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SECTION - 1

SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & QUANTITIES

1.1.0 SCOPE

1.1.1 The scope of work under this specification is Civil Works of 220 kV Switchyard at 1x370 MW Yelahanka CCP, Bengaluru by Bharat Heavy Electricals Ltd. The Customer is Karnataka Power Corporation Limited.

1.1.2 The Civil Works shall generally include, *but not limited to*, following:

- (i) Tower Foundations
- (ii) Equipment foundations.
- (iii) Cable trenches including precast covers & cable trench crossings.
- (iv) Drainage including Sump Pits
- (v) Stone spreading including antiweed treatment,
- (vi) Fencing and gates
- (vii) Roads & Culverts
- (viii) Metering room
- (ix) Any other work required for the project.

1.1.3 The works to be performed in the above construction includes preparation of bar bending schedules, based on the drawings released for construction and getting the same approved by the Engineer-in-charge plus the execution of the work including providing of all labour, supervision, materials, scaffolding, power, fuel, construction equipments, tools and plants, supplies, transportation, all incidental items necessary for successful completion of the work including contractor's supervision and in strict accordance with the drawings and specifications and with inspection and testing standards. The nature of work shall generally involve excavation in all type of soil and rock including dewatering, shoring, strutting, and filling under and around structures, backfilling with available excavated earth around completed structures, cable trenches with covers, disposal of surplus soil, formwork, providing necessary steel embedments and other inserts, drainage work, stone spreading (including antiweed treatment), Surface dressing, concreting, brickwork, plastering as per technical specifications and other works in switchyard all complete as per detailed specification, drawings and directions of Engineer-in-charge.

1.2.0 SPECIFIC TECHNICAL REQUIREMENT

1.2.1 The specific technical requirements for the execution of civil works shall be as per Customer Technical Specification/IS. In case of any conflict between Standard Code and Technical Specifications, the provisions of Technical Specification shall prevail.

1.3.0 BILL OF QUANTITIES

1.3.1 The Bill of Quantity shall be as per pages from 1.3 to 1.9

1.3.2 The quantities indicated in the 'Bill of Quantity' are indicative and can vary to any extent. Contractor shall not be entitled for any claim for any such variation in the quantities.

1.3.3 The provision of Bill of Quantity, specifications and drawings shall be read in conjunction with each other and in case of conflict amongst them, the clarification shall be obtained from the Engineer-in-charge whose decision shall be final and binding.

1.3.4 Method of measurement:
Excavation shall be measured in cubic meters. The lateral dimensions to be considered for working out excavation quantity shall be the PCC dimension below the footing as per approved drawing. Nothing extra shall be paid for slope cutting, etc. Backfilling & disposal quantities shall be worked out based on the above dimensions only. However the contractor shall maintain the required slope and working space as per the safety /statutory requirement and its cost is deemed to be included in the quoted rate.

Clause No. 2.1.0 of CPWD Specification Volume-I shall be followed for classification of soils.

For other items, unless otherwise described the method of measurement as described in 'Method of Measurement of Building and Civil Engineering Works'-IS 1200(Part I to XXV) latest edition of BIS shall be followed.

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KARNATAKA POWER CORPORATION LIMITED
700 ± 20% MW GAS FIRED COMBINED CYCLE POWER PLANT
AT BIDADI, RAMANAGARA DISTRICT,
KARNATAKA STATE

INTERNATIONAL COMPETITIVE BIDDING

BID SPECIFICATIONS FOR EPC CONTRACT
SPECIFICATION NO. CEGSW / BIDADI / EPC / 001

VOLUME - IV
TECHNICAL SPECIFICATION (CIVIL)
&
DRAWINGS

KARNATAKA POWER CORPORATION LIMITED
CHIEF ENGINEER (GSW)
2nd FLOOR, 'SUDARSHAN COMPLEX',
NO. 22/23, SHESHADRI ROAD,
BANGALORE – 560 009, INDIA

JULY 2012

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SECTION - D4



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CETD-BIDADI-EPC-001

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GENERAL

SECTION: D 4.1

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1. This specification is to cover the design, preparation of general arrangement, construction as well as Fabrication drawings, supply of all labour as well as materials and construction of all civil, structural as well as architectural work on EPC basis.
2. 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. Lists of various civil works are covered under the scope of work given in Section – D 4.2.
3. The work to be performed under this specification consists of design, engineering as well as providing all labour, materials, consumables, equipment, temporary works, temporary labour and staff colony, constructional plant, fuel supply, transportation and all incidental items not shown or specified but reasonably implied or necessary for the completion and proper functioning of the plant, all in strict accordance with the specifications, including revisions and amendments thereto as may be required during the execution of the work.
4. All materials including cement, reinforcement steel and structural steel shall be arranged by the Bidder.
5. The scope shall include setting up a temporary testing laboratory at site to carry out cube tests on concrete and all other tests shall be carried out at nearby engineering colleges.
6. The work shall be carried out according to the design/drawings approved by the OWNER. For all building and structures, foundations, etc., necessary layout and details are to be developed keeping in view the statutory & functional requirements of the plant and facilities and providing enough space and access for operation, use and maintenance, taking into consideration the future expansion of two blocks of similar size and capacity. Certain minimum requirements are indicated in this specification for guidance purpose only. However, the BIDDER's offer shall cover the complete requirements as per the best prevailing practices and to the complete satisfaction of the OWNER.
7. BIDDER shall inspect the site, examine and obtain all information required and satisfy himself regarding matters and things such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local labour, materials and their rates, local working conditions, weather, subsoil conditions, natural drainage, etc. Ignorance and

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wrong assumptions of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time. The submission of a bid will be construed as evidence that such an extensive examination was made and any later claims / disputes in regard to price quoted shall not be entertained or considered by the OWNER on account of ignorance of prevailing site conditions.

