5.0 The stipulations of Datasheet-A, Section-C followed by those of Section-D. shall prevail in case of any conflict between the stipulations of same.

ANNEXURE – I TO SECTION – C : STANDARD ELECTRICAL SCOPE BETWEEN BHEL AND VENDOR

PACKAGE : COOLING TOWER (NATURAL DRAFT)
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

PROJECT :

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
1	415V MCC	BHEL	BHEL	415 V AC, 3 phase, 4 wire supply/ 240 V AC, 1 phase supply shall be provided by BHEL based on load data provided by vendor at contract stage for all equipment supplied by vendor.
2	Local Push Button Station (for motors)	BHEL	BHEL	Located near the motor.
3	Power cables, control cables and screened control cables for a) both end equipment in BHEL's scope b) both end equipment in vendor's scope c) one end equipment in vendor's scope	 BHEL BHEL BHEL	 BHEL BHEL BHEL	1. Termination at BHEL equipment terminals by BHEL. 2 Termination at Vendor equipment terminals by Vendor.
4	Junction box for control & instrumentation cable	Vendor	Vendor	
5	Any special type of cable like compensating, co-axial, prefab, MICC, fibre Optic cables etc.	Vendor	Vendor	Refer scope/ C&I portion of specification for scope of fibre Optic cables if used between PLC/ micro processor & DCS.
6	Cabling material (Cable trays, accessories & cable tray supporting system)	Vendor	Vendor	1. Layout details between vendors supplied equipment & installation dwgs by vendor. 2. BHEL will provide cable trench along with cabling material up to the terminal point approx. 10 m away from cooling tower. Further cabling (supply and E&C) shall be in vendor's scope.
7	Cable glands ,lugs, and bimetallic strip for equipment supplied by Vendor	Vendor	Vendor	1. Double compression Ni-Cr plated brass cable glands 2. Solder less crimping type heavy duty tinned copper lugs for power and control cables.
8	Equipment grounding & lightning protection	Vendor	Vendor	Material and sizes shall be as per specification and subject to BHEL approval during detailed engineering stage.
9	Below grade grounding	BHEL	Vendor	MS rod material shall be provided by BHEL. All other materials/ consumables are in vendor's scope.
10	LV Motors with base plate and foundation hardware (in case applicable for NDCT)	Vendor	Vendor	Makes shall be subject to customer/ BHEL approval at contract stage.
11	Lighting System	Vendor	Vendor	In addition to other lighting system items, vendor shall consider aviation lights & their control as per statutory requirement and Lighting panels (LP) & timer

PACKAGE : COOLING TOWER (NATURAL DRAFT)
SCOPE OF VENDOR: SUPPLY, CIVIL WORKS, ERECTION & COMMISSIONING OF VENDOR'S EQUIPMENT

S.NO	DETAILS	SCOPE SUPPLY	SCOPE E&C	REMARKS
				control as per requirement. Further wires, any other material required for lighting system shall also be considered by vendor in their scope. **BHEL will provide the power supply for LP, from LDB at one location near Cooling Tower. Further, distribution from LP including material is in vendor scope.**
12	Aviation Lighting	Vendor	Vendor	
13	Any other equipment/ material/ service required for completeness of system based on system offered by the vendor (to ensure trouble free and efficient operation of the system).	Vendor	Vendor	
14	**Engineering activities** during detailed engineering stage, including those listed below: a. Electrical load data submission in PEM format b. Electrical equipment GA drawings and layout drawings c. Cable trench/ tray layout drawings d. Control cable schedules showing routing details [including cables supplied by PEM for CT equipment]. e. Grounding and lightning protection system layouts f. Cable termination/ interconnection details (diagram)/ Cable block diagram	Vendor	--	1. Documentation shall be submitted as per project schedule for BHEL/ customer approval. 2. Vendor shall be responsible for necessary coordination with BHEL for required engineering interfacing during contract stage. 3. Any approval required from electrical inspection authority for electrical equipment shall be arranged by vendor.

NOTES:

1. Make of all electrical equipment/ items supplied shall be reputed make & shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
2. All QPs shall be subject to approval of BHEL/customer after award of contract without any commercial implication.
3. In case the requirement of Junction Box arises on account of Power Cable size mis-match due to vendor engineering at later stage, vendor shall supply the Junction Box for suitable termination.
4. Wherever BHEL is indicated above, if the scope of supply and E&C of any of the above listed items is in BHEL's Customer scope, then the respective items shall be supplied, erected and commissioned by BHEL's Customer. For such items, BHEL as indicated in SUPPLY and E&C column above shall be read as "BHEL's CUSTOMER".

