clods shall be suitably broken to small pieces. Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 75 microns shall not be more than 20 %. In any case, the materials to be used for filling purpose shall have the prior written approval of the Engineer.

8.02.00 Fill shall be placed in horizontal layers not exceeding 300 mm compacted thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction / density of 95% of Standard Proctor Maximum Dry Density

8.03.00 Compaction shall be carried out with 12 tonne rollers smooth wheeled, sheep foot or wobbly wheeled as directed by the Engineer. Each layer shall be wetted or the material dried by aeration to a moisture content of 3-5% above the optimum. Each layer shall be watered, rammed and compacted and tested for ensuring the desired degree of compaction.

8.04.00 Earth generated from excavation work of raw water reservoir, other foundation work/cooling tower basin etc. shall be used for site levelling purpose.

9.00.00 COOLING TOWERS

Type of cooling tower shall be as defined in part A of tech. spec The civil works for cooling towers are related mainly to following areas, but not limited to:

9.01.00` Cooling Tower Basin, Sumps and Duct

The basin underneath the cooling tower for collection of cold water shall be

made of RCC of grade M-25. The inside walls of cold water basin sumps,outlet channel and desludging sumps and other similar structure shall be applied with extended two component coating system or its equivalent as specified in Tables -D. The floor of the basin shall be sloped to minimum 1V:120H towards drain sumps which will be connected through CI pipe to sludge sump. For drainage arrangement of basin reference shall be made to mechanical technical specification. One outlet channel shall beconstucted from the outer faces of the basin and connected to the C.W. system. The stoplogy gate shal be tested for water tightness as stated elsewhere in the specification.

Lifting arrangement for the gate/stoplog gate shall be provided with necessary civil and structural works. The outlet channel shall be covered on top with removable precast concrete slabs with G.I. handrail on both sides for access to gate lifting arrangement.

9.02.00 Induced Draught Cooling Tower

9.02.01 Foundation

Cooling tower including basin shall be provided with suitable foundation system at a depth minimum 1.5m or as required below finished ground level. No deviation shall be checked for uplift forces considering empty of the basin with ground water table at finished ground level. A minimum factor of safety of 1.20 against uplift shall be ensured for the following conditions:

i) Basin walls constructed upto finished ground level and ther is no water in the basin and super structure clumns not constructed and ground water table at finished ground level.

ii) No pressure relief valves shall be provided in the cold water basin. The water tightness of the basin shall be ensured to prevent mixing of ground water with sweet water of C.W. system.

9.02.02 Super structure

Cooling tower support structures like columns, beams and slabs etc. shall be of reinforced cement concrete of grade M-25 as per IS: 456.

The fan deck slab shall be property sloped so that rainwater does not

accumulate over the deck slab. The slope shall be 1V:120H (min). The slope may be provided with screed concrete (1:2:4) also. Deck slab and alll other over ground platforms shall be provided with 32 mm dia G.I. hand rails (vertical post as well as horizontal pipes) and with the guard around.

9.02.03 **Cells and distribution systems**

Cooling tower cells shall consist of RCC columns and beams. Hot water distribution channel shall also be made of R.C.C. Only cell division partition walls may be of precast concrete blocks. The grade of concrete shall be M-25 for all the above structures.

Hot water channel shall be suitably covered with pre-cast/cast-in-situ concrete slab. Whenever flow control valves are located over hot water basin these shall be placed over suitably designed pre-cast concrete covers. The thickness of RCC fan stack shall be minimum 125 mm with reinforcement in both the faces of the concrete.

9.02.04 Two nos. stairs, one each at gable end shall be provided.

All stairs shall be RCC of grade M-25, with G.I. hand railing.

9.02.05 Steel structrues such as stoplogs, chequered plate/grating floors, ladders, etc. shall be hot dip-galvanised as per IS:4759 with minimum value of average mass of coating 750 gm/sq.m. All inserts, embedments, bolts nuts, etc. shall also be hot dip galvanised as per IS:4759, 4826 and 5358.

9.02.06 Formwork for underground work shall be of ordinary quality. For super structures plywood form work shall be provided.

9.02.07 Single sheet steel hinged door of 1.2 mm (18G) mild steel, heavy hot dipped galvanised shall be provided in each fan stack at fan deck level. Minimum door size shall be 2100 mm high (clear) and 1200 mm wide (clear). The galvanisation shall not be less than 750 gm/sq.m on each side as per IS:4759.

9.02.08 External surface of cooling tower shall be painted with three coats of water proof cement paint of approved colour applied over a coat of primer.

9.02.09 **Stability**

Computation shall be provided to verify the stability of cooling tower structures

at different levels of construction to ensure that a satisfactory margin of safety always exist during construction.

9.02.10 **Fan Stack**

The RCC fan stack shall be made of RCC M-25 grade with minimum 125 mm. thickness. Design of the fan stack shall be made on the basis of relevant stipulations. of IS:11504 for Natural Draught Cooling Towers.

9.02.11 **Design Cosiderations**

a) R.C.C. Structures

Design of R.C.C. structures of cooling tower which are not in contact with water/water sprary/moist air shall be carried out generally as per IS:456, Code of practice for plain and reinforced concrete for general building construction. The basis for design of all RCC structures shall be as per working stress method of design as outlined in IS:456. However, all other structures in contact with water/water spray/moist air, excluding C.W. basin shall be designed as per working stress method based on IS:456 for concrete but the stresses in reinformcement steel shall be limited to the values as given in IS:3370.

b) Pre-stressed Concrete

Design, contruction and workmanship of pre-stressed members shall be in accordance with IS:1343. Steel wires of pre-stressing shall conform to IS:1785. Particular attention shall be paid to achieve effective bonds of wires in pre-tensioned concrete units. For this purpose identical wires shall be used.

c) Fill Support structures

Fill support structures shall be of RCC M25 grade concrete. The loads of the design fill support structure shall include weight of falling water and weight of minimum 5 mm thick sludge deposit/moss.

d) Grade of Concrete

Grade of concrete to be used in all concrete elements, structures, including supporting blocks, partition walls etc. shall be design mix

concrete (controlled concrete) of grade M-25. Grade of concrete in pre-cast concrete members shall be M-25. Lean concrete to be placed below grade slab or below foundations shall be proportion 1:3:6 with a minimum thickness of 100mm.

9.03.00 Natural Draght Cooling Tower

9.03.01 For load combination the stressess in concrete and reinforcement shall be restricted as per limit state method of IS:456 with serviceability criteria of crack width limited to 0.1mm.

The shell of cooling towers shall be designed by limit state method as per IS:456. The stress in the reinforcement steel shall not exceed 87% of the specific characteristic strength of reinforcement steel and the compressive stress in the concrete shall not exceed 45% of the specified 28 days cube stregth of the concrete as per IS:456.

In the design of the cooling tower shell, column, pile caps, pedestals, ring, beams, etc. no increase in the strength with the age of the concrete shall be permitted. The age factor equal to 1.0 shall be considered.

Permissible stress for steel structures shall be as per IS:800 (latest) based on working stress

9.03.02 General

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

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

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

Geometric imperfections, if exceed the permissible limit then the analysis of

shell shall take into account of such imperfections and resubmitted for owner's approval.

Boundary conditions shall be realistic and based on actual configuration. The magnitude of the calculated displacements should be within limits of the applied theroy.

A detailed dynamic analysis shall be carried out for the complete tower for seismic forces by response spectrum method. Cooling tower shall also be designed for cross wind oscillations (Wind induced vibration) if the fundamental natural frequency of the tower is less than or equal to 1 Hz. Frequency calculation for free vibration analysis shall also be furnished by bidder during detailed engineering.

9.03.03 **Size and Shape**

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

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

H/D = 1.2 to 1.55

Where H is the total tower height above basin sill level.

Hb/H=0.75 to 0.85

Hb is the vertical distance from the throat to basin sill level and 'D' is the base diameter at basin sill level.

However, other proven profiles may be permitted subject to approval from the owner. Bidder's shall submit along with the offer complete details of the profile, in case the profile is not within the limits stated above, and the names of the sites where such shell profile have been successfully constructed. Notwithstanding what is stated above, the owner reserves the right to accept/ reject the shell profile.

9.03.04

TOWER SHELL BOUNDARY CONDITIONS

A. Shell Analysis and Design

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

(a) **At upper Edge**

The top edge of the shell shall be gradually thcikened to form a ring beam to guard against possible instability of the top of the shell due to high velocity with 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 rign 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 be considered as elastically supported by discrete columns.

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

a. Meridional and circumferential direct stress resultant and the tangential shear stress resultants.

b. Meridional and circumferential bending moments.

c. Displacement normal to the shell mid-surface

B. Buckling of Tower Shells

Critical dynamic pressure (wind pressure) at buckling shall be as given below:

Pcr = 0.07E (d) 7/3/r

Pcr = Critical dynamic pressure

Ec = Modules 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.

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

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

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

C. Openings in shells :

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

Openings shall be provided with additional edge reminforcement of a minimum cross sectional area at each edge equal to 75% of the reinforcement intercepted by the openings in the direction parallel to the edges. In addition, diagonal reinformcement shall be provided at each corner as close as possible. The total cross-sectional area in cm2 of this reinforcement shall be 0.5d at each corner where'd is the shell thickness in cm.

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

D. Minimum Thickness of Shell:

The minimum thickness of the shell not be less than 200mm

E. Minimum Reinforcement in Shell Spacing and Placement.

The reinforcement used shall be cold worked steel high strength deformed bars of grade Fe415 conforming to IS:1786-latest. All reinforcement steel shall be corrosion resistant steel of Marine grade suitable for marine application. Reinforcement steel higher than Fe415 grade may be used if permitted by the Owner. The Minimum reinforcement to be provided shall be as follows:

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

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

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

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

The concrete cover shall be 50mm minimum. However, the clear cover shall not be less than 1.5 dia of bars.

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

Provision of meridional ribs in Cooling Tower Shell

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

Minimum thickness of shell excluding ribs shall not be less than 200mm

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

Shell buckling and strength shall be checked as per Clause-B above without considering the effect of ribs.

All other stipulations as specified in these specifications shall be met with.

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

9.03.05 **Raker Columns**

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

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

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

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

9.03.06 **Crack width control**

Under working stress method the maximum crack width of tower shell, lintels, raker columns, cold water basin and fill support structure shall be controlled upto 0.1mm on basis of formulas as per IS:456 and relevant British codes.

9.03.07 Fill support structures and Drift Eliminators (if required) shall be designed as per the various load combination. Appropriate Live Loads and imposed loads shall also be considered in addition. The design shall conform to limit state method as per IS:456 and 9.10.05 except noted otherwise

9.03.08 **Prestressed Concrete Members**

Design, construction and workmanship of Prestressed concrete members shall be in accordance with IS:1343 (Latest revision). Steel wire for prestressing shall conform to IS:1785 (Part I) (latest) or IS:6003 (latest edition). Crack width control shall be limited to 0.1mm.

Particular attention shall be paid to achieve an effective bond of the wires in prestensioned concrete units. For this purpose, indented wire shall be used. Wire shall be corrosion resistant.

9.04.00 **General**

9.04.01 Water proofing admixture (plasticiser cum water proofing compound) as approved by Engineer, shall be added as per manufacture's recommendations to the concrete for basin, ducts, channels, drainage pits, hot water basin/channels.

9.04.02 PVC sealing strips shall be used for all expansion and construction joints where water is retained or dry working conditions are required. The minimum thickness of PVC sealing strip will be 6mm and minimum width 230mm. The expansion joint shall be as per IS:3370. At expansion joints, joint filter material with polysulphide sealing compound shall be provided through out the height of the cooling tower.

9.04.03 Lean concrete 100mm thick of 1:3:6 proportion shall be provided below all structural concrete resting directly on soil/founding strata.

9.04.04 All other civil works required to make installation of cooling towers complete, including the connection of the cooling water discharge duct shall be provided by bidder.

9.04.05 Excavation in all types of soil shall include dewatering till the backfilling is over, backfilling and disposal of the surplus earth to the areas as per the instructions of the Engineer. The material to be backfilled shall have prior approval of the Engineer.

9.04.06 Compaction of all back filled material shall be carried out as specified elsewhere in this specification.

9.04.07 Drain sump(s) along with sludge pit.

9.04.08 Liquid retaining structures

a) Design of C.T. Basin, (including outer face i.e. face in contact with earth) sump, outlet channel, duct, sludge pit, H.W. distribution basin/H.W. Channel shall be designed as uncracked section as per IS:3370. The allowable stress of concrete and steel for above structures shall be as per IS:3370. Grade of concrete shall be M-25 as per IS:456. The C.T. basin, ducts, sludge pit etc. shall be designed for the following conditions:

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

ii) Earth pressure plus 2000 kg/sq.m. surcharge outside and no water inside and ground water table at specified level.

iii) For safety against uplift reference shall be minimum 1.20.

b) For design of basin slab, when uplift due to ground water table or due to water logging is present, the same shall be designed with C.T. basin empty as well as basin full conditions. The basin slab shall be designed as per IS:3370. The provision of flap valve/pressure release valves shall not be considered in the design of C.T. basin.

The minimum thickness of the base slab shall not be less than 150mm. The minimum reinforcement steel (HYSD) to be provided in each direction of basin slab shall be 0.24% of the gross cross sectional area.

9.04.09 The minimum concrete clear cover to reinforcement in all RCC structures shall be as per IS:3370, except as mentioned for the following:

Staircase 25 mm for slab

	Foundation (for either isolated footing or raft/strip) for all elements.	50mm
	Columns (below and above ground level)	50mm
	Fan Stack	30mm

9.04.10 The minimum cement content as specified in relevant codal provisions shall be applicable for all structures of cooling towers.

9.04.11 R.C.C. staircases shall be minimum 1000mm wide clear and risers shall be 180mm maximum and treads 250mm minimum.

9.04.12 Steel Structures

These structures shall be designed, fabricated and erected as per IS:800 (latest revision) for structural steel work.

Stoplog and its lifting arrangement shall be designed for a condition when water in the basin is upto full level and not water outside. Proper rubber seal shall be provided in the stoplog so as to avoid any leakage of water.

All mild steel parts or structural steel works used in cooling towers shall be hotdipgavanised as per IS:4759 with 750 gm/sq.m coating. Nails and all components coming in direct contact with water shall be of stainless steel of AISI 304 or equivalent.

a) All welds shall be subject to 100% visual examination.

b) Dye penetration test on welds shall be carried out.

c) Welding shall be done as per approved procedures and by qualified welders.

d) Rubber seal used in stoplogs shall be tested as per the requirements of relevant code.

e) Stoplogs shall be checked in dry condition for smooth operation and wet condition for water tightness.

f) Galvanising shall be checked/tested for all tests as per IS:2629.

For other detail on steel structures gates etc. refer elesewhere.

9.04.13 **Test for water tightness**

The water tightness of C.T. basin, outlet channel, hot water channel, fire water pump house and all other water retaining structures shall be tested as per the provisions of IS:3370.

10.00.00 **C.W. SYSTEM & RAW WATER SYSTEM/OTHER PUMP HOUSE**

10.01.00 C.W. Pump House/ Raw Water Pump Houses/Aux. Cooling Water Pump House/ Other Pump Houses

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

10.01.01

a) All pump houses shall be provided with minimum two sets of stop logs for the respective pump bay dimensions along with electrically operated hoisting arrangements. Steel embedments required for stop logs shall be provided for all bays.

b) All bays of pump houses shall be provided with a removable trash rack including electrically operated hoisting arrangements and cleaning arrangements. Moreover, one spare trash rack of respective pump bay dimension shall also be supplied for each pump house.

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

10.01.02 The sub-structure of all pump house including their forebays shall be RCC with M-25 grade of concrete confroming to IS:456. The superstructure of all pump houses shall consist of either structural steel frames or RCC portals.

10.01.03 C.W. pump house and other pump houses shall be structurally separated from their forebays by providing an expansion joint. All pump houses shall be provided with a separate maintenance bay for maintenance of various equipment and an electrical switchgear room. Length of maintenance bay shall be adequate for one pump maintenance. However, minimum length of maintenance bay for C.W. pump house shall be 10 m.

10.01.04

a) The dimension of pump bays and forebay for C.W. pump house shall be fixed up initially based on Hydraulic Institute Standard. All the dimensions of pump bays, forebays shall be further confirmed by conducting a Hydraulic Model Study at a recognised hydraulic research laboratory. Scale of the model shall be 1:12. The hydraulic model study shall be conducted to study the flow conditions in the approach C.W. channel, forebay, pump bays, for different discharges and different depths of water, different combinations of pump operations to study the velocity distribution in approach channel, forebay area, pump bays, etc. The model shall be based on Froude's law of similitude and shall also be tested for the following two more flow conditions viz.:-

i) At twice the prototype maximum Froude number i.e. the Froude number of model is two times that of the prototype.

ii) At equal velocity criterion i.e. the velocity is same both in the model and prototype.

Recommendations for modification shall be made based on hydraulic model studies for the forebay length, angle of divergence of expansion for forebay, pier length, clearances around bell-mouth, additional structural features required, such as flow straighteners, baffle walls, mesh screens, guide vanes, splitter cones, etc. for elimination of non-uniform velocity distribution, swirls and vortices in the model etc.

The report of model study shall be submitted for Owner's approval and the final copies of the same shall be submitted to the Owner in 8 copies after the approval.

b) For the pump houses other than C.W. pump house, the dimensions and geometry of forebay and pump house sub-structure shall be decided based on the Hydraulic Institute Standards and the Hydraulic model study for these pump houses shall not be necessary.

10.01.05

For all other structures other than the C.W. pump house where flow regulation is required, suitable steel gates/ stop logs along with the electrically operated hoisting arrangement shall also be provided.

10.01.06

All stop logs and trash racks shall be of structural steel, which shall be hot double dip galvanised. Proper rubber seal shall be provided for the stop logs so as to avoid any leakage of water. Rubber seal provided for the stop logs

shall be tested in accordance with the relevant Indian Standards. Stop logs shall be checked for water tightness and smooth operation in dry and wet conditions.

All mild steel parts used in the water retaining structures shall be hot double dip galvanised. The minimum coating of zinc shall be 610gm/sq.m for galvanised structures and shall comply with IS:4759 and other relevant codes. Galvanising shall be checked and tested in accordance with IS:2629.