8. **GEOTECHNICAL INVESTIGATION**

Bidders are advised to analyse the report of preliminary geo technical investigation carried out by the owner and are advised to take a few more bore logs, if felt necessary, before submitting the bid.

9. **SURVEY DATA**

The OWNER has carried out a preliminary survey of the area and drawings indicating the survey detail along with contour map shown in drg. no. CEGSW-BIDADI-CM-001. This should be treated as for reference only. However, the BIDDER has to carryout a detailed topographical survey of the area through some reputed / approved agencies, if necessary and the same shall be submitted for OWNER's review. It is the responsibility of the BIDDER to verify the various features on his own.

10. **STATUTORY REQUIREMENT**

Bidder shall comply with all the applicable statutory rules pertaining to Factory act, Fire safety rule of LPA, Water act for Pollution control, Explosives act etc. Provisions of Safety, health and welfare according to Factories act shall also be complied with. Statutory clearances and norms of State Pollution Control Board as well as MOEF guidelines shall be followed. Bidder shall obtain approval of Civil / Architectural drawings from concerned authorities before taking up the construction work.

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SCOPE OF WORK

SECTION: D 4.2

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- 1.0 The works covered in this section consists of collection of all site related data, conducting topographical surveying if necessary, site investigations, design, preparation of all construction drawings, supply of all materials, construction, fabrication, erection and testing where necessary, of all structures required for housing all equipment and civil works for all services required for the Power Plant defined in the specification document. The Civil works shall include those required for Installation, Commissioning, testing, operation and maintenance of the Power Plant. The Scope will cover but not limited to the following buildings / structures / systems / facilities.
- 1.1 Site related investigations, consisting of
- a) Topographical Surveying
 - b) Geotechnical Investigation
- 1.2 Site development works, consisting of
- a) Site clearance
 - b) Site grading (excluding power block area, which has been graded to RL 717.00)
 - c) Roads, drains and culverts
 - d) Storm water and sewage disposal system.
- 1.3 Construction enabling works
- 1.4 Gas / Steam Turbine Generator building
- 1.5 Control room building
- 1.6 Steam generator / Deaerators Supporting structure
- 1.7 Steel chimneys
- 1.8 Steam generator area paving and foundations
- 1.9 Transformer yard structures
- 1.10 Switch yard structures including relay room
- 1.11 Switch gear rooms
- 1.12 Fuel gas system
- 1.13 D.M. Plant
- 1.14 Condenser cooling water system
- 1.15 Induced Draft Cooling towers
- 1.16 Raw water system
- 1.17 Miscellaneous plant buildings, consisting of
- a) Workshop
 - b) Permanent stores / Ware house
 - c) Emergency Diesel generator house
 - d) Compressor house
- 1.18 Non plant buildings, consisting of
- a) Administration building
 - b) Canteen

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- c) Gate house / Time office
- d) Fire station complex
- e) First aid centre
- f) Parking sheds.
- g) Technical and supporting staff Building in plant area.
- h) Guest House with six Suites

- 1.19 Effluent treatment plant
- 1.20 Pipe and cable racks
- 1.21 Horticulture and landscaping

2.0 It is not the intent to specify herein all the works in the scope of this contract. The scope also includes all other buildings, structures and works necessary which are not specifically mentioned here but required for construction, operation and maintenance of the power plant are deemed to be included in the scope. All works shall conform to the specification. The works shall conform to high standards of design, engineering and workmanship. Design and construction shall conform in every respect to all local and state regulations governing such works and to stipulations of Indian Standards unless stipulated otherwise in detailed specification.

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**DOCUMENTS TO BE SUBMITTED ALONG WITH
EPC BID DOCUMENTS**

SECTION: D 4.3

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1. Suggested plot plan locating all buildings, structures, facilities roads, temporary site office, etc and also indicate/earmark the area required for future expansion of two blocks of similar size and capacity.
2. A study note on proposed site grading
3. Write up on proposed storm water drainage system furnishing layout of the drains, types of drains and suggested disposal system.
4. Write up on proposed sewage disposal system for the toilet in various buildings and scheme for usage / disposal of the clear water.
5. Write up on proposed treatment and disposal of effluent / waste water generated in the plant and scheme for usage / disposal of clear water.
6. A detailed write up on Condenser cooling water system along with schematic drawing showing preliminary sizing and details of Cooling towers, channels, forebay and pump house, cold and hot water conduits and the method of construction.
7. A detailed write up on make up water system for the cooling tower blowdown, covering source of water, Intake / withdrawal arrangement, pump houses, conduits along with the method of construction.
8. A detailed write up on Raw water system covering source of water, conveying system, reservoir, over head tank, pump houses etc.
9. A report on foundation proposed for various structures, buildings and facilities. Allowable safe bearing capacity for open foundation, depth of foundation, need for pile foundations, soil improvement if any required, special precaution against aggressive soil etc shall also be covered in the report.
10. A write up on dewatering system proposed at the time of construction where deep construction such as C.W. forebay and pump house etc. are to be executed and where water table is higher.
11. General arrangements / architectural drawings for all buildings and structures showing dimensions, levels, plans, sections, elevations, materials proposed, types of framing, wall / cladding, floors, roofs, types of finishes etc.
12. Detail design criteria proposed to be adopted for each building, structures, foundations, facilities etc.