SECTION – C3

SPECIFIC TECHNICAL REQUIREMENTS (CIVIL)

1.0 GEO-TECHNICAL INVESTIGATION & FOUNDATION SYSTEM

BHEL is in the process of carrying out preliminary geo-technical investigation in the proposed cooling tower site and sub-strata details shall be furnished to bidders seperately before submission of the bids.

The geotechnical data (which will be submitted seperately) shall be solely for the purpose of guidance to the bidder. BHEL/owner will not take any responsibility about the accuracy and applicability of the geo-technical data. The onus of correct assessment/ interpretation and understanding of the existing sub-strata conditions is on the bidder. Any variation in the data between the one furnished and to that found during execution of the work at site shall not constitute a valid reason in affecting the terms & conditions of this bid and the bidder shall note that nothing extra will be payable on this account.

The bidder shall fully satisfy himself about the nature of sub-strata expected to be encountered including the type of foundation, ground water table and construction methodology to be adopted etc prior to the submission of the bid.

TECHNICAL SPECIFICATION
FOR
NATURAL DRAFT COOLING TOWER (NDCT)

(4 X 270 MW Manuguru Project)

3.00.00 **CIVIL DESIGN BASIS**

3.01.00 Loading

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

a) Dead loads

b) Wind loads

c) Earthquake forces

d) Loads due to temperature and shrinkage effects. Temperature effects due to solar radiation shall also be considered.

e) Construction load

f) Foundation settlement etc.

g) Any other load likely to come on cooling tower.

3.01.01 **Dead Load**

For assessing the self weight of the structure, the specific weight of the concrete shall be taken as 2500 kg/m3. All other dead loads shall be assessed in accordance with relevant codal provision. Dead load shall include the self weight of structure, weight of fill material, weight due to plugging/chocking of fills, weight of falling water, weight of hot water pipe, weight of water in hot water channel and distribution system including the self weight of channel and distribution system, weight of drift eliminators etc.

Secondary stresses, if any, due to permanent fixtures on the shell shall also be considered. In addition, live load on the supporting structure due to maintenance activities related to fills /ducts/distribution system shall be considered.

3.01.02 **Wind Load**

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

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

For conducting model tests, bidders should survey the whole terrain and make their own assessment of likely critical wind forces & wind structure interaction. It would be the responsibility of the contractor to collect necessary meteorological data duly vetted from the recognized govt. agencies/institutions. After collection of necessary meteorological data, most critical wind speed, wind pressure distribution and other necessary parameter shall be determined by the bidder and get the same vetted by the above agency/appropriate agency(s). Then with the help of physical model tests in a wind tunnel, offering appropriate aerodynamic similitude, the contractor shall obtain the most critical forces, stresses etc. with cooling tower at various levels and locations. Such model test shall also include all adjacent topographical features, buildings, and other structures which are likely to influence the wind load pattern on the tower significantly. The model test shall be carried out in a well reputed institute/testing laboratory after obtaining prior approval from the Owner. The testing agency selected by the contractor shall have requisite experience and should have successfully carried out tests in the past for at least one cooling tower of similar capacity. The model tests shall be duly witnessed and approved by the Owner/consultant. The model test results shall be made available before final approval of the design.

The complete cooling tower shall be designed for all possible wind directions and on the basis of worst load conditions as obtained from Model test and theoretical methods. Under the theoretical method, the circumferential net wind pressure distribution and wind pressure coefficient (p1) for the tower shell (without meridional ribs) shall be obtained from the “Criteria for structural design of Reinforced concrete Nature Draft Cooling Towers IS: 11504-1985.

The above circumferential wind pressure coefficient (p1) shall be increased by multiplying it by 1.43 to account for turbulence in the incident wind and load intensification due to turbulence induced by the adjacent cooling tower or the other structures of significant dimensions. Therefore, the actual design circumferential net wind pressure coefficient (p) shall be computed as p=1.43(p1), where (p1) is the wind pressure coefficient as per IS: 11504-1985. Enhancement factor 1.43 is considered to take the interference effect of adjacent structures of significant dimensions into account. 10% increment shall be considered (i.e: 1.43 x 1.1) for the imperfection in construction as per IS :11504. However, the foundations, pedestals and raker columns shall be designed for wind pressure coefficient specified as per IS 11504-1985 to a multiplying factor as 1.1x1.1 (in absence of model test result)

This design net pressure coefficient (p) and the distribution along the circumference of tower shall be used at all heights of the tower. The above design net pressure coefficient (p) shall include the effect of internal suction.