The galvanising shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.

10.01.07 **Raw water reservoir**

Raw water reservoir shall have a net usable capacity of 1,33,000 cu.m. excluding additional capacity required to account for evaporation losses and dead storage. The sizing of the reservoir shall be such so as to utilize the allocated area for the reservoir as per the layout drawing of the plant and as directed by the owner. Bottom 500 mm (minimum) depth of reservoir shall be treated as as dead storage for settlement of any silt etc. The reservoir shall be provided with a free board as per requirement of IS code or 500mm, whichever is more.

Raw water reservoir shall be of RCC construction with two compartments. An aerator shall be provided and shall be located near raw water reservoir. A raw water pump house shall be provided along with raw water reservoir. Separate bays shall be provided for each pump bay with intermediate dividing piers.

An aerator of RCC construction shall be provided adjacent to raw water reservoir.

10.02.00 **C.W. DUCTS**

10.02.01 CW ducts from C.W. pumps house upto condensers and from condensers upto cooling towers shall either be steel pipe encased in concrete or factory made steel hume pipes (steel pipe having cement concrete lining inside and cement mortar coating with pre-tensioned wire on the outside) or ready manufactured RCC pipes (of M-25 grade) with steel liner of minimum 3mm thickness for water- tightness like "BONNA PIPES".

For C.W. pipe liner, specifications given elsewhere in these specification shall be followed. Top of C.W. ducts shall be minimum 1.5 m below grade/formation level.

Sand filling shall be provided as back fill, minimum upto the centre of the pipe in case of steel hume pipe. For the remaining height, for steel hume pipes and for full height for RCC Bonna pipes and steel lined concrete encased ducts, selected non expansive material having permissible concentrations of sulphates and chlorides as approved by Employer shall be used for back filling and same shall be arranged by the Bidder. Excavated earth can also be used for backfilling, if the same is non-expansive and having permissible concentrations of sulphates and chlorides and approved by the Owner.

For steel pipes encased in concrete, concrete encasement to steel pipe shall be with M20 grade concrete conforming to IS:456 and shall be minimum 300 mm thick all round for pipes upto 2100 mm diameter and 500 mm all around for pipes having diameter more than 2100mm. The minimum thickness of steel pipes shall be as follows including corrosion tolerance of 2 mm:

a) For pipes upto and including 2200 mm dia - 12 mm

b) For pipes above 2200 mm upto and including 3200 mm dia - 14 mm

c) For pipes greater than 3200 - 16 mm

Required number of stub connections shall be provided to fix air release valves. Flow measurement devices as required shall also be provided. As required ducts shall be tested for leak proof upto a pressure upto 1.5 times the normal operating pressure. Pressure tests shall be conducted in segments after laying.

Steel hume-pipe shall have minimum 25mm thick internal spun concrete lining of M-25 grade with 10 mm nominal size aggregates and 40 mm thick out side cement mortar (1:3) brush coating with pre-tensioned wire.

All additional measures as necessary for protection against corrosion of C.W. pipes and to take care of any adverse soil characteristics shall be provided by the Bidder.

10.02.02 The C.W. ducts shall be tested for leak proof by hydraulic testing. Each piece of pipe shall be hydraulically tested in shop for water tightness. Each field joint shall be tested against leakage by applying hydraulic pressure locally at the field joint or by testing the complete length of pipeline. Hydraulic pressure for all testing shall be 2 times the working pressure of C.W. pumps or 1.5 times the design pressure of C.W. pumps, whichever is higher. The testing pressure shall

be held for minimum period of 30 minutes without any signs of leakage or failure of weld.

Any defect observed during testing shall be rectified and if instructed by Employer, defective pipes shall be replaced by new pipes and the system shall be retested. Necessary valve pits, thrust blocks and anchor blocks shall be provided.

10.02.03 For inlet/outlet structures suitable stop logs alongwith lifting bean and electrically operated hoisting arrangement shall be provided.

10.02.04 All mild steel parts used in the water retaining structures shall be epoxy painted.

10.03.00 **Stop logs and Trash Racks**

10.03.01 All stop logs and trash racks shall be of structural steel, which shall be hot double dip galvanised. The leakage, if any, through the rubber seal shall be measured and it should not be more than 5 lit./min./meter length of seal under maximum load.

10.03.02 The stop log units shall be operated under balanced head and they shall be designed for maximum water head to which they shall be subjected to. The stop log shall be used only for the maintenance/ inspection of pumps. These are not to be designed for lowering under flowing water. The stop log shall be operated by means of a monorail trolley with electric rope hoist and a lifting beam which shall engage and disengage automatically with stop log in required position. Lifting beams shall be designed and fabricated by the Bidder in coordination with the manufacturer of monorail with electric hoist. The structural design of stop log shall conform to IS:5620.

10.03.03 Trash racks shall be installed in inclined position. Trash racks shall be designed for a differential head of 1m of water column. Each unit of trash rack shall consist of vertical flats and horizontal flats of minimum 10 mm thickness from durability point of view. The grating shall be pressure locked. Size of the openings for the trash racks shall be 100 mm x 100 mm(clear). All trash racks should be capable of being lowered in the associated stop log grooves to enable drawal of clean water while a particular trash rack is raised for cleaning purposes. Details of block -outs to be provided in structural concrete for stop logs and trash racks shall also be shown on the drawings.

10.03.04	All the design computations and drawings for the structural and mechanical parts including hoist supporting structure and connections of various components for stop logs and trash racks shall be submitted by the Bidder for approval of the Employer before the manufacture is taken up. Detailed drawings of mechanical parts such as wheels, wheel parts, hoists and various component parts of the hoists shall also be supplied along with calculations.
10.03.05	Bidder shall prepare all necessary shop drawings for the fabrication of stop log/ trash rack and shall be responsible for the correct fitting of all parts. Any fabrication done before the shop drawings are approved will be at the Bidder's risk. The Employer shall have the right to instruct the Bidder to make any change in the Bidder's fabrication details, which may be necessary in the opinion of the Employer to make the finished construction conforming to the requirements and intent of these specifications without additional charges to the Employer. Fabrication shall conform to the requirements of the relevant Indian Standards.
10.03.06	Approval of the Bidder's drawings by the Employer, shall not relieve the Bidder of any part of the Bidder's responsibility to meet the requirement of these specifications, or of the responsibility for the correctness of the drawings. The Bidder shall furnish the Employer for record purposes three complete sets of the final shop drawings from which the stop logs/ trash racks etc. have actually been fabricated. Dimensions, tolerances, types and grades of materials and various component parts shall be shown in sufficient detail to enable the Employer to make a complete review and thoroughly check the drawings.
10.03.07	All components of stop logs and trash racks covered under this specification shall be subjected to inspection tests by Employer during manufacture at works. Shop tests shall include all tests to be carried out at Bidder's works, works of his sub-Vedner and at works where raw materials are supplied for manufacture. The tests to be carried out shall include but not be limited to the tests described herein.
10.03.08	Bidder shall conduct all tests according to relevant I.S. or according to relevant British/ American Code of Practice in the absence of suitable I.S. Code to ensure that all the components and accessories of stop logs, trash racks, bulk heads, hoists etc. to be supplied as per the contract conform to the requirements of this specification. The accessories, e.g. bearings, couplings, etc. will be subjected to tests as per Manufacturer's Standard. The applicable test reports/ certificates shall be submitted to Employer.

10.03.09	Tests on motors shall be conducted as per latest revision of IS: 325 and IS:4029. Tolerance in dimensions shall be within the limits as prescribed in the relevant I.S. Codes and Standards. Surface defects shall be removed as required by the relevant Standards. All local repair, grinding or machining shall be smoothly blended into the surrounding surface.
10.03.10	Complete stop logs, trash racks including exposed surfaces of hoists, gear housing, shafting bearing pedestals, base plates and other machinery shall be fully galvanised.
10.03.11	After the equipment has been installed in the field it will be operated and tested by the Employer and when so operated and tested it shall meet all the requirements of specifications and drawings. The gates shall be raised and lowered several times for their full lengths of travel. The primary requirement for acceptance shall be that each stop log operates smoothly and guarantees satisfactory water tightness. Any equipment required for inspection and testing shall be provided by the Bidder and no such equipment shall be supplied by the Employer. All defects detected during testing shall be repaired to the satisfaction of the Employer after completion of all installations, the frames and guides etc. shall be thoroughly cleaned of dirt, dust, rust and concrete spalls or other foreign materials.
10.03.12	The stop logs shall be thoroughly cleaned with particular attention being paid to bearing and seating surfaces. The mechanical hoist equipment shall be properly lubircated. Each set of stop logs, Bulkheads and Trash Rack shall be tested under dry conditions and under full water load conditions, by traversing the item concerned from its extreme raised position to full seating position and return at least thrice.
10.03.13	Upon successful completion of such tests, final acceptance shall be made by the Employer. But before a completion is issued by Employer, the Bidder shall have to remove from the area of operation, on which the work has been executed, all scaffoldings, surplus materials, rubbish and other materials. If the Bidder fails to comply with this requirement, the Engineer shall get it done by other agencies at Bidder's Cost.
10.03.14	The Bidder shall strictly follow at all stages of fabrication, transportation and erection of steel structures, raw materials and other tools and tackles, the stipulations contained in the Indian Standard Safety Code for erection of structural steel work IS:7205. Local Statutory labour safety regulations are also applicable.

10.03.15 The Bidder shall furnish to the Employer a complete and unused set of all special tools and tackles, which are necessary, or convenient for erection, commissioning, maintenance and overhauling of any of the equipment provided under the specificaiton. The tools shall be shipped or transported in separate containers clearly marked with the name of equipment for which they are intended.

10.03.16 Leakage tests shall be carried out with the stop logs lowered onto the sill. Before that observation for leakage, the stop logs shall be raised and lowered about one meter several times in order to dislodge any debris that might have lodged in the side and bottom seals.

10.03.17 Materials for the various components of Stop logs:

S.No.	Component Parts	Recommended	Reference materials
01	Stoplog/Gate Leaf, Stoplogs/Gate frames and embeded parts, Guide Shoe.	Structural Steel	IS:2062
02	Wheels (the hardness of wheel track surface shall be kept 50 points higher than that of wheel tread), Guide.	Cast steel	IS:1030
03	Wheel axles, wheel track	Corrosion Resistant steel	IS:1570
04	Seals	Rubber	IS:5620 Appendix-D
05	Bearings	SKF or equivalent	04 Cr 19 Ni
06	Seal seats, Lifting pin	Stainless Steel	IS:1570

10.03.18 Materials for Trash Rack shall be of IS 2062.

11.00.00 **SEWERAGE SYSTEM**

11.01.00 Cement concrete pipes of class NP-3 as per IS:458 shall be used below ground level for sewage disposal in all areas other than main plant area. However, for pressure pipes and in main plant areas, spun C.I. pipes conforming to IS:1536 of required class shall be used.

11.02.00 RCC manholes with CI cover shall be provided at every 30m along the length, at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline. This shall be as per IS:4111.

11.03.00 Sewage pump house shall be provided as per IS:4111.

11.04.00 Sewage treatment plant is to be provided by the Bidder. Bidder shall have to provide complete arrangement for sewage disposal up to the Sewage treatment plant including pumping facilities. Extended Aeration method of sewage treatment shall be used.

12.00.00 **SWITCHYARD CIVIL WORKS**

12.01.00 **Civil works are related to the following:**

(a) Towers, lightning masts, beams, columns, equipment supporting structure etc.,

(b) Foundations for towers, lightning masts, buildings, transformers, shunt reactor, equipment support, etc.

(c) Cable trench with covers, fencing with gate, fire protection walls, earthing mat, etc.,

(d) Roads and drains in switchyard area.

(e) Entire area of the switchyard shall be provided with 150 mm thick gravel filling which shall consist of 75 mm thick stone metal filling of 40 mm stone aggregate on the top and 75 mm thick filling of 20 mm stone aggregate below. 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 chemcial shall be procured from reputed manufacturer. The contractor 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 contractor at no extra cost to the Employer. The contractor 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, whichiever is later.

(f) Oil soak pits, oil separation pits, oil drains to the oil seperation pits.

12.02.00 All structural steel members including stub members, bolts, nuts, spring washers, etc., shall be hot dip galvanised after fabrication. Weight for zinc coating shall be atleast 610 g/sq.m.

12.03.00 Structural arrangement, foundation system, miscellaneous requirements, finishes, etc., shall be as specified elsewhere in this specifications.

12.04.00 Lightning masts shall be provided with minimum two number of platforms, (with one at top level) and an internal ladder for climbing purpose upto platform at top level. Top of platform shall have grating, railing and toe guard plates.

13.00.00 PLANT STORM WATER DRAINAGE SYSTEM

13.01.00 All plant effluent drainage shall be through buried concrete pipes unless otherwise specifically required and all storm water drainage shall generally be through open drains.

13.02.00 Open storm water drains shall be provided on both sides of the roads and shall be designed to drain the road surface as well as all the free and covered areas, etc.,

13.03.00 Open RCC rectangular section shall be provided for all drains. RCC drains located within and along both sides of peripheral roads of the main plant area, shall be covered with perforated precast RCC slabs of minimum 50 mm thickness with provision of openable galvanised steel grating covers at about 4.0M intervals.

Similarly all artery drains and the drains along the periphery of building shall also have perforated precast RCC covers of minimum 50 mm thickness with

provision of openable galvanised steel grating covers at about 4.0 m intervals. In areas where vehicular loads would be coming, precast RCC covers of suitable thickness without perforations and designed for the vehicular loading shall be provided. The thickness of side walls and bottom slab of RCC drains shall be minimum 200 mm or as per design considerations whichever is higher. RCC box/pre cast R.C.C pipe culverts shall be provided for road and rail crossing. All drains in the Main Plant area shall be provided with heavy duty hot-dipped galvanised steel grating.

13.04.00 All drains inside the building shall have minimum 40 mm galvanized thick grating covers. In areas where heavy equipment loads would be coming, precast RCC covers shall be provided in place of steel grating.

13.05.00 Invert of the drains shall be decided in such a way that the water can easily be discharged to the natural water bodies above the high flood level.

13.06.00 For pipe drains, concrete pipes of class NP3 (Minimum) shall be used. For road and rail crossings concrete pipes of class NP3 and NP4 respectively shall be used. The pipes shall be laid as per IS:783. In this case open catch water drain shall be provided on the other side of road and connected to pipe drain through RCC manholes. RCC manholes shall be provided at every 30m interval along the length, at connection points and at every change of alignment, gradient and diameter of pipeline.

The invert of the in-plant and plant peripheral drains shall be kept such that water can be discharged by gravity to the main/ trunk drains under all conditions.

14.00.00 ROADS

14.01.00 A detailed CBR test shall be carried out as per the procedure outlined in IS:2720 (Part 16). Shoulders with 150mm thick WBM with 75 mm-thick PCC interlocking blocks shall be provided on either side of the roads.

14.02.00 Unless otherwise specified, all roads including access road to buildings/facilities (other than patrol road) shall be double lane roads with 7.0 m wide black topping and 2.5 m wide shoulders on either side of the road. Patrol roads shall be single lane with 3.75 m wide black topping and 1.0 m wide shoulder on either side. The base and sub-base of the road shall be of water Bound Macadam.

14.03.00 All roads shall be provided with edge protection on both edges of black topping using pre-cast concrete blocks of M-25 grade.

14.04.00 All roads for the complete plant areas shall be provided by Bidder. Cutting/ extending/ re-routing/ remaking of existing roads including associated works to maintain continuity of road system shall also be carried out by the Bidder. In addition, access roads to all buildings and facilities (road approaches/ connections) and other equipment areas (where access is necessary from inspection, operation & maintenance point of view) shall also be provided by Bidder.

14.05.00 Finished top (crest) of roads shall be 250mm above the surrounding grade level.

14.06.00 Road construction including bitumen macadam, water bound macadam base and sub-base shall be as per IRC standards. Minimum total thickness of black topping (premix carpeting) shall be 50 mm in 2 layers of 25 mm each followed by seal coat (Type B). First layer shall be provided during construction and second layer after the commissioning of the plant. Seal coat shall be provided over the second layer. For premix carpet, recommendation of IRC-14 shall generally be followed. Spreading of black topping work shall be carried out using paver.

14.07.00 All culverts and RCC bridges at crossing of all roads / facilities (included in the scope of Bidder) with nallahs / channels / drains / roads / pipes / other facilities etc. RCC culvert cum road-bridge shall be provided by the Bidder.

15.00.00 MISCELLANEOUS REQUIREMENTS

15.01.00 **Joints in Concrete Structures**

15.01.01 **Construction Joints**

Construction joints for basement type under ground structures and all liquid retaining/ carrying structures shall be made watertight by chemical injection grouting or by providing PVC water stops. The PVC water stop shall meet the requirements of IS:12200 and shall have a minimum thickness and widths of 6 mm and 230 mm respectively. In either of the cases, a suitable shear key joint shall be provided.

Two - Part polysulphide sealant conforming to IS:12118 or silicon sealing

compound conforming to BS shall be used for sealing of joints for liquid retaining/carrying structures.

Preformed bitumen impregnated fibre board conforming to IS : 1838 shall be used as joint filler. The bitumen sealing compound shall be as per IS:1834.

15.01.02 **Expansions Joints**

In case of expansion joints, preformed bitumen impregnated fibre board conforming to IS:1838 shall be used as joint filler. The joints shall be sealed with bitumen sealing compound conforming to IS: 1834, however in case of liquid retaining/carrying structures, two parts polysulphide sealant conforming to IS:12118 or silicon sealing compound shall be used in case of all liquid retaining/ carrying structures.

15.01.03 IS:3414 shall be followed for details of joints in buildings. 3 mm thick stainless steel strip in matt or buff finish shall be provided over building expansion joints.

15.02.00 All steel sections and fabricated structures, which are required to be transported on sea, shall be provided with anti corrosive paint before shipment to take care of sea worthiness.

15.03.00 A screed or concrete layer not less than 100 mm thick and of grade not weaker than M 10 conforming to IS: 456 shall be provided below all water retaining structures. A sliding layer of bitumen paper or kraft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structure.