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**DOCUMENTS TO BE SUBMITTED ALONG WITH
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13. A write up on the sizing and constructional details of steel chimney with sketch showing detail of foundation, wind shield and liners along with list of appurtenances.
14. List of software proposed to be used in various areas for analysis, design, drafting as well as project monitoring along with their sources and validation report for software.
15. List of all Sub-CONTRACTORS that the BIDDER proposed to employ, in case the contract is awarded to him, indicating their addresses with telephone number, experience on similar jobs, name, qualification and experience of persons who shall be employed in the job on behalf of the Sub-CONTRACTOR etc shall be submitted to the OWNER. Only the Sub CONTRACTOR, approved by the OWNER shall be engaged.
16. Details of quality control laboratory with a list of testing equipment shall be furnished.
17. Schedule of unit prices duly filled in with rates.
18. All deviations from bid document shall be furnished in the format given in the specification document. **Deviation** furnished elsewhere in the bid other than at the place titled "**Deviations**" will not be considered as deviations.
19. List of furniture and furnishings proposed for plant control room(s).
20. Any exclusions from the scope mentioned shall be clearly mentioned separately in a section titled "EXCLUSIONS". Only the details mentioned in this section shall be considered as exclusions. All works, other than these, shall be deemed to be included in the scope of this contract and shall be executed at no extra cost.

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DOCUMENTS TO BE SUBMITTED BY THE SUCCESFUL BIDDER AFTER THE AWARD OF CONTRACT

SECTION: D 4.4

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1.0 The following documents are to be submitted for approval of the OWNER, prior to commencement of fabrication & erection / construction. All drawings shall be of standard sizes (Metric system) and shall be made on AUTOCAD latest version. The list is not exhaustive but indicative only:

- (a) Topographical survey drawings along with location and details of Bench mark, grid and boundary pillars based on detailed survey conducted after the award of work.
- (b) Geotechnical investigation report based on geotechnical investigation carried out along with foundation recommendation for various buildings / structures / facilities.
- (c) Site grading (excluding power block area) and storm water drainage study furnishing levels of various terraces, arrangement and details of drains, culverts etc for storm water drainage system.
- (d) Study note on disposal of sewage and other effluent from the plant to satisfy the statutory requirement.
- (e) General plant layout drawing with co-ordinates of roads, boundary wall, watch towers, roads connecting watch towers, buildings and facilities, piping / cable corridors, pipe and cable trestles, landscaping, diversion drains, equipment lay down areas etc.
- (f) Design basis memorandum for all buildings, facilities, services and structures.
- (g) Architectural floor plans, elevations, cross sections and perspective view in colour for all buildings. For main plant building two different schemes along with a report elaborating the underlying philosophy of the proposed architectural concepts shall be submitted.
- (h) Design calculations and drawings for foundations / substructure and superstructure of all buildings including pump houses and other structures.
- (i) Design calculations including dynamic analysis and drawings for all foundations subjected to dynamic loads like foundations for GTG, STG, BFP, etc.
- (j) Design calculations and drawings for structures and foundations in switchyard, transformer yard, etc.
- (k) Design calculations and drawings for structures pertaining to Cooling water system.
- (l) Design calculations and drawings for structures for raw water / make up water system such as, but not limited to, intake, raw water reservoir, pump house, over head tank, etc.

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- (m) Design calculations and drawings for civil structures / works associated with fuel gas system.
- (n) Drawings of all architectural works including finish schedule, colour scheme (both internal and external), doors and windows, flooring and false ceiling, etc.
- (o) All design and drawings for the Cooling towers.
- (p) All design and drawings for steel chimney.
- (q) Drawing showing underground facilities with co-ordinates of these facilities like buried pipes, buried cables, trenches, ducts, sewer, drains, sumps, pits, culverts, foundations etc.
- (r) All other designs, details / drawings or any other submissions as indicated else where in this specification and as required by the OWNER.
- (s) Details of corrosion protection measures for all structures.
- (t) Copies of all reports on investigation and studies carried out shall be submitted.
- (u) Total quantity of concrete (grade wise), reinforcement steel (diameter wise) and structural steel (section wise) in all construction drawings.

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DESCRIPTION OF BUILDING, STRUCTURES AND FACILITIES

SECTION: D 4.5

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1.0 The description against each service / building / system is indicative only and not exhaustive. Although almost all the systems are covered here but any other system (Civil, Structural and Architectural) required for successful completion of the project shall form a part of this contract and shall be deemed to be included in the scope of works.

2.0 **SITE RELATED INVESTIGATION**

2.1 **Topographical surveying**

The work of conducting topographical survey has already been conducted. Temporary BM (RL +724.794 & RL +717.794) is available in the plant boundary. Bidder to confirm the values with respect to the GTS benchmark value. The BIDDER has to carry out a detailed topographical survey of the area through some reputed / approved agencies, if necessary and the same shall be submitted for OWNER's review.