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

The wind pressure at a given height [P(z)] shall be computed as per the stipulations of IS: 875 (Part 3)-1987. For computing the design wind pressure at a given height the basic wind speed (Vb) shall be taken as Vb=44m/sec at 10.0 meters height above mean ground level. For computing design wind speed (Vz) at a height z, the risk co-efficient K1=1.07 shall be considered. For coefficient K2, Terrain category 2 and class ‘C’ as per table 2 of IS: 875 (Part-3) – 1987 (Latest) shall be considered. Coefficient K3 shall be determined by taking into account nearby plant site and other features of the station & topography. The wind direction for design purposes shall be the one which would induce the worst load conditions. However, coefficient K3 shall not be less than one under any circumstances. The wind pressure at a given height shall be computed theoretically in accordance to the IS Codal position given as under:
Pz = 0.6 Vz2 N/m2

The bidder shall also compute the wind pressure (pz) along the wind direction by Gust

Factor (GF) or Gust effective factor method (GEF). Method for estimating the wind load on the tower and other elements, shall be based on IS: 875 (Part-3)-1987. While calculating the gust factor, the term ‘b’ shall be taken as the diameter of the throat in Fig. 10 of IS: 875 (Part-3)-1987.

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

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

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

3.01.03 **Earthquake Forces**

The seismic analysis shall be carried out in accordance with IS:1893 (all latest parts) by modal analysis for the hyperbolic cooling towers or any other method as approved by the Owner. The earthquake analysis of the shell and its support columns including the foundations shall be carried out by response spectrum method. For the fill supporting structures (RCC frames) response spectrum method is permitted. The modulus of elasticity for concrete shall be obtained from IS: 456-2000. All the analysis shall be carried out as per the theory of elasticity.

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

3.01.04 **Loads due to temperature effects**

Stresses due to temperature effects:

The cooling tower shell shall be designed for stress due to axi-symmetric temperature distribution corresponding to external ambient temperature variation from 12^0C to 50^0C. However, the detailed analysis of actual thermal gradient by considering temperatures inside the tower and external ambient temperatures shall be carried out furnishing detailed references and justification for the same.

The shell shall also be checked for thermal stresses arising due to partial operation of the tower in case the operational philosophy so demands. The analysis for the stresses resulting from non-axi-symmetric temperature loading shall be carried out. In such non-symmetric temperature loading, the calculation shall be based upon the operating specification. Besides, the shell shall also be designed for one sided solar radiation effect. Nevertheless an effective temperature difference of at least 25^0 C across the shell thickness constant over the height and follow a sine functions along half the circumference shall be considered.

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

3.01.05 **Construction Loadings**

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

a) Barrowing of concrete

b) Scaffolding and formwork

c) Loads produced by anchoring devices of climbing scaffolds.

d) Hoist fixings

e) Storage of materials on scaffolding

f) Temporary access

g) Tower crane fixings

h) Works temporarily omitted for access purposes.

Any other load such as foundation settlement, etc.

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

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

3.01.06 **Load Combinations**

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

a) DL + WL + SL

b) DL + Se L

c) DL + TL

d) DL + WL + TL + SL

e) DL + Se L + TL + SL

f) 1.0 DL + 1.5 WL

g) 0.9 DL +1.5 WL

h) 0.9 DL-1.5WL

Where,

DL = Dead Load WL = Wind Load SL = Settlement Load Se L = Seismic Load TL = Thermal Load

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

3.01.07 **Permissible Stresses**

For load combination (a) to (e) working stress method shall be done without considering 33% increase in permissible stresses in concrete and reinforcement.

For the load case (f) to (h) the shell of cooling towers shall be checked by limit state method as per IS: 456. The stress in the reinforcement steel shall not exceed 87% of the specific characteristic strength of reinforcement steel and the compressive stress in the concrete shall not exceed 45% of the specified 28 days cube strength of the concrete as per IS: 456.

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

Permissible stress for steel structures shall be as per IS: 800 based on working stresses.

3.02.00 **Tower Design Consideration**

3.02.01 **General**

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

the structural analysis. Analysis based on a recognized bending theory of the elastic shells shall be adopted for the design of the tower and supporting structures.
Regardless of analysis method adopted, the equilibrium checks of internal forces and external loads shall be performed.