Minimum 75mm thick lean concrete M-7.5 shall be provided below all other underground structures, foundations, trenches, etc., to provide a base for construction.

15.04.00 Monorails, monorail girders and fixtures shall be provided, wherever required to facilitate erection / maintenance of equipment.

15.05.00 a) Wherever possible all floor openings shall be provided with 100 mm thick 50 mm high RCC kerb all around.

b) Angles 50 x 50 x 6 mm (minimum) with lugs shall be provided for edge protection all around cut outs/openings in floor slabs, edges of concrete drains supporting grating/covers, edges of RCC cable / pipe trenches supporting covers/chequered plates/ grating, edges of manholes

supporting covers, supporting edges of precast RCC covers and any other place where breakage of corners of concrete is expected.

15.06.00 Floor of switchgear room shall be provided with embedded M.S. channel suitable for easy movement of breaker panels.

15.07.00 Anti termite chemical treatment shall be given to all vulnerable areas susceptible to termite including column pits, wall trenches, foundations of buildings, filling below the floors, etc., as per IS: 6313 and other relevant Indian Standards.

15.08.00 Trenches shall project at least 200 mm above the finished formation level so that no storm water shall enter into the trench. The bottom of the trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected through pipe drains to the nearby RCC manholes (to convey water from trenches) of storm water drainage system, but avoiding back flow of storm water. The precast covers shall not be more than 300 mm in width and shall not weigh more than 65 kg. Lifting hooks shall be provided in the precast covers. The trenches shall be given a slope of 1 in 250 in the direction perpendicular to the run of the trenches. PVC water stops shall be provided at all expansion joints of all trenches.

15.09.00 All steel platforms above grade shall be provided with kick plates at edge of platform.

15.10.00 Duct banks consisting of PVC conduits conforming to IS:4998 for cables shall be provided with proper sealing arrangement consisting of fire retardant sealing compound.

15.11.00 Independent network of lines for sewerage and drainage shall be provided.

15.12.00 The sub-grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor density at Optimum moisture content (OMC.)

15.13.00 Detailed scheme for dewatering shall be prepared, wherever required, before starting of deep excavation work. IS: 9758 shall be followed as general guidance for dewatering.

15.14.00 All buildings shall be provided with peripheral drains by the side of plinth protection for catering the storm water from roofs and adjacent area.

15.15.00 The under side level of base plates for structural steel columns shall be decided in such away that bolts, gussets, etc., do not project above the floor level. These shall be encased by concrete cover upto floor level.

15.16.00 Non-shrink flowable grout shall be used for under-pinning work below base plate of columns. Nominal thickness of grout shall be 50 mm. Non-shrink cum plasticizer admixture shall be added in the grout. Crushing strength of the grout shall generally be one grade higher than that of the base concrete. However, for equipment foundations, high strength (minimum characteristic compressive strength of 60 N/mm2 at 28 days) ready mixed non-shrink, chloride free, cement based, free flowing, non-metallic grout as recommended by equipment manufacturer shall be used.

15.17.00 Fencing for transformer yard area shall be of the same type as specified, elsewhere in this specification.

15.18.00 Plant effluent shall not be mixed with either storm water or sewage.

15.19.00 **Concrete**

15.19.01 **General**

a) Concrete work shall be carried out as per IS:456. Mix design concrete shall be used for all areas other than lean concrete work and plain cement concrete where nominal/volume mix can be permitted. Design mix shall be carried out as per IS:10262. Specific approval of the Engineer shall be obtained regarding degree of quality control to be adopted for design mix.

b) Grade of concrete for all foundations including piling shall be M25 unless noted otherwise. Grade of concrete for other structures/ areas (other that of machine foundations) shall be M25.

c) The minimum Grade of concrete for foundation of gas turbine (GT) and steam turbine (TG) shall be M35.

d) Higher grade of concrete than specified above may be used at the discretion of the Employer.

e) Unless otherwise specified, 20mm and down aggregates shall be used for all structural concrete works.

f) All underground concrete structures like trenches, substructures of pump houses, all water retaining/ carrying structures, etc., shall have super-plasticizer cum water proofing cement additive conforming to IS:9103. In addition, limit on permeability as given in IS:2645 shall also be met with.

15.19.02 Special requirements for concreting of major equipment foundations shall be as given below.

a) **Coarse Aggregates**

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, high percentage of reactive silica content, aggregate may be allowed where low alkali content 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 foundations). However, in case other types of suitable aggregate is not available, the Employer may allow the use of lime stone aggregate provided the Bidder gets the sample tested from a reputed testing laboratory for satisfactory performance under high temperature and repeated temperature cycle. Unless otherwise specifically approved by the Employer, the tests shall be carried out for a temperature range from 10 °C to 65 °C and for 60 (sixty) temperature cycles.

b) **Temperature Control of Concrete**

The temperature of fresh concrete shall not exceed 25 °C when placed. For maintaining the temperature of 25 °C in the top decks of machine foundations, crushed ice shall be used in mixing water.

c) **Admixture**

Plasticizer /super plasticizer admixture shall generally be added to the concrete for promoting workability. In addition, plasticizer/super plasticizer-cum-ratarder shall be added to retard the setting time for mass concreting work as required. In case of pumping, suitable pumping additive shall also be added to avoid segregation and increase flowability. The slump shall generally be in the range given below:

Top decks of TG,	-	150 mm to 200 mm
Block foundation	-	100 mm to 150 mm
Column	-	100 mm to 150 mm

d) **Form work**

Plywood with film face form work shall be used for the top decks of all machine foundations and also for columns of STG and GT foundations.

e) **Placing of Concrete**

Base Raft and top deck of machine foundations shall be cast in a single pour.

f) **Ultrasonic Testing**

Ultrasonic pulse velocity test shall be carried out for the top decks of all machine foundations and TG substructure to ascertain the homogeneity and integrity of concrete. In addition, additional cubes (at the rate of one cube per 150 cu.m. 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 defect, the Bidder shall rectify the defects suitably using cement/epoxy grout, etc.,

g) **Scheme for Concreting**

Weigh Batching Plants, transit mixer, concrete pump shall be mobilised. Arrangements for standby Plant and Equipment shall also be made.

15.20.00 **Formwork**

Plywood with film face formwork shall be used for all structures and concrete works.

15.21.00 **Fencing and Gate**

15.21.01 **Fencing**

Fencing with gate shall be provided around transformer yard and other areas wherever necessary due to security, safety, and statutory requirements as per following specifications.

The fencing, with gate (unless specified otherwise) shall comprise of PVC coated G.I. welded wire mesh fencing of minimum 4 mm diameter (including PVC coating) of mesh size 75mmX75mm of height 2.4m above the toe wall with a 600mm high galvanised concertina at the top, such that total fence height of 3.0m above the toe wall is achieved. The diameter of the steel wire for chain link fence (excluding PVC coating) shall not be less than 2.5 mm.

The PVC coated chain link will be stretched by the clips at 0.5m intervals to three strands of galvanised high tensile spring steel wire (HTSSW) of 2.5 mm diameter interwoven with chain link wire mesh and kept under tension which in turn are attached to the fence post with security nuts and bolts. On every fourth post a clamping strip will be threaded through the links of chain link and bolted to the fence post with the help of security nuts and bolts.

Above the chain link a 600mm high tensile serrated galvanised wire (HTSW) concertina made with wire diameter of 2.5mm will be stretched to 6m and attached to two strands of galvanised HTSSW of 2.5 mm diameter by means of clips at 1m intervals. These two HTSSW strands will be attached to the fence posts with 12 mm security fasteners.

All nuts, bolts, fasteners, clamping strips, clamps, clips, etc., shall be galvanised.

All fence posts shall be of 75 x 75 x 6 MS angles spaced at 2.5m c/c distance. All corner posts will have two stay posts and every tenth post will have transverse stay post. Suitable R.C.C. foundations for the post and stays shall be provided based on the prevailing soil conditions. Galvanizing (PPCL).

Toe walls either of brick masonry with bricks of minimum 75 kg./sq.cm. crushing strength or of hollow concrete block masonry shall be provided between the fence posts all along the run of the fence with suitable foundation. Toe wall shall be minimum 200mm above the formation level with 50mm thick P.C.C. coping (1:2:4) and shall extend minimum 300mm below the formation level. Toe wall shall be plastered with cement sand mortar (1:6) on both sides and shall be painted with two coats of textured cement paint (Sandtax Matt or equivalent) of approved colour and shade. Toe wall shall be provided with weep holes at appropriate spacings.

15.21.02 **Gate**

All gates shall be of structural steel of minimum 3.75 metres clear width for single lane access road and 7.75 m clear width for double lane access roads. The height of gate shall be same as that of the fence. Each gate shall have provision for wicket gate of size 1.0 m x 2.1 m.

The gate frame and post shall be fabricated from medium class MS pipe of nominal diameter not less than 75 mm. The panel plate shall be of minimum thickness 2.5 mm conforming to IS:513.

The gate shall be complete with fabricated hinges, MS aldrops with locking arrangement, tempered steel pivot, guide track of MS tee, bronze aluminium ball bearing arrangement, castor wheel, etc.

15.22.00 **Grating**

All gratings shall be electroforged types. Thickness of the grating shall be minimum 40 mm. The opening size shall not be more than 30mmx100mm. The minimum thickness of the main bearing bar shall be 5 mm. Cutting of gratings shall not be carried at site. Any cutting of gratings required to provide passage for columns/pipes/cables/ducts, etc. shall be done by the bidder in shop and cut edges of grating shall be suitably reinforced with binding strips. All gratings shall be blast cleared to Sa 2&1/2 finish and shall be hot dip galvanised at the rate of 610 gm/sq.m.

15.23.00 Minimum 1000mm high handrailing shall be provided around all openings, projections, balconies, walkways, platform, steel stairs, etc. All handrails and ladder pipes shall be 40mm nominal bore MS pipes (medium class).

Hand rails shall have top and middle rails and the vertical post spacing shall not exceed 1.5m with provision of kick plates (100 mm high and 6mm thick).

Hand rails and ladders shall be painted or galvanised as per architectural requirements. The galvanisation shall be at the rate of 610 gm/sq.m. as per IS:4736. Paints shall be as specified for structural steel work.

15.24.00 **Fabrication**

The fabrication shall be done as per fabrication drawing which would clearly indicate

various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld.

All galvanizing of structural steel works are to be hot-dipped.

15.25.00 **Welding**

15.25.01 a. The works shall be done as per approved fabrication drawing which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld.

b. Welding of structural steel shall be done by an electric arc process, submerged arc welding / MIG welding / manual metal arc welding. Welding shall conform generally to relevant acceptable standards viz. IS: 816, IS: 9595, IS: 814, IS: 1024, IS: 4354 and Indian Standard hand book for metal arc welding, and other standards, codes of practice internationally accepted. For welding of any particular type of joint, contractor shall give evidence acceptable to the owner of having satisfactorily completed appropriate tests as described in any of the Indian Standards - IS: 817, IS: 7307 and international standard as relevant.

c. Welding process employing semi-automatic welding machine and / or MIG welding and / or fully automatic welding machine shall be used for welding longitudinal fillet welds (connecting flange with web) and butt joints for fabrication of columns, framing beams and crane girders, unless manual arc welding is specifically approved by the engineer. Necessary jigs and fixtures and rotation of structural shall be so arranged that vertically down-hand position of welding becomes possible. 'open-arc-welding' process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.

d. Wherever welding is done for assembling the components of structural, the job shall be so positioned that down-hand welding is possible.

e. Any structural joint shall be welded only by those welders who are qualified for all welding procedures and positions required in such a joint.

f. The contractor shall maintain records of all the welders identification marks, the joints welded by each welder, the welding procedure adopted, welding machine employed, pre and post heating done and any

non destructive test done and stress relieving / heat treatment performed on such joints. All such records for entire welding operation shall be accessible to the engineer for scrutiny.

g. In fabrication of plated columns / beams and built-up members all shop splices in each component part shall be made before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fitting between components to be assembled for welding, these welds shall be ground flush prior to assembly.

h. The members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 3mm. If the separation is 1.5mm or greater, the fillet weld size shall be increased by the amount of separation.

i. The bins / silos shall be made of mild steel plates joined together with full strength butt weld and provided with stiffeners at regular intervals. Stiffeners shall be welded on the external face.

15.25.02 **Electrodes**

a. The electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of welding and quality of welds desired. Only low hydrogen electrodes shall be used for welding of medium / high tensile steel and for mild steel plate thickness above 20 mm.

b. All low hydrogen electrodes shall be baked and stored before use as per manufacturer's recommendation. The electrodes shall be re-baked at 250 deg.C - 300 deg.C for one hour and later on cooled in the same oven to 100 deg.C. It shall be transferred to a holding oven maintained at 60 deg.C - 70 deg.C. The electrodes shall be drawn from this oven for use.

c. Where coated electrodes are used they shall meet the requirements of IS: 814 and relevant ASME - Sec. II. Covering shall be heavy to withstand normal conditions of handling and storage.

d. Only those electrodes that give radiographic quality welds shall be used for welds, which are subjected to radiographic testing.

e. Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux-wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS: 3613. The electrodes shall be stored properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.

f. The contractor shall take specific approval of the weld for the various electrodes proposed to be used on the works before any welding is started.

15.25.03 **Edge Preparation for Welding**

a. Suitable edge as per weld joint detail shall be prepared either by machines or by automatic gas cutting. All edges cut by flame shall be ground before they are welded.

15.25.04 **Pre Heating and Post Heating**

a. Mild steel and medium / high tensile steel plates thicker than 20mm, will require Pre-Heating of the parent plate prior to welding as mentioned in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, however, higher pre heat temperature may be required as per approved welding procedure and it shall be followed. In welding materials of unequal thickness, the thicker part shall be taken for this purpose.

b. Base metal shall be preheated, not withstanding provisions of IS: 9595 to the temperature given in Table - 1 for mild steel and Table - 2 for medium / high tensile steel, prior to welding or tack welding. When base metal not otherwise required to be pre heated is at a temperature below 0°C it shall be pre heated to atleast 20°C., prior to tack welding or welding. Pre heating shall bring the surface of the base metal to the specified pre heat temperature and this temperature shall be maintained as minimum inter-pass temperature while welding is in progress.

TABLE - 1

MINIMUM PREHEAT AND INTERPASS

TEMPERATURE FOR WELDING MILD STEEL

Thickness of thicker part at Point of welding	Welding Using	
	Low hydrogen electrode or submerged arc welding	Other than low hydrogen electrode
Upto and including 20mm	None	None
Over 20mm and up to and including 40mm	20°C	Not allowed
Over 40mm and up to and including 63mm	66°C	Not allowed
Over 63mm	110°C	Not allowed

Note: Type of electrode and the preheating requirements for welding shall be as per approved welding procedure.

TABLE - 2

MINIMUM PREHEAT AND INTERPASS TEMPERATURE

FOR WELDING MEDIUM / HIGH TENSILE STEEL

Thickness of thicker part at Point of welding	Welding Using: Low hydrogen electrode or submerged arc welding	Welding Using: Other than low hydrogen electrode
Upto and including 20mm	None	Not Allowed
Over 20mm	120oC - 140°C	Not Allowed

Note : Type of electrode and the preheating requirements for welding of medium and high tensile steel shall be as per approved welding procedure.

c. Pre heating may be applied by external flame which is non-carbonizing like LPG, by electric resistance or electric induction process such that uniform heating of the surface extending up to a distance of four times the thickness of the plate on either side of the welded joint is obtained.

d. Thermo-chalk, thermo-couple or other approved methods shall be used for measuring the plate temperature.

e. All butt welds with plates thicker than 50mm and all site butt welds of main framing beam supporting the bunker shall require post weld heat treatment as per procedure given in AWS D-1.1. Post heating shall be done up to 600oC and rate of application shall be 200oC per hour.

f. The post heat temperature shall be maintained for 60 minutes per 2.5cm thickness. For maintaining slow and uniform cooling, asbestos pads shall be used for covering the heated areas.

15.25.05 **Welding Sequence**

a. The sequence of welding shall be carefully chosen to ensure that the components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect or by a counter distortion.

b. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

c. Each case shall be carefully studied before finally following a particular sequence of welding.

d. Butt weld in flange plates and / or web plates shall be completed before the flanges and webs are welded together.

e. The beam and column stiffeners shall preferably be welded to the webs before the web and flanges are assembled unless the web and flanges of the beam or column are assembled by automatic welding process.

f. All welds shall be finished full and made with correct number of runs. The welds being kept free from slag and other inclusions. All adhering slag being removed from exposed faces immediately after such run.

g. Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid as to leave the edges unmelted.

h. Puddling shall be sufficient to enable the gases to escape from the molten metal before it solidifies.

i. Non-uniform heating and cooling should be avoided to ensure that excessive stresses are not locked up resulting ultimately in cracks.

j. The ends of butt welds shall have full throat thickness. This shall be obtained on all main butt welds by the use of run off and run on pieces adequately secured on either side of main plates. The width of these pieces shall not be less than the thickness of the thicker part joined. Additional metal remaining after the removal of extension pieces shall be removed by grinding or by other approved means and the ends and surface of the welds shall be smoothly finished. Where the abutting

parts are thinner than 20mm the extension pieces may be omitted but the end of the butt welds shall then be chipped or gouged out to sound metal and side welded to fill up the ends to the required reinforcement.

k. The fusion faces shall be carefully aligned. Presetting shall control Angle shrinkage. Correct gap and alignment shall be maintained during the welding operation.

l. All main butt welds shall have complete penetration and back surface of the weld being gouged out clean before first run of the weld is given from the back. However, partial penetration butt weld shall be permitted, when specifically shown in the fabrication drawings.

m. Intermittent welds shall be permitted only when specifically approved in the fabrication drawings.

n. The welding shrinkage shall be minimised by adopting the correct welding procedure and method. In long and slender member extra length should be provided at the time of fabrication for shrinkage.

15.25.06 **Testing Of Welders**

a. On the basis of the welding procedure, the contractor shall conduct qualification test. All the welders to be employed for the job shall have to qualify the appropriate tests laid down in IS: 817 and IS: 1181 and ASME IX / AWS D1.1.

b. All necessary arrangements required for the testing of welders are to be provided by the contractor.