2.1.1 Precision Surveying shall be carried out under the direction and control of a Licensed Land Surveyor. Surveying shall be carried out using Total Station. All Bench Mark (BM) levels of the survey shall be established with reference to the nearest GTS bench mark available. Precision levelling shall be carried out for establishing the BM at site by carrying levels from GTS BM adopting double circuit levelling.

2.1.2 All boundary lines shall be located with their distances, included angle and bearings. A closed traverse survey shall be carried out to form the framework for the detailed survey work.

2.1.3 Two reference line, North-South line and East-West line at right angles to each other shall be established with grid pillars constructed at 200 metres c/c in both directions. Bench mark pillars shall be provided at least at 6 locations. Pillars shall also be painted using synthetic enamel paint for easy identification. Coordinates shall be painted on these grid pillars. These pillars shall be properly protected to prevent disturbance during construction activities. BM shall be distinguished from grid pillars with different type of painting.

2.1.4 Spot levels shall be taken in a grid of 50 meters and contours shall be established at an interval of 500 mm. All Contour levels shall be with respect to MSL.

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2.1.5 The survey map should identify all topographical features such as but not limited to buildings, structures, burial grounds, wells, natural drains, roads, footpaths, depressions, rock out crops, underground sources, overhead transmissions lines, telephone lines or any other obstruction, trees and prominent vegetation. In addition, all wet land and marshy stretches shall also be identified. The contour map to a scale of 1 in 1000 in AutoCAD shall be prepared. In addition, LS and CS of the site at suitable intervals to adequately represent actual topography shall be prepared. For natural drains and other water courses sections at closer intervals shall be provided.

2.1.6 One soft copy in the form of CD along with six copies of all survey drawings shall be submitted to the Owner for his reference.

2.2 Geotechnical investigations

Detailed geotechnical investigation shall be carried out by the Bidder on award of work. Based on the plot plan developed, the field and laboratory testing scheme shall be prepared and obtain the approval of Owner prior to commencing the investigation. In the power block boreholes shall be provided and spread judiciously to cover all major structures as well as equipment foundations. Generally, a grid of 50m centre to centre bothways is recommended from stack to end of switchyard. In the other areas it shall be ensured that the boreholes are provided near all major structures.

2.2.1 Following field tests shall be conducted:

- i) Bore Holes and standard penetration tests.
- ii) Static Plate load tests
- iii) Cyclic Plate load test
- iv) Permeability tests
- v) Density and moisture content tests
- vi) Vane Shear tests
- vii) Static Cone and dynamic cone Penetration tests
- viii) Soil resistivity tests.
- ix) Pressure meter tests
- x) Block Vibration tests

2.2.2 Bore holes shall be located wherever it is felt necessary and at the locations of all important structures. All bore holes shall be sunk up to a depth of 20.0 m or 5 m continuous into hard rock whichever is earlier.

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- 2.2.3 Standard penetration tests (SPT) and collection of undisturbed soil samples (UDS) shall be carried out alternatively at 1.0 m intervals and at significant change of strata. The interval shall be increased to 1.5 m below 5 m depth of boring. UDS shall be replaced by SPT in cohesionless strata. Even in highly weathered / disintegrated rock, where core recovery is poor, SPT shall be conducted. The first SPT in any borehole shall be conducted at 1m depth.
- 2.2.4 In rock strata, core recovery and Rock Quality Designation (RQD) shall be noted carefully for each run, immediately after cores are taken out of barrel.
- 2.2.5 During boring, the level at which ground water is struck shall be carefully noted. Ground water samples shall be collected for chemical analysis. Water samples shall be collected before the addition of water or drilling mud to the hole.
- 2.2.6 Following laboratory tests shall be conducted: (Preferably on Undisturbed soil samples and if UDS is not possible, on remoulded soil samples.)
- (a) Grain size analysis
 - (i) Hydrometer analysis
 - (ii) Sieve analysis
 - (b) Specific Gravity
 - (c) Chemical Analysis of soil and ground water including Sulphates, Chlorides, pH value, etc.
 - (d) Chemical Analysis of 2:1, Water : Soil extract of the samples giving SO_3 content.
 - (e) Consistency Limit: Liquid Limit, Plastic Limit, Plasticity Index, Shrinkage Limit and Shrinkage ratio.
 - (f) Consolidation test giving all relevant parameters.
 - (g) Swelling pressure and free swell index for expansive soils.
 - (h) Unconfined Compressive Strength on soil samples
 - (i) Direct Shear Test
 - (j) Triaxial Compressive Strength Tests:

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- (i) Unconsolidated Undrained Test
- (ii) Consolidated Undrained Test
- (iii) Consolidated Drained Test

(k) Moisture-density relations for Standard Proctor and Modified Proctor tests.

(l) Crushing Strength, specific gravity, unit weight, water absorption test on Nx size rock specimens.