Geometric imperfections, if exceed the permissible limit, then the analysis of shell shall take into account of such imperfections and resubmitted for Owner’s approval.

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

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

3.02.02 **Size and Shape**

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

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

H/D = 1.2 to 1.55

Where H is the total tower height above basin sill level

Hb/H = 0.75 to 0.85

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

3.02.03 **Tower Shell Boundary Conditions**

A. **Shell Analysis and Design**

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

a) At Upper Edge

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

b) At Lower Edge

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

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

i) Meridonal and circumferential direct stress resultants and the tangential shear stress resultants.

ii) Meridional and circumferential bending moments.

iii) Displacements normal to the shell mid-surface.

B. **Buckling of Tower Shells:**

Critical dynamic pressure (wind pressure) at buckling shall be calculated from BS: 4485 Part-4:1996. Buckling of Cooling Tower shell be checked as per Finite Element Analysis using software such as NISA 2, Ansys etc. The factor of safety for snap through buckling shall be more than 5. This requires non linear analysis including simulation of opening in the model. Alternatively, bifurcation buckling factor can be calculated using linear eigen value analysis with modulus of elasticity E=0.8Ec, to account for cracked section, with factor of safety more than 7. Besides above, a buckling analysis with wind forces should be made using the theoretical tower geometry and boundary conditions, including the influence of dead weight, by the method of buckling stress state (BSS) approach in accordance with the provisions of VGB/BS 4485.

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

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

C. **Opening in Shells**

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

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

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

D. **Minimum Thickness of Shell**

- The thickness of the shell shall be minimum 220 mm or more as per design.

E. **Minimum Reinforcement in Shell Spacing and Placement**

- The reinforcement used shall be cold worked steel high strength deformed bars of grade Fe 415/500 conforming to IS: 1786 – latest. All reinforcement steel shall be corrosion resistant steel/HCRM. The minimum reinforcement to be provided shall be as follows:

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

- Minimum bar diameter shall be 10 mm in transverse direction and 12 mm in meridional direction.

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

  - The two layers of reinforcing meshes shall be adequately joined by S-hook over the total shell surface. At least two S-hooks in each square metre area of shell surface shall be provided. The hooks shall be of minimum 8 mm diameter bars.

- The concrete cover shall be 50 mm minimum. However, the clear cover shall not be less than 1.5 times diameter of bars. The relevant provisions of IS: 2210 – Criteria for the design of reinforced concrete shell structures and folded plates and IS: 2204 – Code of Practice for construction of reinforced concrete shell roof shall also be deemed to be applicable. All other design criteria for the cooling tower shell which are not specified above shall be in accordance with BS: 4485 Part 4 and BTR.

F. **Provision of meridional ribs in Cooling Tower Shell**

- Meridional ribs in the cooling tower shell may be provided subject to the following conditions:
- Minimum thickness of shell excluding ribs shall not be less than 220 mm.
- Coefficients for pressure distribution around the cooling tower circumference including suction may be taken as per VGB-BTR KUCHLTURMEN SPECIFICATIONS (latest). All other factors including load intensification factors shall be as specified elsewhere in these specifications.
- Shell buckling and strength shall be checked as per clause-9.02.03 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 KUCHLTURMEN GERMAN SPECIFICATIONS (Latest) during detailed engineering stage.

3.02.04 **Raker Columns**

Inclination of the column shall closely match the meridional slope at the shell so that the load transfer to foundation takes place through predominantly axial force in columns. Raker columns shall be designed for the most critical forces transferred to an individual raker column from superstructure considering various load combinations as specified in this document.

For selecting effective length of the raker columns, following restraints shall be considered:

- 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.
- 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 + 1.5 WL which shall be designed as per limit state of strength method of IS: 456.

- The size of pedestals shall be such that it will have minimum 200 mm clear projection from the raker column.

9.02.05 **Crack Width Control**

Under working stress method the maximum crack width of tower shell, lintels, raker columns, cold water basin and fill support structure shall be controlled up to 0.1 mm on basis of formulas as per IS:456-2000 and relevant British codes.

Fill support structures and Drift Eliminators shall be designed as per the load combinations specified in this document. Appropriate Live Loads and imposed loads shall also be considered in addition. The design shall confirm to limit state method as per IS: 456. For fill support structure, the design shall be done considering the weight of fills, falling water, plugging/scaling load and the live load due to the maintenance activities.