15.26.00 **Erection of Structures**

All erection work shall be done with the help of cranes, use of derrick is not envisaged.

15.26.01 **Erection Marks**

a) Erection marks in accordance with fabrication drawing shall be clearly painted on the fabricated steelwork. Each piece shall be marked in at least on two places. Each piece shall also have its weight marked thereon.

b) The centre lines of all columns, elevations and girder bearings shall be marked on the sections to ensure proper alignment and assembly of the pieces at site.

15.26.02 **Erection Scheme**

a) The Erection Scheme for the erection of all major structures shall be furnished. The erectability of the structure shall be checked by the Bidder before commencement of fabrication work to avoid future modification. The erection scheme shall indicate the approximate weight of the structural members, position of lifting hook, crane boom length, crane capacity at different boom length and at different boom inclination, etc., Bidder shall take up the erection work only after he has obtained the approval of the erection scheme from the Engineer.

b) The erection scheme shall also give details of the method of handling, transport, hoisting, including false work/staging, temporary, bracing, guying, temporary strengthening, etc., It will also give the complete details of the number and capacity of the various erection equipment that will be used such as cranes, winches, etc., along with disposition at the time of erection of columns, trusses, etc.

c) The erection of columns, trusses, trestles, portals, etc., shall be carried out in one single piece as far as practicable. No column shall be fabricated and erected in more than 3 pieces. Galleries shall generally be erected as box i.e. the bottom chord and bracings, top chord and bracings, side vertical posts and bracings, end portals and roof-trusses shall be completely welded prior to erection and if required temporary strengthening during erection shall be made. The inside sheeting runners and roof sheeting purlins may be erected individually. When erection joints are provided in columns, their location shall generally be just above a floor level.

15.27.00 **Boundary Wall**

Boundary wall shall be of masonry (brick or stone) construction with plastered surfaces on RCC frame. It shall be 3.0 m high above the formation level of the plant. On the top of masonry wall, eight strings of galvanized concertina wire clamped with vertical Y-shaped M.S. angle posts of 600 mm (min.) high embedded at a spacing not exceeding 3.0 m centres and fabricated out of

galvanized angle section (min. L50x50x6) shall be provided.On the top of Y-shaped M.S. angle posts galvanized concertina spiral wire shall also be provided.

15.28.00. **Canteen Building**

The scope includes a canteen building. The canteen building shall be of single story RCC frame structure including dinning area, kitchen, washing area, toilet blocks both for ladies and gents toilets etc. The space shall be sufficient for the total number of personnel during O&M stage. Floor area of canteen building shall beminimum 500 sq.m. with a provision to add one floor above structures and foundations shall be designed accordingly.

15.29.00 **O&M Store**

O&M store building shall of RCC frame structure with one underground basement floor and three (03) nos. above the ground floors complete with all associated civil and architectural works. Minimum floor area shall be 4500 sq.m for each floor. Each floor shall be provided with a crane. The capacity of crane shall be 10% more than the heaviest component to be stored.Scrap yard of 500 sq.m with fencing shall be provided.Additionally, 300 sq.m store yard shall be provided for used oil drums, with fencing. Scrap yard and open store-yard shall be provided with concretc paving.

15.30.00 **Covered Car Parking**

Bidder shall provide a covered car parking of pleasant architecture consisting of reinforced concrete pavement with approaches from the main road by the side of control cum facility building. The capacity shall be for twenty (20) number of cars and forty (40) number of scooters.

15.31.00 **Hard surface for vehical Parking**

Hard surface of concrete paving shall be provided at gate complex for vehical parking.

15.32.01 **Gate Complex and Guard room**

15.32.01 A decorative frame structure shall be provided at plant main entrance gate. The gate structure shall be of steel/ RCC/ stone or brick masonry matching with theplant structures and surroundings as approved by Employer.

15.32.02 The main entrance gate shall be fabricated out of mild steel sections completed with synthetic enamel painting. The structural steel works for gates shall include supply, fabrication, transportation, erection of structural steel gates complete with fabricated hinges, M.S. aldrops, locking arrangements, tower bolts, GI pipe stub, tempered steel template, tempered steel pivots, guide track MS tee, castor wheel with bearing arrangements and placing in position embedded parts in concrete/brick work and in road surface including cutting, grinding, drilling of holes, welding and painting etc. complete. The mild steel gate shall be electrically operated. The gate will be double leaf sliding type, which can be operated from remote push buttons from the security control room.

15.32.03 A security building of single story RCC construction having minimum floor area of 32 sq.m shall be provided at gate complex.

15.33.00 **Watch tower**

Watch towers of RCC construction complete with staircase and roof canopy shall be

16.00.00 GENERAL ARCHITECTURAL SPECIFICATIONS

16.01.00 **General**

a) Minimum 1000 mm high (from floor/ roof level) hand railing shall be provided around all floor/roof openings, projections/balconies, walkways, platforms, steel stairs, etc., All handrails and ladder pipes (except at operating floors) shall be 50 mm nominal bore MS pipes (medium class) conforming to IS:1161 and shall be galvanised as per IS : 4736 treated with etch primer and finished with suitable paint. All rungs and ladders shall also be galvanised. Minimum weight of galvanising shall be 610 g/sqm.

For RCC stairs and around all floor openings at operating floors, 1000 mm high hand railing with 32 NB (polished) stainless steel pipe shall be provided.

b) All stairs shall have a maximum riser height of 180 mm and a minimum tread width of 275 mm. Minimum clear width of stair shall be 1200 mm unless specified otherwise.

c) All buildings having metal cladding shall be provided with a 150 mm high RCC toe kerb at the edge of the floor along the metal cladding. 900 mm high hand railing shall be provided on this RCC kerb, wherever required from the safety point of view.

d) In all buildings, structures, suitable arrangement for draining out water collected from equipment blowdowns, leakages, floor washings, fire fighting, etc., shall be provided for each floor. All the drains shall be suitably covered with grating or precast RCC panels.

e) RCC staircase shall be provided for main entrance of Turbine building; control tower area and all other RCC construction buildings.

f) Parapet, Chajjas over window and door heads, architectural facias, projections, etc., shall be provided with drip course in cement sand mortar 1:3.

g) 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 fire fighting equipment. In detailing of all buildings, fire safety requirements conforming to IS: 1641 and IS:1642 shall be followed.

16.02.00 **Water Supply and Sanitation**

16.02.01 Two numbers of roof water tanks (one for storing service water and another for potable water) of adequate capacities depending on the number of users and 24 hours requirement shall be provided for each building and pump house. Polyethylene water storage tanks conforming to IS:12701 shall be used. The tanks shall be complete with all fittings including lid, float valve, stop cock, vent pipe, etc.

One number underground RCC tank with two compartment for drink water storage of adeguate capacity (minimum 20cum.) shall be privided along with 2 number pumps (One working + One Standby) for filling overhead potable water tanks.

Galvanised MS pipe of medium class conforming to IS: 1239 shall be used for internal piping works for service water and potable water supply. The pipes shall be concealed, and painted with anti-corrosive bituminous paint (as per IS: 158) wherever required.

Sand Cast Iron pipes with lead joints conforming to IS: 1729 shall be used for sanitary works above ground level.

Minimum one number main toilet block each (for male and female) with required facilities shall be provided on each floor of Main plant building, and Service/office building. Attached toilets shall be provided for all senior executive rooms and conference rooms. All other buildings shall have minimum one toilet block each. The facilities provided in the toilet block shall depend on the number of users. However, minimum facilities to be provided shall be as stipulated in subsequent clause. IS:1172 shall be followed for working out the basic requirements for water supply, drainage and sanitation. In addition, IS:2064 and IS:2065 shall also be followed.

16.02.02

i) Each toilet block shall have the following minimum facilities. Unless specified, all the fittings shall be of chromium plated brass (fancy type).

a) WC (Indian type, Orissa pan (580 x 440mm) as per IS : 2556 with all fittings including photo-voltaic sensor operated flushing system of appropriate capacity and type.

b) Urinal with all fittings with photovoltaic control flushing system as per IS: 2556 .

c) Wash basin (oval shape) with photo-voltaic control fittings as per IS : 2556 to be fixed on concrete platform finished and under fixed with 20mm thick polished granite stone and float glass mirror (600 x 450 x 5.5mm) with bevelled edges.

d) 25 mm dia Stainless steel towel rail (600 x 20mm).

e) Stainless steel liquid soap holder cum dispenser with all fittings.

f) Janitor space

g) Provision for installation of water cooler with recessed floor and stainless steel grating for draining of spillage water, including provision for potable water supply connection.

h) Electric operated hand dryer with photo voltaic control.

ii) Attached toilets provided for senior executive rooms shall have one no.

European WC, wash basin (oval shape) with all fittings as per IS : 2556 to be fixed on concrete platform finished and under fixed with 20mm thick polished granite stone and float glass mirror (600 x 450 x 5.5mm) with bevelled edges, 1 towel rail, 1 liquid soap holder cum dipensor with all fittings. WC shall be of western type 390 mm high as per IS:2556 (Part-2) with toilet paper roll holder and all fittings including flushing valve of appropriate capacity and type. Unless specified all other fitting and fixtures in the toilet shall have same specifications as stipulated in above clause. with photo-voltaic sensor/controls.

iii) Ladies toilet shall be provided at all level of control cum facility building. It shall consist of 1WC (European type) and one counter top washbasin, with all fittings such as Mirror, towel rail, soap container, paper holder etc. as specified above.

iv) Pantry space of adequate size shall be provided at main control room level and in service building, with stainless steel sink and pre-polished granite counter

v) In addition to the facilities stipulated elsewhere, following facilites shall also be provided in toilet at ground and operating floor of main plant:

a) Bathroom with rotating type chromium plated shower including all fitting and fixtures.

b) Toilets in control room at main plant operating floor and all toilet blocks in service building shall be provided with wall to wall mirror of entire counter length (5.5 mm thick float glass, minimum height 900 mm) in place of 600x450x5.5 mm mirror above wash basin counter.

vi) Stainless steel kitchen sink of size 610x510x200 mm as per IS: 13983 shall be provided in pantry. Platform in pantry shall be finished with 20 mm thick pre-polished granite stone of approved shade and colour.

vii) Laboratory sink shall be of white vitreous china of size 600x400x200 mm conforming to IS:2556 (Part-5).

viii) A toilet block shall be privided adjacent to common control room for exclusive use of operation personnel.

16.03.00 **Flooring**

16.03.01 The nominal total thickness of floor finish shall be 50 mm i.e. underbed and topping. The floor shall be laid on an already laid and matured concrete base. The underbed for floors and similar horizontal surfaces shall consist of cement

	concrete (1 part cement, 2 part sand and 4 part stone chips by volume). Stone chips shall be 12.5 mm down well graded.
16.03.02	Sunken RCC slab shall be provided in false flooring area and all toilet areas so as to keep the finished floor level of these areas 12 mm below as that of the surrounding area. For toilet area, sunken slabs shall be made water tight by suitable water proofing treatment.
16.03.03	Metallic hardener topping shall be 12 mm thick using uniformly graded iron particles, properly treated.
16.03.04	Polished heavy duty white cement cement concrete tiles (carborundum) of size 300 x 300 x 25 mm thick (minimum) as per IS: 1237, using colour pigments and hard chips like carborandum shall be used. Laying of tiles shall be as per IS:1443.
16.03.05	Dust pressed ceramic tiles (heavy duty) Group-V conforming to IS:13755 of size 300 x 300 x 7 mm thick (minimum) of reputed manufacturer and of approved finish shade and colour to be used.
16.03.06	Vitrified ceramic tiles of size 400mm x 400mm or 600mm x 60mm (Mat or Mirror Polished) and of specified thickness (7mm minimum) from reputed manufacturer shall be used. The finish, shade and colour shall be as approved.
16.03.07	For pathway, chequered and designed concrete tiles minimum 22 mm thick, 200x200 mm size conforming to IS: 13801 of approved shade and colour shall be used.
16.03.08	PVC flooring, wherever used, shall be minimum 2 mm thick (virgin) as per IS: 3462. The laying of flooring shall be as per IS: 5318.
16.03.09	Wherever required, carpet flooring shall be provided over cement concrete floor as in conference room of main control room complex. The carpet shall be of tile/roll form, machine/hand made tupled un-cut loop pile and laid with under lay of 10mm thick and shall be laid as per manufacturer's recommendations, in matching grains. It shall be treated with anti fungus and anti-termite before laying.
16.03.10	Kota and Granite stone slabs shall be of min 20mm thick and of approved quality, colour uniform grain and thickness. Exposed edges of granite stone slabs above counters shall be bevelled.

16.03.11 Skirting in general shall be 150 mm high. Dado in toilets & pantries, shall be upto 2100 mm height from finished floor level. Skirting and Dado shall match with the floor finish.

16.03.12 Wherever required, removable metallic false flooring system shall be provided. Nominal height of the false flooring shall be 600 mm. The same shall comprise of special grade steel panels (of size 600x600mm). without any dimensional tolerance 1.2mm thick die cast to shape having 1mm thick top MS sheet spot welded together to form a composite steel panel, sitting on aluminum diecasted heads & mounted on steel pedestals of 25mm dia rod of adjustable height and supporting 1.2mm thick channel frame work at-top and 2mm thick 150x150mm base plate. The top finish shall be 2mm thick antistatic PVC sheet or High pressures laminate. Cavity area below the false flooring shall be made dust proof by using Polyurethane sheet.

16.03.13 Inter locking concrete blocks used for paving shall be of minimum M 30 grade of concrete, and of thickness 60 mm, of approved colour and pattern. It shall be laid on the sub base and bedding as per recommendation of manufacturer of inter locking concrete blocks.

16.03.14 **Paving**

a) The RCC paving minimum 150 mm thick of M20, 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 subgrade to the required level, laying of stone soling of 225 mm compacted thickness with 63 mm and down aggregate with interstices filled with selected sand followed by 75 mm thick 1:4:8 PCC (1 part cement, 4 parts sand and 8 parts stone aggregate) with 40 mm nominal size aggregate. Paving areas shall be provided with the metallic hardener floor finish as specified elsewhere in the specification. However mill maintenance area and vehicular passage shall be provided with non-metallic hard granular finish in place of metallic hardener topping. Non metallic hard granules shall be spread over the green concrete paving slab at the rate of not less than 5 kg/ sq.m. Paving shall be provided for the following areas:

i) Entire main plant area from HRSG stack to transformer yard as enclosed within the peripheral roads (shown on General Layout

Plan) of the main plant area shall be provided with paving (on stack side, paving shall be upto the edge of the storm water drain to be provided by Bidder. This paving shall be provided as one block having regular configuration.

ii) Ground floor of all buildings.

b) PCC paving of nominal mix 1:2:4 (1 part cement: 2 parts sand: 4 parts aggregate), 100 mm thick laid over 75 mm thick bed of dry brick aggregate shall be provided for following areas:

i) 750 mm wide plinth protection around all buildings other than those covered under paved area.

ii) 2.0 m wide pathway all along pipe/ cable corridor and all around each cooling tower. 2.0 mm wide ways inter connecting all cooling towers with each other.

16.04.00 **Acid/ Alkali Resistant Lining**

16.04.01 The material shall conform to the following:

i) Bitumen primer shall conform to IS: 158.

ii) Bitumastic compound shall conform to IS: 9510. Where the height of bitumastic layer on vertical surface is more than 2.0 m, the bitumastic layer shall be reinforced with diamond pattern expanded metal steel sheets conforming to IS: 412.

iii) A.R. Bricks/ Tiles shall conform to class II of IS: 4860 & IS: 4457 respectively.

iv) Mortar: Potassium silicate & resin type mortars shall conform to IS: 4832 Part- I&II respectively.

16.04.02 Requirements for acid/ alkali resistant flooring and lining for different areas shall be as given Table-A enclosed at the end of this specification.

16.05.00 **Roof**

16.05.01 Except for the roofs subjected to heavy loads, roof of all buildings having structural steel frame work shall consist of permanently colour coated (on

exposed face) troughed metal sheet decking of approved profile having minimum base metal thickness of 0.8mm of galvanised (with minimum rate of galvanisation of 275 gm/sq.m.) M.S. sheet or minimum 0.8mm of high tensile steel (minimum yield strength 350 MPa) coated with zinc aluminium alloy (zincalume) (coating not less than 150 gm./sq.m). Silicon modified polyster paint having DFT of minimum 20 microns shall be used for permanent coating. The sheeting shall be fixed by means of concealed fixing system or any other compatible method approved by the Engineer. RCC slab of minimum 50 mm clear thickness in excess of trough depth shall be provided over the metal decking. Water proofing cum plasticiser compound shall be added to concrete over the metal decking. Bidder shall demonstrate that the roof is leak proof by carrying out the water-retaining test by maintaining the minimum water depth of 50mm over the roof surface for a period of 48 hours. Water Proofing Treatment as given below for RCC roof slabs shall be provided to ensure that the roof is watertight.

16.05.02 Roof of all buildings having RCC framework shall have cast-in-situ RCC slab. Such 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 polymerised mastic over the roof to achieve smooth surface and primer coat. Wearing course on the top of membrane shall consist of 25mm thick PCC (1:2:4) cast in panels of maximum 1.2 x 1.2m size and reinforced with 0.56mm dia galvanised chicken wire mesh and sealing of joints using sealing compound/elastomeric water proofing membrane. However, chquered concrete tile flooring 22 mm (min.) thick of approved colour and shade conforming to IS: 13801 shall be provided for path way of 1 m. width for access of personnel and handling of equipment and for the entire area of the roof where equipment like AC / 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.

16.05.03 For efficient disposal of rainwater, the run off gradient for the roof shall not be less than 1:100. This gradient can be provided either in structure or subsequently by screed concrete 1:2:4 (using 12.5 mm coarse aggregate) and/ or cement mortar (1:4). However, minimum 25 mm thick cement mortar (1:4) shall be provided on top to achieve smooth surface. The roof shall be provided with RCC water gutter, wherever required. Gutter shall be made water tight using suitable watertight treatment.