(m) Permeability test

2.2.7 The Geotechnical investigation report shall necessarily include, but not be limited to the following information.

- (a) Recommended types of foundation.
- (b) Allowable safe bearing capacities and settlement values in different strata for shallow foundations indicating relevant design criteria adopted, method of analysis adopted etc.
- (c) If pile foundations are necessary, type of piles recommended with reasons for the same, length, diameter, allowable capacity (vertical, lateral and pullout) of individual and groups of piles, negative skin friction if any and magnitude of estimated negative skin friction.
- (d) Recommendations for values for modulus of subgrade reaction for foundation design.
- (e) Type of cement to be used for concrete substructures and in stone / brick masonry foundations with reference to the chemical nature of subsoil and ground water.
- (f) Recommendations regarding excavations (shallow & deep), embankment, safe side slopes for excavation and embankment, dewatering, site drainage, etc.
- (g) Recommended soil properties such as density, specific gravity, cohesion, angle of internal friction etc. for design.
- (h) Precautions to be taken for design of lightly loaded structures when expansive soil is encountered with respect to swelling pressure and free swell index values obtained.

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DESCRIPTION OF BUILDING, STRUCTURES AND FACILITIES

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3.0 **SITE DEVELOPMENT WORK**

3.1 **Site Clearance**

3.1.1 The plant and building areas in the site shall be cleared of all trees, shrubs or other vegetation, rubbish, slush etc., and other objectionable matters. It is Bidder's responsibility to undertake a site visit and accordingly make a note of the existing structures that are needed to be dismantled. If any roots or stumps of trees are met during excavation, they shall also be removed. Where earth fill is intended, the area shall be stripped of all loose / soft patches or top soil containing objectionable matter before filling commences. Any structure or services existing at the site shall be removed / rerouted with the permission of the Owner. Existing wells, pits, marshy areas etc shall be filled up with earth of approved quality. The existing irrigation tank inside the plant boundary shall be retained. The HFL of the irrigation tank is 710.85 m. The water spread area at the full level of the tank has to be maintained to suit with site requirement.

3.1.2 The Bidder shall be deemed to have visited and carefully examined the site and surroundings and to have satisfied himself about the nature of the existing structures, underground services, general site conditions, the site for disposal of surplus materials, debris etc and all other items affecting the work. Claims due to ignorance of site conditions will not be considered after submission of Bid.

3.2 **Site Grading**

3.2.1 The site grading level shall be based on the detailed topographical survey conducted at site.

3.2.2 In order to optimise the use of locally available earth, terraced grading may be considered. Bidder to note that non-swelling selected earth can be used for back-filling. Fills shall normally be made up of CNS material capable of being compacted up to 97% Modified Proctor density. In case earth has to be borrowed from outside the plant boundary, the same shall be arranged by the Bidder himself. Earth from Swamps, marshy as well as bogs, expansive type of clays, peat, organic material, material susceptible for combustion, material which will react with other material already used in work shall not be used as borrow material. A minimum side slope of 1 vertical: 2 horizontal shall be maintained at all slopes.

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3.2.3 Slopes shall be provided with proper protection in the form of stone pitching to prevent erosion.

3.3 **Compound wall**

Boundary wall is existing and only gates, as described in clause 3.5, shall be provided. However necessary modifications, if any, in the boundary wall for providing and fixing the gate shall be included in the scope.

3.4 **Fencing**

Minimum 3 m high fencing above the toe wall shall be provided around switch yard, transformer yard, auxiliary transformer yard, stores etc wherever fencing is necessary due to security / safety / statutory requirements. Fencing shall comprise of 2.4 m high PVC coated galvanised chain link fence of minimum 8 gauge (including PVC coating) with mesh size 75 mm and galvanised barbed wire on inclined member to a height of 600 mm above the chain link fencing. 3 Lines of 12-gauge high tensile spring steel wire shall be provided for the entire length of fencing. Also 50 mm X 6 mm galvanised MS flats shall be provided at every fifth post sandwiching the fencing with post using GI nuts and bolts. Top of toe wall shall be 200 mm above formation level. Toe wall shall be generally of RCC construction and shall extend 150 mm below the formation level and the fencing mesh shall be embedded inside toe wall by minimum 75 mm. Fencing post shall be fabricated out of galvanised MS angle section of minimum 75x75x6 mm size and shall be spaced at a maximum spacing of 2.5 m with struts made up of galvanised MS angle at every fifth fencing post in addition to those at bends. Expansion joint shall be provided at every 60 m. Steel entry gates shall be provided for all fenced areas. Gates shall be formed out of tubular section conforming to IS: 1161. Removable type of fencing shall be provided at suitable location to permit entry and exit of equipment.

3.5 **Security Gate Complex**

3.5.1 The complete security gate complex consisting of approach road, gates, guard house, wicket gate, Time and security office, speed breakers, traffic barriers and parking / waiting space etc shall be carefully planned such that they function smoothly especially at the time of change of shift. The whole complex shall be aesthetically pleasing merging with the architecture of the compound wall.