3.02.06 **Pre-stressed Concrete Members**

Design, construction and workmanship of pre-stressed concrete, members shall be in accordance with IS: 1343 (Latest revision). Steel wire for pre-stressing shall conform to IS: 1785 (Part 1) (latest edition) or IS: 6003 (latest edition). Crack width control shall be limited to 0.1 mm.

Particular attention shall be paid to achieve an effective bond of the wires in pre-tensioned concrete units. For this purpose, indented wire shall be used. Wires shall be corrosive resistant. Concrete and grout used shall be sulphate resistant.

The bidder shall furnish a write-up for the method to be used for pre-stressed concrete structures.

3.02.07 **Liquid Retaining Structures**

- The cold water basin including sludge pits, cold water channels, shall be designed as per IS: 456 (latest) with crack width control of 0.1 mm for outer face of the wall and inside face of the wall shall be designed as per IS 3370.

The structures shall be designed for the following conditions:

i) Water filled inside up to maximum level and no earth outside.

ii) Earth pressure with surcharge load of 2.5 t/m2, as applicable, and with/without ground water table at 1.0m below finished ground level outside and no water inside.

- The basin and associated structures shall be checked against uplift for basin empty condition. Stability shall be checked during construction stage as well as maintenance stage. The factor of safety shall be as per IS: 3370. Loads during construction, erection and maintenance stage shall also be considered. Temperature fluctuations from operation shall be obtained from the design data. Hot water temperature inside and cold air temperature outside shall be considered

- Minimum thickness of basin slab shall be 300 mm with minimum reinforcement 0.35% of gross sectional area in both the directions. Reinforcement shall be placed in two layers, top and bottom surface. The effect of provision of flap valves/pressure release valves shall not be considered in the design of CW basin. In the space underneath the basin floor slab a layer of at least 100 mm thick PCC of mix 1:3:6 shall be provided.

- All reinforcements used shall be corrosion resistant steel/HCRM.

- The basin floor shall be cast in alternate bays in chequered pattern with sides not exceeding 4.5 meter

- No pressure relieve valve to be used at basin floor.

3.02.08 **Water Distribution System**

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

- Self weight, other imposed loads and live load.

- Hydraulic pressures during normal operations including pressure surges.

- Hydraulic pressure due to mal-operation of the tower or supply pumps.

a) The water distribution system shall be provided with adequate pressure surge relief facilities to prevent pressure loading in excess of values used in the design. If such facilities are not provided, a further increase in loading shall be considered in the design.. The design of water distribution system and its supports shall be capable of accommodating all thermal stresses and movements due to changes in inlet water temperature and ambient temperature. The possibility of vibrations being imposed on the distribution system shall be investigated in the design. Seismic loading on the water distribution system shall also be taken into account.

b) The design shall be carried out based on uncracked section as per IS: 3370 under normal
operating conditions. Strength check for worst loading including malfunctioning shall be carried out with stress limitations as per IS: 3370. The construction shall be completely water tight without the use of fillets, sealing compounds etc. The method of construction shall be such so as to avoid excessive rise in temperature of concrete due to release of heat of hydration.

c) Hot water distribution basin/trough/channel at top shall be covered by removable precast concrete slab to prevent direct exposure from sunlight. Corners of pre-cast concrete slabs shall be protected by angles. Lifting lugs shall also be provided for handling of concrete slabs.

f) Basin channel wall shall be designed for a minimum surcharge load of 25 KN/Sqm. Paving shall be provided all round cold water basin.

3.02.09 **Platforms, Walkways, Stairways, Staircases, Internal Grillage etc.**

These shall be designed as per working stress method IS: 456-2000 and IS: 800. The crack width in all RCC structures shall be limited to 0.1 mm. A minimum live load of 500 kq/sqm shall be considered for the design of all platforms, walkways, staircases etc. in addition to their own weight.

Platforms shall be minimum 1.2 M wide and walkways shall have 1.5 M wide.

3.02.10 **Steel Structures**

All structural steel members shall conform to IS: 2062 (GR-A). These structures shall be designed, fabricated and erected as per IS: 800 and other relevant Indian Standard codes for structural steel work. All steel structures shall be coated with anticorrosive system.

9.02.11 **Slide Gates and Screens**

Slide Gates and Screens, as per IS: 5620 conforming to IS: 2062 Gr. A, shall be designed for worst combination of operating and maintenance condition. All steel components shall be coated with anti-corrosive paint system. However, all guides of slide gates and screens shall be of stainless steel of Grade AISI 316L.