16.05.04	For Building where metal cladding is envisaged medium class galvanised mild steel pipes conforming to IS: 1239/IS:3589 with welded joints shall be provided to drain off rain water from the roof. For rest of the buildings cast-iron pipes with lead caulked joints conforming to IS:1230 shall be used. These shall be suitably concealed with masonry work, cement concrete / or sheeting work to match with the exterior finish. The number and size of down comers shall be governed by IS:1742 and IS:2527. Roof drain level of all RCC framed buildings having cast-in-situ RCC roof shall be provided with Rain water gutter and/or 45 x 45 cm size Khurras having minimum thickness of 30 mm with 1:2:4 concrete over PVC sheet of 1 m x 1 m x 400 micron and finished with 12 mm thick cement sand plaster 1:3. All the pipes shall be provided with suitable fittings and fixtures. Gratings shall be of stainless steel.
16.05.05	Roof of all buildings shall be provided with access/approach through staircase or ladder. Roof where equipment are mounted shall be provided with access through staircase.
16.05.06	RCC parapet wall of minimum 1000 mm height (above top of slab) for all accessible roofs and 600 mm height for all non-accessible roofs shall be provided.
16.05.07	Fillets at junction of roof and vertical walls shall be provided with cast-in-situ cement concrete (1:1.5:3) nominal mix followed by 12mm thick 1:4 cement sand plaster.
16.05.08	Pathways for handling of materials and movement of personnels shall be provided with 22mm thick chequered cement concrete tiles as per IS:13801 for a width of 1000mm.
16.06.00	**Walls**
16.06.01	All walls shall be non-load bearing infill panel walls.
16.06.02	For initial height upto 3 metres from ground floor one brick thick masonry wall shall be provided wherever metal cladding is specified.
16.06.03	All internal walls shall be with one brick thick in cement mortar (1:6) with coarse sand. However, internal partition walls for office area and toilets shall be with half brick masonry thick with cement mortar (1:4) with coarse sand.
16.06.04	For Main plant building, Control tower and other buildings, the type, thickness and initial height of external cladding facing the transformer yard shall be according to the requirements of Tariff Advisory Committee (TAC). TAC requirements shall also be complied with for all other buildings while deciding cladding type & thickness.

External face of Toilets, Air-conditioned and pressurised areas shall be provided with masonry wall as per functional / aesthetic requirements. (Inside the metal cladding wherever provided).

For external face of the building, where, permanent external finish is to be provided with fire clay bricks, half brick thick fire clay brick (conforming to IS: 6) cladding in cement mortar shall be provided and shall be finished with recessed pointing.

16.06.05 50 mm thick DPC in Cement concrete (1:1.5:3) with water proofing compound followed by two layers of bitumen coating 85/25 grade as per IS:702 @ 1.7 kg./sq.m. shall be provided at plinth level before starting the masonry work.

16.07.00 **Metal cladding**

a) **Permanent colour coated Insulated metal cladding system**

i) Permanent colour coated sandwitched (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 frame work & and any other building with metal cladding where thermal insulation is required.

ii) Permanent colour coated (non-insulated) M.S./High tensile steel metal cladding of approved colour combination shall be provided for boiler roof/canopy, and cladding over parapet walls of buildings where metal cladding is specified.

iii) Troughed galvanised M.S. sheet having 0.6 mm minimum thickness with minimum rate of galvanisation 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 of approved colour shade. Inner face of the sheet shall be provided with suitable pre-coating of minimum 7 microns, of off-white colour.

iv) Galvanised M.S. sheets of minimum 0.6 mm thickness with minimum rate of galvanisation of 275 gms/sq.m. or. high tensile steel, having minimum yield strength of 350 MPa of 0.5mm minimum thickness, coated with zinc aluminium alloy at the rate of 150 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.

v) Z spacers if required shall be made out of at least 2 mm thick galvanised steel sheet of grade 275 as per IS: 277.

vi) 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.

vii) The insulation shall be of Glass wool, having a density of 32 kg/cu.m. for glass wool, 48kg/cu.m. for rock wool or 40-45 kg./cu.m

b) **Permanent colour coated (non-insulated) metal cladding system**

Troughed galvanised M.S. sheets having 0.6 mm minimum thickness with minimum rate of galvanisation of 275 gms./sq.m. (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, of approved colour/shade and the inner side (internal face) shall be coated with same paint of minimum DFT 20 microns over primer of off-white shade. These shall be fixed with concealed fixing system or any other compatible method approved by the Engineer. The sheets shall meet the general requirement of IS:14246 and shall conform to class 3 for the durability.

c) **Flashings, caps, trim closures etc. for jambs, lintels, softies, cornices**

All flashings, trim closures, caps etc. required for the metal cladding system shall be made out of plain sheets having same material and

any weather/moisture sealnts with appropriate material and coating specification as mentioned above for the outer face of the sandwiched metal cladding. Overlap shall be min. 100 mm or as specified by manufacturer.

16.08.00 **Plastering**

16.08.01 Outer face (i.e. rough side) of all brick walls shall have 18 mm thick and inner face (i.e. smooth side) of all walls shall have 12 mm thick cement sand plaster 1:6.

16.08.02 Plaster of paris (Gypsum Anhydrous) conforming to IS:2547 shall be used for plaster of paris punning over cement plastered surfaces. The finish surface shall be smooth and shall be of 2 mm nominal thickness.

16.08.03 All R.C.C. walls shall have minimum 12mm thick cement sand plaster 1:6.

16.08.04 All RCC ceilings (except areas provided with false ceiling, cable vault ceiling and metal decking) shall be provided with 6mm thick cement sand plaster 1:4.

16.08.05 Groove of uniform size 12 x 12 mm up to 20 x 15 mm in plastered surface as per approved pattern, shall be provided as per approved drawing.

16.08.06 All plastering work shall conform to IS:1661.

16.09.00 **Painting**

16.09.01 All painting on masonry or concrete surface shall preferably be applied by roller. If applied by brush then same shall be finished off with roller.

16.09.02 All paints shall be of approved make including chemical resistant paint.

16.09.03 Minimum two finishing coats of paint shall be applied over a coat of primer.

16.09.04 Exterior masonry paint (water or solvent base) shall consist of special resins & additives, mixed with fine, hard stone aggregates & finest available pigment. The paint shall be applied on a coat of primer over dried, prepared plastered surface as per manufacturer's guidelines.

The final, finished coating shall be fungus resistant, UV resistant, water repellant, alkali resistant, and extremely durable with colour fastness.

16.09.05 Acrylic emulsion paint shall be as per IS:5411 (Part-I). Oil bound distemper shall be as per IS:428. Cement paint shall conform to IS:5410, white wash/ colour wash shall conform to IS:627.

16.09.06 Fire resistant transparent paint as per IS:162 shall be provided on all wood work over French polish or flat oil paint. French polish shall conform to IS:348. Flat oil paint shall conform to IS:137.

16.09.07 All fire exits shall be painted in post office red/signal red colour shade, which shall not be used anywhere else except to indicate emergency or safety measure.

16.09.08 For painting on concrete, masonry and plastered surface IS:2395 shall be followed. For painting on wood work IS:2338 shall be followed.

16.09.09 For painting on steel work and ferrous metals, BS: 5493 and IS:1477 shall be followed. The type of surface preparation, thickness and type of primer, intermediate and finishing paint shall be according to the painting system adopted.

16.09.10 Bitumen primer used in acid/alkali resistant treatment shall conform to IS:158.

16.09.11 All plastered areas above false ceiling shall be provided with two or more coats of white wash.

16.09.12 Resin bonded granular textured finish, for external applications shall consist of crushed stone / quartz chips of 2.5 mm size and of approved colour/ shade and bonded with synthetic resins, Adhesives and additives, all together in a single pack mix.

It shall be applied externally, on cured and dried plastered surfaces, with a dry film thickness of min. 2.0 mm. The final finish shall have UV-Resistant, fungus/ bacterial resistant properties.

Grooves shall be provided as per drawing and the same shall be filled with polysulphide sealant of matching colour/shade.

16.10.00 **Doors & Windows**

16.10.01 Doors, windows and ventilators of air-conditioned areas, entrance lobby of all buildings (where ever provided), and all windows and ventilators of main plant and facility building shall have, electro colour dyed (anodised with 15 micron

coating thickness) aluminium framework with glazing. All doors of office and toilet areas shall be of aluminium. All other buildings doors windows ventilators (unless otherwise specified) shall be of steel.

16.10.02 Main entrance of the common control room and control equipment room shall be provided with air-locked lobby with provision of double doors of aluminium framework with glazing. Doors shall be of double action floor springs mounted.

16.10.03 For common control building, double glazed wall panels with hermetically sealed glass with aluminium frame shall be provided between air-conditioned and non air-conditioned areas and on the side of common control room and control equipment room(s) to have a clear view. One glass, on external side of control room shall be tinted one.

16.10.04 Single glazed panels with aluminium framework shall be provided as partition between two air-conditioned areas wherever clear view is necessary.

16.10.05

a) The doors frames shall be fabricated from 1.6 mm thick MS sheets and shall meet the general requirements of IS:4351.

b) All steel doors shall consist of double plate flush door shutters. The door shutter shall be 35 mm (min.) thick with two outer sheets of 1.2 mm rigidly connected with continuous vertical 1.0 mm stiffeners at the rate of 150 mm centre to centre. Side, top and bottom edges of shutters shall be reinforced by continuous pressed steel channel with minimum 1.2 mm. The door shall be sound deadened by filling the inside void with mineral wool. Doors shall be complete with all hardware and fixtures like door closer, tower bolts, handles, stoppers, aldrops, locks etc.

16.10.06 Steel windows and ventilators shall be as per IS:1361 and IS:1038.

16.10.07 Wherever functionally required Rolling shutter (fully closed/partly grilled) with suitable operating arrangement (manual/Electric) shall be provided to facilitate smooth operations. Rolling shutters shall conform to IS:6248. M.S sliding doors with suitable mechancial and electrical operations fixtures as per requirement for bigger openings shall be used.

16.10.08 All windows and ventilators on ground floor of all buildings shall be provided with suitable grill.

16.10.09 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. 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/wood insulation.

16.10.10	Hollow extruded section of minimum 3 mm wall thickness as per IS:1285 shall be used for all aluminium doors, windows and ventilators.
16.10.11	Minimum size of door provided shall be 2.1 m high and 1.2 m wide. However for toilets minimum width shall be 0.75 m and office areas minimum width shall be 1.00m.
16.10.12	Electrically operated, self operable/closing, aluminium framed with tinted glass (12mm thick) sliding doors shall be provided at the entrance of all common control rooms, entrance lobby of facility building.
16.11.00	**Glazing**
16.11.01	All accessible ventilators and windows of all buildings shall be provided with min. 4mm thick float glass, plain or tinted for preventing solar radiations, unless otherwise specified.
16.11.02	All inaccessible (where regular maintenance is not feasible) ventilators and windows of all buildings shall be provided with 6mm 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 continous use up to a temperature of 1000C. Suitable aluminium beading shall be used. The open ends of the sheet shall be sealed as per manufacturer's recommendations.
16.11.03	The sky light/ north light shall have Multiwall Polycarbonate sheet fixed with anodised aluminium frame of approved colour & the same shall be made leak proof.
16.11.04	All windows and ventilators located in fire prone areas shall be provided with minimum 6 mm thick wired glass conforming to IS:5437.
16.11.05	For single glazed aluminium partitions and doors, float glass of minimum 5.5 mm thickness shall be used.
16.11.06	Double glazing shall consist of two 6 mm thick glass hermetically sealed and separated by 12 mm gap to provide thermal insulation. The outerside of the glazing shall be of tinted glass where exposed to sunrays.
16.11.07	Ground glass of minimum 4 mm thickness shall be used for all windows/ ventilators in toilets.

16.11.08 All glazing work shall conform to IS:1083 and IS:3548.

16.12.00 **False ceiling**

16.12.01 Aluminium panel lineal false ceiling system

Aluminium panel (coil coated) lineal / panel ceiling system shall consist of rolled formed, coil coated aluminium precoated magnesium alloy (Al-Mg AA 5050) carrier and panels of minimum 0.9 mm and 0.5 mm thickness respectively. The ceiling system shall be of approved pattern. The system shall be complete with edge cover profile, special panels, carrier splice, etc. The carrier shall be suspended from roof by 4 mm diameter galvanised steel wire hangers having special height adjustment clips made from spring steel at maximum spacing of 1.2 m c/c both ways.

16.12.02 False ceiling with Mineral Fibre Tiles

False ceiling shall consist of regular or tapered 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. 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 hot dipped M.S. galvanised (grade 180 as per IS:277). Nominal size of T-section shall be 24 x 38 mm for main runners and 24 x 30 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.

16.12.03 Gypsum plaster board, used for false ceiling, shall be minimum 12mm thick conforming to IS:2095.

16.12.04 Glass wool insulation shall be laid on top of false ceiling panels. Additional hangers and height adjustment clips shall be provided for return air grills, light fixtures, A.C. ducts etc.

16.12.05 Suitable M.S. channel (Minimum MC75 with maximum spacing of 1.2 m C/C both ways) grid shall be provided above the false ceiling level for movement of personnel and to facilitate maintenance of lighting fixtures, AC ducts etc.

16.12.06 Underdeck insulation shall be provided on the ceiling (underside of roof slab) and underside of floor slab of air-conditioned area depending upon the functional requirements. This underdeck insulation shall consist of Glass insulation with 0.05 mm thick aluminium foil & 0.6 mm x 25mm mesh wire netting and shall be fixed to the ceiling with 2 mm wire ties.

16.12.07 Suitable cut-outs shall be provided in false ceiling to facilitate fixing of lighting fixtures, AC grills, smoke detectors, etc.

16.13.00 **Interior Design**

A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the mutlidisciplinary engineering activities involving power plant technology, and architectural & civil engineering for a smooth control hierarchy and man machine interface. All the design aspects such as flooring, false ceiling, furniture, colour scheme equipment design & layout, illumination, fire fighting, acoustics and ergonomics requirements shall be detailed out so as to present an overall unified aesthetic spatial appearance.

The areas to be undertaken for this interior design process shall be control room complex including common control room, computer room, conference rooms and office areas in the 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 drawings, etc.

16.14.00	**Finishing Schedule**
	Interior and Exterior Finishes shall be as given in Tables-B & C respectively. attached at the end of these specification.
17.00.00	**STACK**
17.01.00	**General**
17.01.01	The height of the exhaust gas emission point for the stack shall be as specified elsewhere in the specifications.
17.01.02	The stack shall be capable of serving satisfactorily, under all the respective normal and emergency operating conditions to which they may be subjected during the life of plant. The stack and the lining materials, if any, shall therefore be selected to serve the worst operating conditions. The exit diameter of the stack/lining shall be such that the maximum gas velocity is limited to the values indicated elsewhere in the specification.
17.01.03	The stack shall be provided with access ladders with fall prevention devices using safety belts along with closely spaced circular safety hoops. At least two continuous external platforms with hand railing (one near the top and one near the mid height) shall be provided on each stack.
17.01.04	Thermal insulation for the stack shall conform to the requirements specified elsewhere in the specification.
17.01.05	The stack shall be provided with aviation obstruction lighting system as per ICAO (International Civil Aviation Organisation) regulations. Necessary power supply arrangements and wiring installations shall be provided as per relevant standards. The stack shall also be provided with the required lightning protection and earthing systems.
17.01.06	The other components of the stack includes, doors, hatches, drainage system, ventilation openings, gas monitoring and sampling test ports, cladding, strakes, hood cap etc.
17.01.07	All metal surfaces shall be painted for maintenance free life of at least 10 years. The entire external surface of the stack shall be painted using heat and acid resistant paint, in alternate bands (7 bands) of colours deep red and pure/ bright white.

18.00.00 **MATERIALS**

18.01.00 **Cement**

Fly ash based portland pozzolana cement conforming to IS:1489 (Part-1) shall be used for all areas other than for the critical structures identified below. However, Engineer may allow the use of other types of cement namely, ordinary portland cement & portland slag cement conforming to IS: 269 and IS: 455 respectively under special circumstances on specific request of the bidder and prior approval of the Engineer. Minimum grade of cement shall be Grade 33. Higher grade of portland ordinary cement namely Grade 43 and Grade 53 conforming to IS:8112 and IS:12269 respectively can also be used for specific application. However the ordinary portland cement shall necessarily be used for following structures.

a) TG foundation top deck and sub-structure excluding raft.

b) Spring supported decks of all machine foundations.

c) Structures requiring grade of concrete of M25 and above.

In place of fly ash based portland pozzolana cement fly ash can be added in ordinary portland cement (Grade 43). Batching plant shall be deployed for producing the concrete. Fly ash shall conform to IS:3412. Percentage of fly ash to be mixed in concrete shall be based on trial mix.

18.02.00 **Aggregates**

a) Coarse aggregate

Coarse aggregate for concrete shall be crushed stones chemically inert, hard, strong, durable against weathering of limited porosity and free from deleterious materials. It shall be properly graded. It shall meet the requirements of IS: 383.

b) Fine aggregate

Sand shall be hard, durable, clean and free from adherent coatings of organic matter and clay balls or pellets. Sand, when used as fine aggregate in concrete shall conform to IS:383. For plaster, it shall conform to IS:1542 and for masonry work to IS:2116.

18.03.00 **Reinforcement Steel**

All reinforcement steel used for various structures (underground or Overground) shall be TMT HYSD Bars (Thermo_Mechanically Treated High Yield Strength Deformed Bars) of grade Fe-415 and / or Fe-500 conforming to relevant IS Codes.

Mild steel & medium tensile steel bars and hard drawn steel wire shall onform to grade-1 of IS : 432 (Part-1) or grade A of IS: 2062. Welded wire fabric shall conform to IS:1566.

18.04.00 **Structural Steel**

Structural steel (including embedded steel) shall be straight, sound, free from twists, cracks, flaw, laminations and all other defects.

Mild Steel (Rolled Sections and Plates) shall conform to Grade 'A' of IS:2062 for thickness upto and including 20mm and shall conform to Grade 'B' of IS:2062 for thickness beyond 20mm thickness.

Medium and High Strength steel shall conform to grade 'Fe-490B' of IS: 8500 or equivalent.