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- 3.5.2 Speed breakers shall be provided both outside and inside the compound with manually operated traffic barriers inside.
- 3.5.3 Adequate paved area shall be provided both inside and outside for parking of waiting vehicles. There shall be two main gates 7500 mm wide each with two leaves and a guard house in between. A minimum of 4 wicket gates shall be provided on one side to allow entry and exit of pedestrian and cyclists. The gate posts and guard house shall be of RCC construction. The gate frame shall be made of structural steel tubular / rolled section with plate / mesh for the body. For smooth operation of gates, rollers shall be provided which moves on rails embedded in the road paving. The design of the gates shall be aesthetically pleasing.
- 3.6 **Watch towers**
- Watch towers shall be constructed with RCC framework and brick in fill wall. Floor of the tower shall be at least 6 m above graded level. Covered area for each tower shall be approximately 25 sq.m. Number of towers shall be such that the complete periphery of the plant can be watched from these towers but in no case the number of towers shall be less than Six (6).
- 3.7 **Roads, Drains and Culverts:**
- 3.7.1 All roads and vehicular parking areas shall be of rigid pavement type of concrete construction.
- 3.7.2. The main access road to the plant shall be four laned with a refuge of about 3 m wide in between double lane 'up' and 'down' roads. The road shall be designed to cater to the load and needs of construction and maintenance of heavy trucks carrying machinery and heavy cranes. All other roads providing access to buildings / structures / systems requiring maintenance by vehicles shall be 7 m wide. All other minor roads shall be 4 m wide. 1500 mm wide road shoulder shall be provided on either side of all two lane roads and 750mm wide shoulder on either side of 4.0m wide road. Shoulders shall be provided with cobble stones or with interlocking concrete paving blocks of approved shape/design and colour. Bidder to design as per standard and good engineering practice, which is to be highlighted in Bidder's proposal.
- 3.7.3 On either side of the roads open drains shall be provided. Minimum clear width of the drain shall be 600 mm. The drains shall be designed and constructed using RCC. Drainage lines and other under ground services shall be located at least 1 m clear from the

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edge of the road shoulder. All service and utility lines crossing the roads shall be taken up through NP3 class RCC pipe designed for impact loading. Culverts shall also be generally using NP3 class pipe. In case the diameter of the pipe required is more than 600 mm, cast in situ RCC box culvert shall be provided.

3.8 **Storm Water Drainage:**

3.8.1 The drainage system shall be designed for a maximum hourly rainfall of 75mm. Run off coefficient for paved and unpaved areas shall be taken as 0.9 and 0.6 respectively. Exact terminal point location at plant boundary shall be finalised during detailed engineering.

3.8.2 Storm water drainage system shall be designed in two parts.
(a) Main drains
(b) Auxiliary drains

Main drains shall be designed as a network covering total plant area and shall ultimately be led to nearest water body. Auxiliary / branch drains shall cover individual graded terraces to collect discharge from plant buildings and shall connect to main drain at suitable locations.

3.8.3 Drainage for plant effluent and storm water shall be carried by gravity. The drains shall generally be of open type and constructed with RCC. RCC box culverts shall carry drainage under roads.

3.8.4 At places where covered drainage system is required, channels with removable cover shall be preferred to piping system, as piped system tend to get blocked. Underground storm water piping shall be restricted strictly to areas where surface drains are not desirable or practicable from functional point of view.

3.8.5 Drainage shall be provided where necessary to prevent ponding and ground erosion and to carry surface water away from building, structures and other works including roads, building or equipment foundations.

3.8.6 The storm water drainage for the contaminated area such as fuel oil areas and oil skids etc. shall be designed separately and the discharge shall be led separately for treatment and disposal through oil water separator.

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3.9 **Sewage / Waste Water Drainage**

3.9.1 For plant area sanitary sewage disposal, common septic tanks shall be provided at suitable locations for all buildings. The over flow from the septic tank shall be led to dispersion trenches or soak pits.

3.9.2 Waste water generated from the plant and canteen waste water shall be treated in a full scale effluent treatment system. The treated effluent shall be used for watering the trees and maintenance of green belt area. Provision shall also be made for collection and disposal of solid waste. HDPE or DI pipes shall be used to carry sewage / waste water. The pipes shall be encased in concrete at road crossings. Manholes shall be at junctions and change of direction. In straight stretches manhole shall be provided at a maximum spacing of 30 m.

4.0 **CONSTRUCTION ENABLING WORKS**

4.1 **Construction water:**

Construction water to the extent available at site on as-is basis towards both quality and quantity may be used by the Bidder free of cost, for which Owner is not responsible. Suitability of use of this water has to be examined by the Bidder. Moreover, Bidder has to consider his own arrangement at his own cost for any additional requirement of construction water. Bidder has to make his own arrangement for necessary pumps, pipelines, ground water tanks, pipe network for conveying water to construction site. The water available from the local pond can also be considered if available.

4.2 **Construction power**

Temporary power supplies required for the performance of the Work and other obligations under the Contract (the "Construction Power") shall, to the extent of 2 MVA will be arranged, by the Owner at one suitable location. Such Construction Power shall be in accordance with applicable safety and code requirements. Construction power will be provided Free of cost. Further extension of power line to the various locations required shall be arranged by CONTRACTOR at his cost. Bidder shall make his own arrangement for D.G sets as standby power source. This is especially in the case of structure involving deep dewatering as well as where uninterrupted concreting has to be resorted to. The bidder along with his bid shall indicate his average and peak power demand.

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4.3 **Temporary site buildings**

The Bidder shall provide, at his cost, the following building facilities for proper execution and quality control of the job, while meeting the provision stipulated by Factory Rules regarding staff welfare facilities. All these building shall have brick cladding, CGI sheet roofing over steel roof truss with cement concrete flooring and false ceiling with air conditioning as required.