3.03.00 **Foundations**

The bidder has to select suitable type of foundation compatible with the soil strata and calculated settlement of structure and foundation system. The bidder shall have to furnish conceptual design indicating type of foundation, general arrangement drawing for super structure, basin, pipe supports, pits, founding level etc. including settlement criteria complete with a design basis report with the offer.

The design of the cooling tower foundation structures shall be based on IS: 456 as per working stress method for worst load combination as per clause 9.01.06 In case of load combination DL + 1.5 WL, the limit state method as per IS: 456 shall be adopted.

Foundation shall be checked for safety against overturning, sliding and uplift. The minimum factors of safety for overturning, sliding and hydrostatic uplift shall be 1.5, 1.5 and 1.25 respectively.

While checking stability of the structures, neglect favorably acting loads from water fill, soil cover beyond the edge of the foundation. Ground water table shall be considered at 1.0m below Plant Finished Grade Level for design of foundations and all underground structures.

Minimum grade of concrete shall be M25 for foundation resting over 100mm thick PCC (1:3:6) layer. Clear cover shall not be less than 50mm.

Pile foundation if adopted shall be designed in accordance with IS: 2911(Part-I / Sec-I, II and III).

Generally net tension should be avoided in the foundations/piles for the shell support foundation unless specifically permitted by the Owner.

While accounting for over burden of the soil for checking the foundation against up-lift, dead weight of the soil directly above the pile cap or ring raft, as the case may be, shall only be considered, neglecting the weight of soil in the cone of up-lift above the foundation.

The foundation structures will be subjected to following loading and extreme load combination case shall be considered for design. Most critical forces transferred from superstructure for the various load combinations. Uplift forces loading due to foundation settlement Concentrated local loading from column nodes thermally induced local loading where supply culverts pass through the foundation structures without structural isolation. Surcharge of 2.5 t/sq.m. CW basin surcharge load shall also be considered in addition to the other relevant loads for the design.

3.04.00 **Fill Support Structures and Other Structures**

The self-weight of the pack support structures shall be based on the weight of the packing including weight of standing, running and dripping water, other operation and plugging/chocking (debris/scaling) loads, etc. in accordance with manufacturer’s data. In addition, a live load of 100 kg/m2 shall also be considered for the design of supporting structures.

For other structures like walkways, platforms, etc. a live load of 500 kg/sq.m shall be considered. Hand railings shall be designed for horizontal load of 60 kg/m2.

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

Design of RCC members shall be based on IS: 456:2000 with limiting crack width of 0.1 mm.

The cold water basin slab/raft shall form the common foundation for the pack support structures. The foundation shall be designed for the most critical forces transferred from CW basin & fill supporting structures including loads introduced by constructional equipments and crane deployed for fill supporting structure or shell erection.

3.05.00 **Requirements for Concrete and Reinforcement**

All concrete work for the cooling tower shall comply with the requirements given in technical specification for Cement Concrete (Plain & reinforced) Ordinary Portland cement Grade 53 complying with IS:12269 shall be used in concrete works for all structures and foundations. For PCC, paving and plinth protection works, OPC Grade 43 shall be used.

Fine and coarse aggregate to be used in cement shall comply with IS-383.

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

Durability of the concrete shall conform to severe exposure category as per Table 3 of IS: 456 except noted specifically otherwise.

Plain mild steel reinforcing bar shall conform to IS: 432 grade I quality and high yield strength deform bars (TMT) shall conform to IS: 1786 (Fe-500).

All reinforcements used in RCC structure shall be corrosion resistant. Column reinforcing bars shall be carefully anchored in the shell and foundation. The anchoring length shall not be less than 80 times the diameter of the bars.

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

The minimum grade of concrete of structural components of cooling towers shall be as follows in

accordance with IS: 456.

a) Shell and Raker Columns : M-30 grade

b) Pre-cast pre-stressed elements : M-30 grade

c) All other RCC concrete : M-30 grade

d) PCC encasement concrete except piles : M-25 grade

e) Piles (with OPC/PPC/PFC) : M-25 grade

f) Tower foundation : M-25 grade

g) Mud mat/lean concrete PCC : M-10 grade

Coarse and fine aggregates shall be specially selected to ensure that they are not

susceptible to
alkali/chloride attack or prone to disintegration at high temperatures. In particular limestone aggregates shall never be used. The maximum size of coarse aggregate shall not be larger than 1/8th narrowest dimension between reinforcement bars not more than 20 mm.