Rolled Sections and Plates up to and including 20mm thickness shall be semi-killed condition. Plates beyond 20mm thickness shall be killed condition.

All steel upto and including 40mm thickness shall be in as Rolled condition.

Plates beyond 40mm thickness shall be Normalised and Ultrasonically tested.

Pipes shall conform to IS:1161 Hollow(square and rectangular) Steel Sections shall be Hot Formed conforming to IS:4923 and shall be of Minimum grade Yst 240.

Chequered Plate shall conform to IS:3502 and shall be Minimum 6mm thick excluding projection. Steel for chequered Plates shall conform to Grade 'A' of IS:2062.

All other Materials shall be as per applicable Standards and Codes.

18.05.00 **Bricks**

Fly ash lime bricks conforming to IS:12894 and fly ash clay bricks conforming to IS:13757 shall be used. The crushing strength of bricks shall be minimum 75 kg./sq cm. Minimum percentage of fly ash shall be 25%.

18.06.00 **Water**

Water used for cement concrete, mortar, plaster, grout, curing, washing of coarse aggregate, soaking of bricks, etc. shall be clean and free from oil, acids, alkalis, organic matters or other harmful substances in such amounts that may impair the strength or durability of the structure. Potable water shall generally be considered satisfactory for all masonry and concrete works, including curing. When water from the proposed source is used for making the concrete, the maximum permissible impurities, development of strength and initial setting time of concrete shall meet the requirements of IS:456.

18.07.00 All materials brought for incorporation in works shall be of best quality as per IS unless specified otherwise.

19.00.00 **STATUTORY REQUIREMENTS**

19.01.00 Bidder shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules at Tariff Advisory Committee. Water Act for pollution control, Explosives Act, etc.

19.02.00 Provisions of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkways along the crane - girder level on both sides of building, comfortable approach to EOT crane cabin, railing, fire escape, locker room for workmen, pantry, toilets, rest room etc.

19.03.00 Provisions for fire proof doors, number of staircases, fire separation wall, lath plastering/encasing the structural members (in fire prone areas), type of glazing etc. shall be made according to the recommendations of Tarrif Advisory Committee.

19.04.00 Statutory clearances and norms of State Pollution Control Board shall be followed.

19.05.00 Bidder shall obtain approval of Civil/Architectural drawings from concerned authorities before taking up the construction work.

19.06.00 **LIST OF CODES AND STANDARDS**

All applicable standards, references, specifications, codes of practice, etc., shall be the latest edition including all applicable official amendments and revisions. A complete set of all these documents shall be available at site with Bidder.

List of some of the applicable Standards, in original Codes and references is as given in Annexure-II of this specification.

20.00.00 CONSTRUCTION METHODOLOGY

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

For controlled rock blasting specialized agency, equipped with sensors to assess the impact of the blast on the adjoining existing structures, shall be employed.

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

Pile installation equipment suitable for flushing with air lift technique shall be used for construction of bored piles.

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

All fabrication and erection activities of structural steel shall be carried out using automatic submerged arc welding machines, cutting machines, gantry cranes, crawler mounted heavy cranes and other equipment like heavy plate bending machines, shearing machines, lathe, milling machines, etc. Use of derricks shall not be permitted. Special enclosures, for blast cleaning of steel structure surface preparation, shall be used.

All handling of materials shall be with cranes. Heavy trailers shall be used for transportation.

Mechanized modular units of scaffolding and shuttering shall be used.

Grouting shall be carried out using hydraulically controlled grouting equipment.

Roadwork shall be done using pavers, rollers and premix plant.

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

Heavy duty hoists for lifting of construction materials shall be deployed. Compressors for cleaning of foundations and other surfaces shall be used.

Field laboratory shall be provided with all modern equipment for survey, testing of soil, aggregates, concrete, welding, etc. For testing of steel works, ultrasonic testing machines, radiographic testing machines, dye penetration test equipment, destruction testing equipment, etc. shall be deployed.

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

21.00.00 **FIRE STATION COMPLEX**

Fire Station complex shall consist of the following:

1) Fire station building.

21.01.00 **Fire station Building**

21.01.01 **Garage Bays**

These shall be provided to accommodate all the specified fire tenders included in bidder's scope, one no. of fire jeep and one number fire tender being separately procured by owner, with sufficient space provision around the fire tenders and jeeps based on standard requirements. The garage bays shall be provided with opening on the front as well as on the rear side. Concrete paved open space of at least 10m width with suitable underbed should be provided connecting garage bays and the nearby service road for providing easy maneuverability of the fire tenders and jeeps.

21.01.02 **Watch room/Control room**

This room of minimum area 16sqm should be provided adjacent to the garage bays. An automatic siren/fire alarm, which can be sounded by fireman on duty, shall be provided. Watch room shall have glazed walls towards the verandah and garage bay side.

21.01.03 **Office of the station in-charge**

This shall be of minimum 16 sq.m in area located adjacent of the control room and the wall between the office room as well as control shall be provided with sliding glass door. A toilet shall be provided adjoining the office room and control room.

21.01.04 **General stores/Repair workshop**

These shall be rooms of minimum 32 sq.m in area for storing fire extinguishers, spares etc. in addition, 16 sq.m for repair shop, 16 sq.m for storing fire hoses etc. shall be provided. Adequate racks shall be provided in the storeroom as well as pegs in the hose-room so that water hoses can be properly stacked.

21.01.05 **Rest Room/Recreation room:**

The approximate size shall be 25 sq.m to provide sufficient space for about 10 foremen during off-duty. Adjacent to the rest room, dining room of 16 sq.m and pantry of 8 sq.m with facilities for drinking water shall be provided. A common W.C. and bath room of about 12 sq.m, recreation / class room of 32 sq.m, recorded room of 16 sq.m shall also be provided in the fire station building.

22.00.00 **FACILITY BUILDING**

22.01.00 Facility building shall be provided for operation and maintenance facilities and personnel. This building shall be provided as combined building with control building or as separate building, adjacent to the control building with interconnecting corridor. This building shall have air-conditioned usable area for providing office space for the operating staff.

22.02.00 The total covered area for the facility building has been specified elsewhere in this specification. The building shall be with not more than 5 storied In addition to the above, building shall have specified usable covered area for maintenance facilities and personnel.

22.03.00 The facility building shall have an RCC staircase of clear width of minimum 1400mm.

23.00.00 **Administrative Building**

Administrative building shall be provided for housing the administrative staff and official of various functional departments. This building shall be located closer to plant entrance and shall be located outside main plant battery limit security zone. Administrative building shall be of RCC frame construction with brick walls with not more than three storied.

The total covered floor area for the building shall not be less than 1000 sq.m. Additionally covered parking area at least for 20 cars and 40 scooters with

RCC canopy shall be provided. Building shall be provided with porch at the entrance. The building shall have provision of attached toilet with the cabin of senior executives and conference rooms. The building shall have provision of separate gents toilets and ladies toilets in each floor for common use. In addition, one pantry, library and documentation rooms and one storeroom shall also be provided in the building. The internal partitions of the building shall be done using pre-laminated particle board and clear glass fixed in electro colour coated (anodized) aluminium frame work as per approved layout. False ceiling shall be provided as specified elsewhere in this specification.

Inter-connecting galleries wherever provided shall be covered on top and with appropriate glazing on sides in electro colour coated aluminium framework. Structural arrangement, foundation, cladding, interior and exterior finishes etc. for the building shall be as specified elsewhere in this specification.

24.00.00 LANDSCAPING AND HORTICULTURE WORKS

After completion of construction work, the bidder shall take up final dressing and landscaping of the site. The bidder shall remove the top ash layer of minimum 500mm thick and replace the same with good earth, suitable for horticulture works, approved by the employer.

Landscaping of entire Project Complex shall embrace a number of measures at different stages of site development.

i) The design of structures, Buildings, roads, pathways, lighting system etc. so that these components are not out of scale with the surrounds.

ii) The apt contouring of all ground affected by works, especially the excavations and embankments with a view to unify the landscape and avoid any visual jolt.

iii) The grassing, turfing and planting of trees and shrubs, which properly integrate the environment.

iv) Water supply network, with pipes, valves, stop cocks, complete accessories for irrigation of tree plantation and horticultural works, lawns etc.

The bidder shall prepare and submit landscape drawings required to complete the work up to the satisfaction of the employer. Bidder shall furnish at least two alternative perspective drawings in colour depicting Landscaping and Horticultural Work.

The treatment to be adopted for landscaping will depend on the topography, climate, nature and type of soil, vegetation pattern and other environmental features. For best results, designing of entire complex and landscaping should be regarded as complementary and tackled as a single planning task.

The bidder should arrange services of Landscaping architects and horticulturist to integrate the related aspects.

The bidder shall prepare perspective drawing in colours and models so that landscape features can be studies in advance and further improvement made wherever possible.

The landscape plan shall consists of but no limited to the following components:

Formal or/and informal landscaping, lawns, pathways, rockery, stonework, mounds, water bodies, fountains, cascades, water fall, decorative fencing, suiting to garden/greenery, ornamental lighting, fixtures, plantation, such as trees, shrubs, hedges, creepers, artificial plants, hanging, seasonal flowers beds, rosary, potted plant etc.

TABLE – A

PROPOSED ACID / ALKALI RESISTANT TREATMENT

S. NO.	AREA	PRIMER (ONE COAT)	TYPE OF LINING AND THICKNESS				EPOXY COATING (TWO COATS)
			A.R.BRICKS	A.R. TILES	EPOXY MORTAR	BITUMASTIC	
1	Neutralizing pit						
	i) Floors	Bitumen	75 mm thick			18 mm thick	
	ii) Walls	Bitumen	115 mm thick			18 mm thick	
	iii) Ceiling	Epoxy					150 micron
	iv) Pillasters		115 mm thick			18 mm thick	
2	Chemical House	Epoxy					150 micron
3	Lime, Alum Preparation and dosing tanks	Bitumen	115 mm thick			18 mm thick	
4	Acid / Alkali storage are	Bitumen	38 mm thick			12 mm thick	
5	Floor around chemical handling equipment	Bitumen	38 mm thick			12 mm thick	
6	Pedestals forsupporting chemical handling equipemnt	Bitumen	38 mm thick			12 mm thick	
7	M.S. Grating / Chequered plate in chemical handling / storage area	Epoxy					150 micron
8	Effluent Drains	Bitumen	38 mm thick			12 mm thick	

Note : -

1. The above table is for general guidance only, however, actual areas/ facilities to be covered shall be as per Scope of work.
2. Suitable end sealing shall be provided.
3. Structures shall be tested for waterproofing before application of Acid / Alkali Resistant Treatment.
4. This treatment shall be applied on dry surface.
5. For laying of AR bricks / tiles, the bedding mortar shall be of potassium silicate 6 mm thickness and the pointing mortar shall be of Epoxy / furane 20 mm deep and 6 mm thickness.

TABLE -B

INTERIOR FINISHING

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
1.	Operating/Maintenance areas of workshop, pump houses, compressor house, DG set, Air Washer building, AC Equipt.Room, Air handling area	Cement concrete with Metallic hardener topping	Oil bound distemper over plaster of paris	Oil bound distemper
2.	General storage areas	- do -	Oil bound distemper	Oil bound distemper
3	Cable Vault/cable spreader	- do -	Oil bound distemper	Oil bound distemper
4.	Area paving		-	-
	a) Equipment / vehicle movement area	Reinforced cement concrete with metallie hardener toping		
	b) Balance area	Haeavy duty cement concrete chequered tiles with colour pigment		
	c) Parking area	Inter locking concrete blocks		
5.	GT & STG Buildings			
	a) Ground floor i) Unloading Bay	Cement concrete with Metallic hardener topping	Oil bound distemper over plaster of paris	Oil bound distemper

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
	ii) Balance area including passage	Heavy duty cement concrete tiles	-do-	-do-
	b) Mezzanine floor (excluding grating area)	-do-	-do-	-do-
	c) Deareator floor	Cement concrete with Metallic hardener topping	-do-	--
	d) Operating floor of STG Building			
	i) Operating area, laydown area, heater area	20 mm (Min.) thick polished granite slab (Ist quality)	Oil bound distemper over plaster of paris	Oil bound distemper(except metal deck area)
	ii) General circulation and movement areas	7 mm thick vitrified ceramic tiles in combination of mirror polished and unpolished tiles	-do-	-do-
6.	a) MCC room	7mm thick vitrified ceramic tiles (unpolished)	Oil bound distemper over plaster of paris	Oil bound distemper
	b) Switchgear room	Cement concrete with metallic hardener topping	-do-	-do-
7.	a) Control room area including control room, Computer room, Control equipment room	7mm thick mirror polished vitrified ceramic tiles / false flooring (wherever required	20 mm thick mirror polished marble tiles on masonry walls upto false ceiling height.	0.5 mm, thick precoated (colour)/Al.Lineal false ceiling in approved pattern

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
			Glazed partition with colour anodised aluminium frame.	
	b) Conference room, GM's room	Wooden panel flooring PERGO or equivalent	i) Wooden panel wall, PERGO or equivalent ii) Glazed partition with colour anodized Aluminum frame work	Al.Lineal false ceiling
c)	Record room	20 mm thick polished kota stone	Oil bound distemper Over plaster of paris	Mineral fibre board with MS coated frame work
	d) Locker room	-do-	-do-	-do-
	e) Model room	20 mm thick polished granite stone	Resin bonded granular finish	AL. Lineal false ceiling
8.	Office room, Staff room	7 mm thick unpolished vitrified ceremic tiles	Acrylic emulsion paint over plaster of Paris	AL. Lineal false ceiling
9.	SWAS room	7 mm thick mirror polished vitrified ceremic tiles	Acrylic emulsion paint over plaster of Paris	AL. Lineal false ceiling
10.	Toilet area	i) 7mm thick dust pressed ceramic tiles in combination with 20 mm thick polished	Coloured 5 mm (min.) thick ceramic tiles upto ceiling / false ceiling height with border tiles	oil bound distem-per over plaster of paris / AL. Lineal false ceiling

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
			granite stone.	wherever required
(wheever required)				
		ii) 20 mm thick Polished granite in one piece for wash basin platform.		
11.	Pantry Area	i) 20 mm thick polished Kota stone	Coloured 5 mm thick ceramic tiles upto ceiling / false ceiling height with border tiles wherever required	oil bound distem-per over plaster of paris / AL. Lineal false ceiling, wherever required
		ii) 20mm thick polished granite stone for platform		
12.	Laboratory area	7mm thick dust pressed ceramic tiles	Acrylic emulsion paint over plaster of paris	Oil Bound Distemper over plaster of paris / AL. Lineal false ceiling, wherever required
13.	RCC Stair case			
	i) ADM/CCR/Facility Building	20 mm thick polished granite stone for riser & tread	20 mm thgick polished granite stone with nosing upto 2.1 m height & resin bonded granular finish for	Oil Bound Distemper over plaster of Paris on underside of

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
			balance height	staircase
	ii) Other area	20 mm thick polished kota stone for riser & tread	Coloured 5 mm thick ceremic tiles upto 1.2 m height & resin bonded granular finish for balance height	Oil bound distemper over plaster of Paris on underside of staircase
14.	Entrance Lobbies and Lift areas	20mm thick polished granite stone	20 mm thick polished granite stone with nosing upto 2.1m height & resin bonded granular finish for balance height	
			20 mm thick polished granite on lift facia	
15.	Passages and general circulation areas			
	i) ADM/CCR/Facility building	7 mm thick unpolished vitrified ceremic tiles	Acylic emulsion paint over plaster of Paris	OBD over POP / AL. Lineal false ceiling
	ii) Other Areas	20 mm thick polished kota stone with marble stone border	OBD over Plaster of Paris.	OBD over POP / AL. Lineal false ceili
16.	Battery Room			
		Acid/Alkali resistant tiles	Acid/Alkali resistant tiles	Acid/Alkali resistant paint

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
17.	Oil canal, oil room, oil purification Tank and other areas where oil spillage is likely to occur	Oil resistant paint (epoxy based amine cured) 150 micron over primer. over CC flooring	Oil resistant paint upto 2.1 m height and OBD over POP for balance height	OBD except oil canal area
18.	Chemical house, Chlorination building, CW treatment facility (Other than areas requiring acid/ alkali resistant treatment)	Cement concrete flooring with Metallic hardener topping	Oil Bound Distemper ove rplaster of Paris	Oil bound distemper
19.	Covered parking area/pathway	Interlocking cement concrete blocks with colour pigment	OBD	OBD
20.	Pathways including equipment installation area on top of roof	22 mm thick concrete chequered tiles	———	———
21.	Switchyard Control Roomg	Same as similar area	Same as similar area	Same as similar area
	Control room, equipemnt room, battery room, battery charger room, conference room, office room, lobby, coridor, toilets etc.			
22.	Canteen building			
	a) Kitchen, wash room	i) 20 mm thick polished kota stone ii) 20 mm thick polished granite for platform	Coloured 5mm thick ceremic tiles upto ceiling / false ceiling height with border tiles	OBD over POP AL. false ceiling

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
	b) Dinning area	7mm thick vitrified ceremic tiles	OBD over POP	OBD over POP AL. false ceiling
	c) Toilet	Same as similar area	Same as similar area	Same as similar area
23.	Gate house	20mm thick polished kota stone	OBD over POP	OBD over POP
24.	DG control building	Cement concrete with metallic hardener topping	OBD over POP	OBD
25.	Fire station			
	a) Office room, control room, store, dinning room, pantry, toilet	Same as similar area	Same as similar area	Same as similar area
	b) garage bay	Cement concrete pavement	OBD	OBD
	c) Repair work shop	Cement concrete with metallic hardener topping	OBD	OBD
	d) Rest room, recreation room	7mm thick vitrified ceremic tiles	OBD over POP	OBD over POP
26.	Administrative building	Same as similar area	Same as similar area	Same as similar area

S.NO.	DESCRIPTION OF AREA	FLOORING	WALL FINISH OVER CEMENT PLASTER	CEILING FINISH OVER CEMENT PLASTER/ PLASTER OF PARIS
27.	Store area	20 mm thick polished Kota stone	Oil bound distemper Over plaster of paris	oil bound distem-per over plaster of paris / AL. Lineal false ceiling, wherever required

NOTE :

1. All wall and roof areas above false ceiling shall be plastered and white washed.
2. The colour and pattern of finish shall be as approved by Employer.
3. All material shall be of reputed and established brand approved by Employer.
4. Wherever alternative materials are specified, the final selection rests with Employer.
5. This finishing schedule shall also be applicable to similar functional areas for all other buildings and facilites.
6. All the finishing materials shall be applied/ provided as per manufacturer specification and guidelines.
7. Requirement given above are suggestive and minimum. Bidder is welcome to suggest alternative scheme conforming to design functional requirement subjct to approval of the Employer.