4.3.1 **Site office**

The site office shall make a provision of about 300 sqm of office area with A/C and false ceiling for the use of Owner / Owner's representative in addition to the CONTRACTOR's requirement. Additionally an A/C Conference room to accommodate about 25 people shall also be provided in the site office complex for the Owner's use. In addition to these, basic facilities like toilet for gents and ladies, potable water tanks, soak pit and septic tank for sewage disposal shall also be provided.

4.3.2 **Stores**

A covered store shall be provided with brick cladding and G.I./ colour coated sheeting to store at least one month requirement of cement. Cement in bags shall be stored on a raised floor well away from outer walls and insulated from the floor to avoid moisture. Not more than 15 bags shall be stacked in any tier. Each consignment of cement shall be stored separately and consumed in its order of receipt. The temporary stores building shall be dismantled after all the construction activities are completed and the area shall be cleared.

4.3.3 Covered storage area may also be provided to store other construction material which will be affected on exposure to wind, sun and rain.

4.3.4 Reinforcement shall be stacked on top of timber sleepers to avoid contact with ground / water.

4.3.5 Paved or unpaved storage yard shall be provided with in the stores complex for storage of other material.

4.3.6 Proper fencing and security arrangement shall be provided for the stores complex.

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4.4 **Temporary workshop and garage**

The temporary workshop and garage shall be provided to attend to routine maintenance and repair of the construction equipment as well as the fleet of vehicles used for construction activities.

4.5 **Fabrication yard**

Depending on the extent of fabrication envisaged at site, the Bidder shall establish a full fledged structural fabrication yard with adequate handling facility during and after the fabrication. A fully equipped testing laboratory providing radiography, ultrasonic, dye penetration, magnetic particle test facilities shall be ensured adjacent to the fabrication yard to enforce strict quality control. Portion of the yard shall have covered shed with HOT / EOT cranes so that fabrication work can proceed even during inclement weather.

4.6 **Quality Control Laboratory**

Quality control laboratory as required shall be established at site with qualified personnel to conduct acceptance test on all construction material, weldments, concrete cubes etc. This laboratory shall be housed in a covered building with A/C facility as required by the testing facility. All testing equipment shall be procured and shall be periodically calibrated to the satisfaction of the OWNER. All the sampling & testing shall be done in the presence of OWNER's representative & the contractor shall abide by the observations of owners representative & rectification as suggested shall be effected. The owner shall have the right to carry out such tests independently, as & when so desired by the owner.

4.7 **Staff welfare facility**

4.7.1 Adequate facility for his staff inside the plant boundary such as Toilets for both gents and ladies, Canteen, drinking water facility, rest places, proper disposal of sewage and other waste water as per the requirement of pollution board, etc, shall be provided.

4.7.2 Sufficient area out side the plant boundary to locate his staff and labour colony shall be provided. Construction and maintenance of the staff and labour colony to satisfy all statutory requirement is the sole responsibility of the CONTRACTOR.

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removable type to facilitate transport of transformer. Floors shall be paved with plain cement concrete and shall be sloped towards peripheral drains, which shall lead to a sump from which the drainage is led through an oil water separator. The clear water shall be led to plant drainage.

11.0 **SWITCHYARD**

Extent of the Switchyard will depend on the layout of the switchyard which has been outlined in the Electrical section of this document.

11.1 **Galvanised Steel Structure**

The steel structure for the Switch yard shall be hot dip galvanised structure with welded / bolted connections at shop and bolted connection at site. All bolts and nuts shall also be galvanised.

11.2 Major steel structures are towers, beams, lighting masts etc. They are all of latticed construction. In addition supporting structure for equipment, such as isolator, lightning arrestors, etc shall also be provided. These structures may be of tubular section or latticed as the case may be. Towers, beams etc shall be trial assembled at shop, keeping in view the actual site condition, prior to dispatch to erection at site so that they can be conveniently pre-assembled before erection or conveniently assembled during erection. Lighting masts shall be provided with cage ladder. Where platforms are provided on lighting masts for mounting of lighting fixtures, they shall have protection hand rails formed of galvanised section. Platforms shall be of galvanised gratings.

11.3 **Trenches / paving / fencing**

11.3.1 Trenches shall all be of RCC construction. Trench walls shall be designed to withstand a surcharge load of 1500 kg / sq.m.

11.3.2 Fencing around switch yard area shall comprise of PVC coated chain link fencing.

11.3.3 The complete area within the fencing for switch yard/transformer yard shall be provided with a mild slope towards peripheral RCC drains which in turn will be connected to the plant drainage system.

11.4 **Switchyard Relay Room**

11.4.1 Side cladding shall be of brick work and the main door to the switchgear room shall be steel sliding door having adequate area to

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1.0 **GENERAL**

1.1 Design and construction of buildings, structures etc., shall take into account requirements for operation and maintenance of all equipment and its users. The buildings shall have good architectural features. The surrounding area shall be properly micro levelled and graded.

1.2 **Architectural Concepts For Buildings**

The architectural design concept of buildings, structure shall be evolved considering the functional, technological and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes.

1.3 The Bidder shall obtain and be conversant with all laws, by-laws, regulations of local and Statutory Bodies as applicable to the project. The architectural concept evolved should also take care of these requirements. The Bidder shall provide drawings and documents for such statutory approvals. It is entirely Bidder's responsibility to obtain statutory approval (if any) on architectural drawings/documents designed by him. Hence, all related fees pertaining to the same shall be Bidder's responsibility.