TABLE -C

EXTERIOR FINISH SCHEDULE

S.NO.	DESCRIPTION OF AREA	WALLS AND PROJECTIONS	SOFFIT OF PROJECTIONS
1.	Main plant building GT, STG, Control cum facility building	i) Initial height of 3 m (nominal) permanent finish using combination of a) fire clay bricks cladding in cement mortar finished with recessed pointing and b) Grit finish with marble stone chips over cement plaster	Resin based texturedpaint
		ii) Approved colour/ colour combination of colour coated metal cladding for balance height.	Approved colour/colour combination of colour coated metal cladding
2.	Building with concrete frame work,	Combination of fire clay brick, resin bonded granular textured finish and resin based textured paint to match in harmony with the main plant,	Resin based textured paint
3.	Fire walls, etc.	Combination of grit finish with marble chips, Resin bonded granular textured finish in harmony with main plant	——-
4.	Steel Structures, trestles, etc.	Paint as specified for structures steel of approved specification and shade	———
5.	Boundary wall, watch towers	Water proof cement pant of approved colour / coloue combination	

NOTE :
1. The colour and pattern of finish shall be as finalised by Engineer.
2. All materials shall be of reputed and established brand approved by Engineer.
3. All the finishing work shall be carried out as per manufacturer specifications and of approved colour

TABLE – D

TAR EXTENDED TWO COMPONENT COATING SYSTEM

a. Proving and applying tar extended two component coating system based on synthesized epoxy resin and amine adduct manufactured as per technical specifications of Central Electrochemical Research Institute, Karaikudi, (C.S.R.I. affiliate Institute), Tamil Nadu, Pin-630 006

b. The coating system shall be water compatible, compatible for applying in wet conditions also and shall be tolerant to under prepared surface and existing residual tar/paint. The system shall also be quick curing so as to be suitable for application during shut downs.

c. The coating system shall conform to the following:

Base	Tar extended epoxy – amine adduct quick curing two component
Colour	Black
Volume of solids	80% (minimum)
Drying time (Touch Dry)	2 hrs.
DFT in two coats	300 microns – 350 microns
Chemical resistance	Excellent against chlorides, salts, sulphates, alkalies
Salt spray test	Should pass as per ASTM-B-117 1000 hrs. minimum
Adhesion	3.8 kilonewtons min. as per ASTM-D-4541
Resistance (Impedance)	10^8
Surface preparation	As per manufacturers specification or as per relevant IS codes.

d. Paint material and its application method can be obtained from any manufacturer who has been granted license by CERI, Karaikudi for technical know how for “comprehensive system repair and protection of concrete /steel surface in wet and under water conditions.

ANNEXURE-I

1.00.00 GEOTECHNICAL INVESTIGATION

1.01.01 The Bidder shall carry out geotechnical investigation for establishing the sub-surface conditions and to decide type of foundations for the structures envisaged, construction methods, any special requirements/treatment called for remedial measures for sub-soil/ foundations etc. in view of soft sub-soils, aggressive sub-soils and water, expansive/swelling soils etc. prior to commencement of detailed design/drawings. The Bidder shall obtain the approval for the field and laboratory testing scheme proposed by him from the Employer before undertaking the geotechnical investigation work.

1.01.02 Field test shall include but not be limited to the following:

Boreholes, Standard Penetration Test (SPT), collection of disturbed and undisturbed soil samples (UDS), Trial Pits (TP), collection of water samples, Static Cone Penetration Test (SCPT) of 20T capacity, Pressure Meter Test (PMT) of 80 kg/cm2 capacity, Seismic Refraction Test (SRT), Plate Load Test (PLT), Electrical Resistivity Test (ERT), Cross hole shear wave test (CSWT) etc.

1.02.00 Scheme of Soil Investigation

The diameter of borehole shall be minimum 150 mm in soil and 76 mm in rock. The diameter of UDS sampler shall be 90 mm minimum. Drilling in rock shall be done by means of rotary drilling rig using double tube core barrel with diamond bit attachment.

1.02.01 Field investigations shall be done in sufficient numbers. An indicative numbers of boreholes and depths in some facilities are given in Table-1. The various field tests to be conducted are suggested in Table-2. The depth of borehole in general shall be atleast.

a) 3 times the least width of building/facility for open foundations.

b) 0.5 times the length of pile below the anticipated tip of pile or 35m for pile foundations.

SPT shall be carried out in all types of soil deposits and in all rock formations with core recovery upto 20%, met within a borehole. This test shall be conducted at every 2 m interval or at change of strata. Number of blows shall be recorded for every 15 cm of penetration upto 45 cm or 100 blows whichever occurs earlier. SPT 'N' of 100 and above shall be referred as refusal. UDS shall be collected at every 3 m interval or at change of strata. The depth interval between the top level of SPT and next UDS shall not be less than 1.0 m.

1.02.02 The laboratory tests shall be conducted on soil, rock & water samples collected during field investigations in sufficient numbers as approved by Employer, but shall not be limited to the following.

Laboratory tests shall be carried out on disturbed and undisturbed soil samples for Grain Size Analysis, Hydrometer Analysis, Atterberg Limits, Triaxial Shear Tests (UU), Natural Moisture Content, Specific Gravity and Bulk Unit Weight, Consolidation Tests, Unconfined Compression Test, Free Swell Index, Shrinkage Limit, Swell Pressure Test, Chemical Analysis test on soil and water samples to determine the carbonates, sulphates, chlorides, nitrates, pH, organic matter and any other chemicals harmful to concrete and reinforcement/ steel. Laboratory tests on rock samples shall be carried out for Hardness, Specific Gravity, Unit Weight, Uniaxial Compressive Strength (in-situ & saturated), Slake Durability etc.

1.02.03 On completion of all field and laboratory work, the Bidder shall submit a Geotechnical investigation report for Employer's approval. The Geotechnical investigation report shall contain geological information of the region, procedure adopted for investigation, field and laboratory observations/ data/ records, analysis of results and recommendations on type of foundation for different type of structures envisaged for all areas of work. Recommendations on treatment for soil, foundation, based on subsoil characteristics, soft soils, aggressive chemicals, expansive soils, etc.

1.02.04 Generally, the geotechnical investigation report shall include, but not be limited to, the following:

a) Plot plan showing the locations and reduced levels of all field tests.

b) Geological information of the area.

c) A true cross section of all individual boreholes and trial pits with reduced levels and coordinates, showing the classification and thickness of individual stratum, position of ground water table, results of various in-situ tests conducted and samples collected at different depths and the rock stratum, wherever met with.

d) A set of longitudinal and transverse soil/ rock profiles connecting various boreholes.

e) Plots of Standard Penetration Tests with depths.

f) Results of all laboratory tests summarised (i) for each Borehole alongwith (ii) a consolidated table giving the layer wise soil and rock properties. All the relevant charts, tables, graphs, figures, supporting calculations, conditions and photographs of representative rock cores and trial pits shall be furnished.

For pressue meter tests, the following shall be furnished:

(i) Field pressure meter, creep air calibration curves indicating Po, Pf and Pl. Corrected pressuremeter and creep curves indicating

Po, Pf, Pl. alongwith sample calculaton for the corrections.

(ii) Pressuremeter modulus, shear modulus and coefficient of subgrade reaction alongwith sample calculation.

g) Electrical resistivity of subsoil based on electrical resistance tests including electrode spacing Vs cumulative resistivity curve.

h) Suitability of the sub soil for construction of roads / embankments and their stable slopes for embankment and shallow and deep excavations, values of earth pressures coefficient for active / passive / at rest conditions and modulus of elasticity as a function of depth for the design of underground structures.

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

j) If expansive soil is met with, any special treatment, viz. Soil replacement/lime treatment, etc., required including specifications for materials to be used, construction method, equipments to be deployed, etc. shall be furnished.

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

l) Identification of liquefiable zone. Identification of any other potential geotechnical problems & their remedial measures.

m) Description of measures required for erosion control.

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

o) Recommendations on type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total/ differential settlement permissible for structures and equipments, minimum depth and width of foundation.

p) For shallow foundations the following shall be indicated with comprehensive supporting calculations:

i) Net safe allowable bearing pressure for isolated square footings and continuous strip footings of sizes 2.0 and 6.0 m at two

different founding depths of 1.0 and 3.0 m below natural ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.

ii) Net safe allowable bearing pressure for raft foundations of widths greater than 6 m at 1.0 and 3.0 m depths below natural ground level considering both shear failure and settlement criteria.

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

1.03.00 Geotechnical investigation work shall be got executed by the Bidder through one of the following Indian parties or any other agency to be approved by the Owner:

a) M/s RITES Ltd, Gurgaon

b) M/s WAPCOS, Gurgaon

c) M/s Geotech Consultants Pvt Ltd, New Delhi

d) M/s. DBM Geotechnics & Constructions Pvt. Ltd, Mumbai

e) M/s NKPC, Rajkot

f) M/s Constell Consultants Pvt Ltd, Kolkata

g) M/s CENGRS Geotechnica Pvt. Ltd., Delhi

h) M/s CE Testing Company Pvt Ltd, Kolkata

i) M/s Swayin & Associates, Bhubaneshwar

j) M/s Soil Engineering Consultants, New Delhi

k) M/s. Vax Consultants Pvt. Ltd. Chennai.

l) M/s M.K.Soil testing Laboratory, Ahmedabad.

The detailed Geotechnical Investigation report, Foundation system, founding level to be adopted including the allowable bearing capacities, measures to be adopted as mentioned in the specification shall be submitted to the Employer for approval.

TABLE - 1: INDICATIVE SPACING FOR BOREHOLES

S.No.	Structure	Spacing of boreholes		Remarks	Depth of borehole
		Uniform strata	Erratic strata		
(1)	(2)	(3A)	(3B)	(4)	(5)
1	Main Plant structures and Multistoried buildings	20-40 m in TG hall or at every 3rd column location of other buildings	15-30 m or @ alternate column location	Minimum 5 boreholes shall be done under each structure/facility	50m or refusal whichever is earlier
2	Single to two storied buildings, PT Plant, Control building, Transformer yard GIS building	40-60 m	20 - 40 m	Minimum 2 boreholes shall be done under each structure / storage	40m or refusal whichever is earlier
3	Bridge piers, abutments, Overhead Water Tanks	30 - 40 m	20 - 30 m	Minimum 1 to 2 bore holes per foundation/ Pier	-do-
4	Liquid storage tanks, CW Clarifiers, Pump houses	25 - 30 m	20 - 30 m	Minimum 2 for each tank / Pump house or 3 for two tanks / clarifiers if they are in series	-do-
5	Transmission Towers	At each location if more than 400 m C/C	At each location or under each leg depending upon the size of tower		-do-
6	Embankments	150 to 200 m	80 - 100 m		-do-
7	Corridors for pipe routes	300 m	200 m		7m at crossings 15-20 m
8	Stacks, Cooling Towers Clarifiers	3 on Periphery & 1 at Centre	4 on Periphery & 1 at Centre		50 m at centre and remaining 40 m

9	Roads	400-500 m	200 m		5 m at crossings 20 - 25 m

Buildings / Structures / Facilities not covered in the above table shall be identified and accordingly the scheme shall be put up for Employer's approval.
In case of pile foundations, the largest average width of the pile groups is the governing dimension and the zone of influence extends to twice this dimension below the level of load transfer. However, the depth of borehole shall not be less than 10m below tip of the pile.

TABLE - 2 SUGGESTED QUANTITY FOR FIELD INVESTIGATION

A	Plant area	Quantity
1)	BORE HOLES	As per Table 1
2)	TRIAL PITS	1 each in TG, SG, Stack, CT's PTP
3)	PLATE LOAD TEST	-do-
4)	CYCLIC PLATE LOAD TEST	TG, SG
5)	IN SITU PERMEABILITY TEST IN BOREHOLES	In each strata of bore-hole power house, CT's, PTP, reservoir
6)	SCPT	About 20% of boreholes Depth upto refusal and equipment capacity - 20T
7)	DCPT	About 10-20% of boreholes in case of hard soil or rocky strata @ shallow depth.
8)	VANE SHEAR TEST	Only in soft clay strata
9)	FIELD CBR	About 1000-2000 m C/C along plant & approach roads
10)	ERT	2 each in TG, SG, Stack, CT's & about 10-15 nos. well spread in GIS and Transformer yard
11)	SRT	In Grid covering the Main Power Block from Stack to Transformer Yard
12)	CROSS HOLE SHEAR TEST	In loose silty soils covering plant area
13)	PRESSURE-METER	5 each in each strata at the following facilities: TG, SG, CTs (in each unit), Stack
14)	FIELD CBR	One at every 1000 m. chainage of road

ANNEXURE-II

LIST OF CODES AND STANDARDS

1.00.00 **Excavation and Filling**

IS :2720	Methods of test for soils(relevant parts)
IS:4701	Code of practice for earth work on canals.
IS:9759	Guide lines for dewatering during construction.
IS:10379	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade.

2.00.00 **Properties, Storage and Handling of Common Building Materials**

IS:269	33 grade for ordinary Portland cement.
IS:383	Coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile steel bars and
(Part 1&2)	hard drawn steel wires for concrete reinforcement.
IS:455	Portland slag cement.
IS:702	Industrial bitumen.
IS:712	Specification for building limes.
IS:1077	Common burnt clay buidling bricks.
IS:1161	Steel tubes for structural purposes.
IS:1239	Mild steel tubes, tubulars and other wronght steel fillting - MS tubes.
IS:1363	Hexagon head bolts, screws and nuts of productions
(Part 1-3)	grade - C.
IS:1364	Hexagon head bolts, screws and nuts of productions
(Part 1-5)	grade-A & B.
IS:1367	Technical supply condition for threaded fasteners.
(Part 1-18)	
IS:1489	Portland-pozzolana cement.
(Part-I)	Fly ash based
IS:1542	Sand for Plaster.
IS:1566	Hard drawn steel wire fabric for concrete reinforcement.
IS:1786	High strength deformed steel bars & wires for concrete reinforcement.

	IS:2062	Steel for general structural purposes.
	IS:2116	Sand for masonry mortars.
	IS : 2185	Hollow & solid concrete blocks.
	(Part 1)	
	(Part 2)	Hollow & solid light weight concrete blocks.
	IS:2386	Testing of aggregates for concrete.
	(Part I-VIII)	
	IS:3819	Specification for fly ash for use as pozzolona and admixture.
	IS:4082	Recommendation on stacking and storage of construction materiel and components at site
	IS:8112	43 grade ordinary portland cement.
	IS:8500	Structural steel-Microalloyed (Medium and high strength qualities).
	IS:12269	53 grade ordinary portland cement.
	IS:12894	Specification for fly ash lime bricks.
	IS:13757	Burnt clay fly ash building bricks.
3.00.00	**Cast in-situ Concrete and Allied Works**	
	IS:280	Mild steel wire for general engineering purpose.
	IS:456	Code of practice for plain and reinforcement concrete.
	IS:457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
	IS:516	Method of test for strength of concrete.
	IS:1199	Methods of sampling and analysis of concrete.
	IS:1791	General requirement for batch type concrete mixers.
	IS:1834	Hot applied sealing compound for joints in concrete.
	IS:1838	Preformed fillers for expansion joints in concrete pavement and structures.
	IS:2438	Specification for roller pan mixers.
	IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
	IS:2505	Concrete vibrators - immersion type.
	IS:2506	General requirements for screed board concrete vibrators.
	IS:2722	Specification for Portable Swing weighbatchers for concrete (single and double bucket type).
	IS:2750	Steel scaffoldings

	IS:2751	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
	IS:3150	Hexagonal wire netting for general purposes.
	IS:3366	Specification for pan vibrators.
	IS:3370	Code of practice for concrete structures for the
	(Part 1-4)	storage of liquids.
	IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
	IS:4014	Code of practice for steel tubular scaffolding.
	(Part-1&2)	
	IS:4326	Code of practice for earth quake resistant design and construction of buildings.
	IS:4656	Form vibrators for concrete.
	IS:4925	Concrete batching and mixing plant.
	IS:4990	Plywood for concrete shuttering work.
	IS:5256	Code of practice for sealing expansion joints in concrete lining on canals.
	IS:5525	Recommendations for detailing of reinforcement in reinforced concrete works.
	IS:6461	Glossary of terms relating to cement concrete.
	IS:6494	Code of practice for water proofing of underground reservoir and swimming pools.
	IS:6509	Code of practice for installation of joints in concrete pavements.
	IS:7861	Code of practice for extreme weather concreting.
	(Part -1&2)	
	IS:9012	Recommended practice for shotcreting.
	IS:9103	Admixtures for concrete.
	IS:9417	Recommendations for welding cold worked bars for reinforced concrete construction.
	IS:10262	Recommended guidelines for concrete mix design.
	IS:11384	Code of practice for composite construction in structural steel and concrete.
	IS:12118	Two parts polysulphide based sealants.
	IS:12200	Code of practice for provision of water stops at transverse construction joints in masonry and concrete dams.

	IS:13311	Non destructive testing of concrete - methods of test.
	(Part 1)	Ultrasonic pulse velocity.
	(Part 2)	Rebound hammer.
	SP-16	Design codes for reinforced concrete to IS:456-1978.
	SP-23	Hand book of concrete mixes.
	SP-24	Explanatory handbook on Indian standards code for plain and reinforced concrete. (IS : 456)
	SP-34	Hand book on concrete reinforcement and detailing.
	ACI-318	American Concrete Institute code for structural concrete.
4.00.00	**Precast Concrete Works**	
	SP:7	National Building Code - Structural
	(Part 6/Sec.7)	Design of prefabrication and system building.
	IS:10297	Code of practice for design and construction of floors and roofs using precast reinforced/prestressed concrete ribbed or cored slab units.
	IS:10505	Code of practice for construction of floors and roofs using pre-cast reinforced concrete waffle units.
5.00.00	**Masonry & Allied Works**	
	IS:1905	Code of practice for structural use of unreinforced masonry.
	IS:2212	Code of practice for brick work.
	IS:2250	Code of practice for preparation and use of masonry mortars.
	IS:2572	Code of practice for construction of hollow concrete block masonry.
	SP:20	Hand book on masonry design and construction.
6.00.00	**Sheeting Works**	
	IS:277	Galvanised steel sheets (Plan & corrugated).
	IS:513	Cold-rolled low carbon steel sheets & strips.
	IS:730	Hook bolts for corrugated sheet roofing.
	IS:801	Code of practice for use of cold formed light gauge steel structural members in general building construction.
	IS:2527	Code of practice for fixing rain water gutters and down pipe for roof drainage.
	IS:7178	Technical supply condition for tapping screw.
	IS:8183	Bonded mineral wool.
	IS:8869	Washers for corrugated sheet roofing.

	IS:12093	Code of practice for laying and fixing of sloped roof covering using plain and corrugated galvanised steel sheets.
	IS:12436	Preformed rigid Polyurethane (PUR) and isocyanurate (PIR) foams for thermal insulation.
	IS:12866	Plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced).
	IS:14246	Continuously pre-painted galvanised steel sheets and coils.
	BS:5950	Code of practice for design of light gauge profiled
	(Part-6)	steel sheeting
7.00.00	**Fabrication and Erection of Structural Steel Works**	
	IS:800	Code of practice for General Construction of steel.
	IS:813	Scheme for symbols for welding.
	IS:814	Covered electrodes for manual metal arc welding of carbon & carbon manganese steel.
	IS:816	Code of practice for use of metal arc welding for general construction in mild steel.
	IS:817	Code of practice for training and testing of metal arc welders.
	IS:1024	Welding in bridges and substructured subject to dynamic.
	IS:1181	Qualifying tests for Metal Arc welders (engaged in welding structures other than pipes).
	IS:1182	Recommended practice for Radiographic examination of fusion welded butt joints in steel plates
	IS:1608	Mechanical testing of metals - tensile testing
	IS:1852	Rolling and Cutting Tolerances for Hot rolled steel products.
	IS:2016	Specification for Plain washers.
	IS:2595	Code of practice for Radiographic testing
	IS:2629	Hot dip galvanising of iron and steel
	IS:3502	Steel chequred plate.
	IS:3613	Acceptance tests for wire flux combination for submerged arc welding.
	IS:3658	Code of practice for liquid penetrant flaw detection.
	IS:3664	Code of practice for ultra sonic pulse echo testing contact and immersion method
	IS:3757	High strength structural bolts.
	IS:4000	High strength bolts in steel structure - code of practice.

	IS:4353	Sub merged arc welding of mild steel and low alloy steel Recommendation
	IS:4759	Hot dip zinc coating on structural steel and other allied products.
	IS:5334	Code of practice for magnetic particle flaw detection of welds.
	IS:5369	General requirements for plain washers and lock washer
	IS :6623	High strength structural nuts.
	IS:6649	Hardened and tampered washers for high strength structural bolts & nuts.
	IS:6911	Stainless steel plate, sheet and strip.
	IS:7205	Safety code for erection of structural steel.
	IS:7215	Tolerances for fabrication of structural steel.
	IS: 7307	Approved test for welding procedures
	(Part - I)	Fusion welding of steel.
	IS:7310	Approval test for welders working to approval welding procedure.
	(Part-I)	Fusion welding of steel
	IS:9178	Criteria for design of steel bins for storage of
	(Part-1to 3)	bulk material.
	IS:9595	Recommendations for metal arc welding of carbon & carbon manganese steel.
	IS:12843	Tolerances for erection of steel structures.
	SP:6	ISI Hand book for structural Engineers.
	(Part 1 to 7)	
8.00.00	**Plastering and Allied Works**	
	IS:1661	Code of practice for application of cement and cement lime plaster finishes.
	IS:2402	Code of practice for external rendered finishes.
	IS:2547	Gypsum building plaster.
	(Parts 1&2)	
9.00.00	**Acid and Alkali Resistant Lining**	
	IS:158	Ready mixed paint, brushing, bituminous, black, lead free, acid, alkali & heat resisting.
	IS:412	Expanded metal steel sheets for general purpose.
	IS:4441	Code of practice for use of silica type chemical resistant mortars.

	IS:4443	Code of practice for use of resin type chemical resistant mortars.
	IS:4456	Method of Test for chemical resistant tiles.
	(Part I & II)	
	IS:4457	Ceramic unglazed vitreous acid resisting tiles.
	IS:4832	Specification for chemical resistant mortars.
	(Part - 1)	Silicate type
	(Part - 2)	Resin type
	(Part - 3)	Sulfur type
	IS:4860	Acid resistant bricks.
	IS:9510	Bitumastic acid resisting grade.
10.00.00	**Water Supply, Drainage and Sanitation**	
	IS:458	Precast concrete pipes (with & without reinforcement).
	IS:554	Dimensions for pipe threads, where pressure tight joints are required on the thread.
	IS:651	Salt glazed stoneware pipes and fittings.
	IS:774	Flushing cisterns for water closets and urinals.
	IS:775	Cast iron brackets and supports for wash basins and sinks.
	IS:778	Copper alloy gate, globe and check valves for water works purposes.
	IS:781	Cast copper alloy screw down bib taps & stop valves for water services.
	IS:782	Caulking lead.
	IS:783	Code of practice for laying of concrete pipes.
	IS:1172	Code of basic requirements of water supply, drainage and sanitation.
	IS:1230	Cast iron rain water pipes and fittings.
	IS:1239	Mild Steel tubes, tubulars and other wrought steel fittings
	(Part 1&2)	
	IS:1536	Centrifugally cast (Spun) iron pressure pipes for water.
	IS:1537	Vertically cast iron pressure pipes for water, gas and sewage.
	IS:1538	Cast iron fittings for pressure pipe for water, gas and sewage.
	IS:1703	Copper alloy float valve for water supply fitting.
	IS:1726	Cast iron manhole covers and frames.
	IS:1729	Sand cast iron spigot and socket soil, water and ventilation

		pipes, fittings and accessories.
	IS:1742	Code of practice for building drainage.
	IS:2064	Selection, installation and maintenance of sanitary appliances.
	IS:2065	Code of practice for water supply in buildings.
	IS:2326	Automatic flushing cisterns for urinals.
	IS:2548	Plastic seats and covers for water closets.
	IS:2556	Vitreous sanitary appliances (vitreous china).
	IS:3114	Code of practice for laying of cast iron pipes.
	IS:3311	Waste plug and its accessories for sinks and wash basins.
	IS:3438	Silvered glass mirrors for general purposes.
	IS:3486	Cast iron spigot and socket drain pipes.
	IS:3589	Seamless or electric welded steel pipes for water, gas and sewage (168.3 mm to 2032 mm outside diameter).
	IS:3989	Centrifugally cast (Spun) iron spigot and socket soil, waste and ventilating pipes, fittings and accessories.
	IS:4111 (Part 1 to 5)	Code of practice for ancillary structure in sewerage system.
	IS:4127	Code of practice for laying of glazed stone ware pipes.
	IS:4764	Tolerance limits for sewage effluents discharged into inland surface waters.
	IS:4827	Electroplated coating of nickel and chromium on copper and copper alloys.
	IS:5329	Code of practice for sanitary pipe work above ground for buildings.
	IS:5382	Rubber sealing rings for gas mains, water mains and sewers.
	IS:5822	Code of practice for laying of electrically welded steel pipes for water supply.
	IS:5961	Specification for cast iron grating for drainage purpose.
	IS:7740	Code of practice for construction and maintenance of road gullies.
	IS:8931	Copper alloy fancy single taps combination tap assembly and stop valves for water services.
	IS:9762	Polyethylene floats for float valves.
	IS:10592	Industrial emergency showers, eye and face fountains and combination units.
	IS:12592	Specification for precast concrete manhole covers and frames.

	IS:12701	Rotational moulded polyethylene water storage tanks.
	IS:13983	Stainless steel sinks for domestic purposes.
	SP:35	Hand book on water supply and drainage with special emphasis on plumbing.
	CPH&EEO	Manual on sewage and sewage treatment
	Publication	- as updated.
11.00.00	**Doors Windows and Allied Works**	
	IS:204	Tower Bolts.
	(Part 1)	Ferrous metals
	(Part 2)	Non - ferrous metals
	IS:208	Door Handles.
	IS:281	Mild steel sliding door bolts for use with padlocks.
	IS:362	Parliament Hinges.
	IS:420	Putty, for use on metal frames.
	IS:451	Technical supply conditions for wood screws
	IS:733	Wrought aluminium and aluminium alloy bars, rods and sections for general engineering purposes.
	IS:1003	Timber panelled and glazed shutters (doors shutters).
	(Part I)	
	IS:1003	Timber panelled and glazed shutters
	(Part-1)	door shutters.
	IS:1038	Steel doors, windows and ventilators.
	IS:1081	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
	IS:1285	Wrought aluminium and aluminium alloy extruded round tube & hollow section (for general engineering purposes).
	IS:1341	Steel butt hinges.
	IS:1361	Steel windows for Industrial buildings.
	IS:1823	Floor door stoppers.
	IS:1868	Anodic coatings on Aluminium and its alloys.
	IS:2202	Wooden flush door shutters (solid core type) particle
	(Part-2)	board face panels and hard board face panels.
	IS:2209	Mortice locks (vertical type)
	IS:2553	Safety glass.

	(Part-1)	General purposes
	IS:2835	Flat transparent sheet glass.
	IS:3548	Code of practice for glazing in buildings.
	IS:3564	Door closers (Hydraulically regulated)
	IS:3614	Specification for fire check doors :
	(Part-1)	plate, metal covered and rolling type.
	(Part-2)	Resistance test and performance criteria.
	IS:4351	Specification for steel door frames.
	IS:5187	Flush bolts.
	IS:5437	Figured, rolled and wired glass.
	IS:6248	Specification for metal rolling shutters and rolling grills.
	IS:6315	Specification for floor springs (Hydraulically regulated) for heavy doors.
	IS:7196	Hold fast.
	IS:7452	Hot rolled steel sections for doors, windows and ventilators.
	IS:10019	Mild steel stays and fasteners.
	IS:10451	Steel sliding shutters (top hung type)
	IS:12823	Prelaminated particle boards.
12.00.00	**Roof Water Proofing and Allied Works**	
	IS:3067	code of practice for general design details and preparatory work for damp proofing and water proofing of buildings.
	ASTM	Standard specification for high solid content cold
	C836-89a	liquid applied elastomeric water proofing membrane for use with separate wearing course.
	ASTM	Standard guide for high solid content cold
	C898-89	liquid applied elastomeric water proofing membrane for use with separate wearing course.
13.00.00	**Floor Finishes and Allied Works**	
	IS:5318	Code of practice for laying of flexible PVC sheet and tile flooring.
	IS:8042	White portland cement.
	IS:13755	Dust pressed ceramic tiles with water absorption of 3%, E 6% (Group B11a).
	IS:13801	Chequered cement concrete tiles.

14.00.00 **Painting and Allied Works**

IS:162	Ready mixed paint, brushing fire resisting, silicate type for use on wood, colour as required.
IS:428	Distemper, oil, emulsion, colour as required.
IS:1477	Code of practice for painting of terrous metals in buildings.
(Part -1)	Pretreatment.
(Part -2)	Painting.
IS:1650	Specification for colours for building and decorative materials.
IS:2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming.
IS:2338	Code of practice for finishing of wood and wood based materials.
(Part -1)	Operations and Workmanship.
(Part -2)	Schedule.
IS:2395	Code of pratice for painting concrete, masonry and plaster surfaces.
(Part-1)	Operations and Workmanship.
(Part -2)	Schedule.
IS:2524	Code of practice for painting of nonferrous metals in buildings.
(Part -1)	Pretreatment
(Part -2)	Painting.
IS:2932	Enamel, synthetic, exterior, (a) under coating and (b) finishing.
IS:2933	Enamel exterior, (a) under coating, (b) finishing.
IS:4759	Hot dip zinc coatings on structural steel and other allied products.
IS:5410	Specification for cement paint.
IS:5411	Plastic emulsion paint.
(Part-1&2)	
IS:6278	Code of practice for white washing and Colour washing.
IS:10403	Glossary of term related to building finish.
IS:12027	Silicone based water repellent
IS:13238	Epoxy based zinc phosphate primer (2 pack)
IS:13239	Epoxy surfacer (2 pack)
IS:13467	Chlorinated rubber for paints
IS:14209	Epoxy enamel, two component glossy.

	BS:5493	Code of practice for protective coating of iron and steel structures against corrosion.
15.00.00	**Piling and Foundation**	
	IS:1080	Code of practice for design and construction of shallow foundations on soils.
	IS:1904	Code of practice for design and construction of foundation in Soils : General Requirements.
	IS:2314	Steel sheet piling sections.
	IS:2911	Code of practice for design and construction of pile foundations.
	(Relevant Parts)	
	IS:2950	Code of practice for designs and construction of Raft foundation.
	(Part-1)	Design
	IS:2974	Code of practice for design and construction of machine
	(Part-1 to 5)	foundation.
	IS:4091	Code of practice for design and construction foundations for transmission line towers and poles.
	IS:6403	Code of practice for determination of Bearing capacity of Shallow foundations.
	IS:8009	Code of practice for calculation of settlement of foundation.
	(Part -1)	Shallow foundations.
	(Part -2)	Deep foundations.
	IS:12070	Code of practice for design and construction of shallow foundations on rocks.
	VDI:2056	Criteria for assessing mechanical vibrations of machines.
	VDI:2060	Criteria for assessing the st of balance of rotating rigid bodies.
	DIN:2089	Helical compression spring made of round wire and rod : calculation and design of compression .
	DIN:2096	Helical compression spring out of round wire and rod : Quality requirements for hot formed compression spring.
	DIN:4024	Flexible supporting structures for machine with rotating machines.
16.00.00	**Roads**	
	IRC:5	Standard specifications and Code of practice for road bridges,
	(Section-1)	General Features of Design.

	IRC:14	Recommended practice for 2cm thick bitumen and tar carpets.
	IRC:15	Standard specifications and code of practice for construction of concrete roads.
	IRC:16	Specification for priming of base course with bituminous primers.
	IRC:19	Standard specifications and Code of practice for water bound macadam.
	IRC:21	Standard specifications and Code of practice for road bridges.
	(Section-III)	Cement concrete (plain and reinforced).
	IRC:34	Recommendations for road construction in water logged areas.
	IRC:36	Recommended practice for the construction of earth embankments for road works.
	IRC:37	Guidelines for the Design of flexible pavements.
	IRC:56	Recommended practice for treatment of embankment slopes for erosion control.
	IRC:58	Guidelines for the design of rigid pavements for highways.
	IRC:73	Geometric Design standards for rural (non-urban) highways.
	IRC : 86	Geometric Design standards for urban roads in plains.
	IRC:SP:13	Guidelines for the design of small bridges & culverts.
	IRC -	Ministry of Surface Transport (Road wing),
	Publication	specifications for road and bridge works.
	IS:73	Paving bitumen.
17.00.00	**Loading**	
	IS:875	Code of practice for design loads (other than earthquake) for
	(Relevant parts)	buildings and structures.
	IS:1893	Criteria for earthquake resistant design of structures.
	IS:4091	Code of practice for design and construction of foundation for transmission line towers and poles.
	IRC:6	Standard specifications & Code of practice for road bridges.
	(Section-II)	loads and stresses
18.00.00	**Safety**	
	IS:1641	Code of practice for fire safety of buildings - General principles of fire grading and classification.
	IS:1642	Code of practice for fire safety of buildings - Details of construction.
	IS:3696	Safety code for scaffolds and ladders.

	(Part-1&2)	
	IS:3764	Excavation work - code of safety.
	IS:4081	Safety code for blasting and related drilling operations.
	IS:4130	Demolition of buildings - code of safety.
	IS:5121	Safety code for piling and other deep foundations.
	IS:5916	Safety code for construction involving use of hot bituminous materials.
	IS:7205	Safety code for erection of structural steel work.
	IS:7293	Safety code for working with construction machinery.
	IS:7969	Safety code for handling and storage of building materials.
	Indian Explosives Act 1940)	(As updated)
19.00.00	**Architectural Design of Buildings**	
	SP:7	National Building Code of India
	SP:41	Hand book on functional requirements of buildings (other than industrial buildings)
20.00.00	**Chimney**	
	IS:4998	Criteria for design of reinforced chimneys
	IS:6533	Code of practice for design and construction of steel chimneys
	ICAO	International Civil Aviation Organisation (ICAO)
	DGCA	Instruction of Director General of Civil Aviation , India
	ACI:307	Specification for the design and construction of reinforced concrete chimneys
	BS:4076	Specification for steel chimneys
	CICIND	Model Code for concrete chimneys
		Model code for steel chimneys
	ASCE Code	Design and construction of steel chimney liners prepared by Task committee on steel chimney liners. Fossil power committee, Power division published by ASCE - 1975.
	IS:1554	PVC insulated (heavy duty) electric cables

	IS:2606	Alloy lead anodes for chromium plating
	IS:3043	Code of Practice for Earthing
	IS:9537	Rigid steel conduits for electrical wiring
		The Indian Electricity Rules
		The Indian Electricity Act
		The Indian Electricity (Supply) Act
		The Indian Factories Act
	IS:2309	Practice for protection of buildings and allied structures against lightning
21.00.00	**Miscellaneous**	
	IS:802 (Relevant parts)	Code of practice for use of structural steel in overhead transmission line towers.
	IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrically welded in storage tanks.
	IS:10430	Criteria for design of lined canals and guidance for selection of type of lining.
	IS:11592	Code of practice for selection and design of belt conveyors.
	IS:12867	PVC handrails covers.
	CIRIA Publication.	Design and construction of buried thin-wall pipes.