2.0 **ROOF ACCESS**

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

3.0 **PLATFORMS AND WALKWAYS**

3.1 Platforms shall be provided to all major equipment, which are not directly accessible from the floors, for maintenance. Platforms and connecting walkways shall have a minimum width of 750 mm. Platforms in front of the entry shall be atleast 900 mm wide. Platforms located close to each other shall be connected with walkways.

3.2 All steel platforms above grade level shall be constructed with kick plates at edge of the platform to prevent tools or materials from falling off. It shall consist of 8 mm thick steel plate projecting 100

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mm above the platform surface. Kick plate shall be painted with the same type of coating as the material to which it is attached.

- 3.3 Continuous walkway of at least 500 mm wide shall be provided along the crane girder level with hand rails on both side of the building. Approach to EOT crane shall be ensured by Cage ladder or staircase.

4.0 **STAIRS AND LADDERS**

4.1 **Steel stairs**

All steel staircases shall normally have minimum clear width (back to back of stringer) of 1000 mm and maximum inclination with horizontal of 35.75° . However, in case of space restriction, minimum clear width upto 750 mm and slope upto 45° may be provided. The vertical height between successive landings shall not exceed 5m. Channels (min MC 200) shall be provided as stair stringers. Treads shall be minimum 250 mm wide of hot-dip galvanized grating, with suitable anti-skid nosing, and spaced equally so as to restrict the rise to maximum 180 mm.

4.2 **Steel ladders**

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

4.3 **RCC stairs**

All stairs shall have maximum riser of 150 mm and a minimum tread of 300 mm. Minimum width of stairs shall be 1500 mm generally. All stairs normally shall have not more than 15 risers in one flight. The treads & raisers shall be provided with 20 mm thick polished granite slabs of approved quality & colour with necessary nosing's and as approved by the owner.

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5.0 **HANDRAILS**

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

5.2 All handrails shall be of 32 mm nominal bore MS pipes (medium class) as per IS:1161 galvanised using 750 gms / sqm of zinc. Hand railing for platforms, walkways and projections shall be a two-rail system with the top rail 1000 mm above the walkways surface and the intermediate rail 450 mm below the top rail. Handrail post spacing shall be limited to 1500 mm as far as possible but can be proportioned to the length of the protected horizontal opening. In such a case spacing shall not exceed 1850mm centre to centre of posts. Handrails shall be shop fabricated for specific locations and field welded or bolted to the erected structural steel. For platforms at elevation more than 30m, three rail systems with top rail at 1500mm shall be adopted. .

5.3 For RCC stairs, hand railing with 20 mm square MS bar balustrade for every step with suitable MS flat and Aluminium / Teakwood handrail shall be provided, unless specifically mentioned otherwise.

6.0 **EDGE PROTECTION**

Wherever possible around floor openings an RCC kerb of 100 mm wide 150 mm high shall be provided. All concrete edges, where breakage of concrete corner is expected shall be provided with angles of minimum size L 50x50x6 mm with lugs for edge protection e.g. all-round the cut-outs / openings in floor slab, edges of drains supporting grating covers, edges of RCC cable / pipe trench supporting covers, edges of manhole supporting covers and supporting edges of precast covers etc.

7.0 **ANCHOR BOLTS AND INSERT PLATES**

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

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

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8.0 **VERTICAL HEAD SPACES**

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

Finished floors to ceiling (buildings)	3600 mm
Doors, Walkways, Platforms, Stairs etc	2100 mm
False ceiling of office areas	3000 mm
Walkway above false ceiling	1000 mm
Safety cage for ladders	2500 mm
Access for forklift trucks	2800 mm
Main roads / Railway crossings & crane access	7000 mm
Other plant roads and truck access	7000 mm
Cable & Pipe rack	3000 mm except at road / rail crossings.

9.0 **EXPANSION /CONSTRUCTION JOINTS**

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

9.2 Two part polysulphide sealant conforming to IS: 12118 shall be used for sealing of all joints. Preformed bitumen impregnated fibre board conforming to IS: 1838 shall be used as joint filler.

10.0 **BRICK MASONRY AND PARAPET WALL**

10.1 All masonry works shall be designed in accordance with IS: 1905, IS: 2212, IS: 4326, IS: 2185 and other relevant IS codes as applicable. Structural design of load bearing and non-load bearing walls shall be in accordance with criteria specified by Section 4 of National Building Code of India Part VI.

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- 10.2 All walls shall be non-load bearing in filled panels walls. External walls of all buildings shall be at least one brick thick. All internal walls shall be at least one brick thick except for internal partition walls for office area, canteen, change rooms, first aid rooms and toilets which may be half brick thick. RCC bands (transoms and mullions) shall be provided for all half brick walls and wherever necessary to curtail the unsupported length/width of the wall.
- 10.3 50mm thick DPC (1:1.5:3) with water proofing admixture shall be provided at plinth level before starting masonry work.
- 10.4 Bricks having minimum 50 kg / sqcm compressive strength shall be used for non load bearing super structure brick work. Cement sand mortar 1:6 for one brick thick wall and 1:4 for half brick thick wall shall be used. For half brick walls, RCC transoms and mullions shall be provided. Transoms shall be provided at lintel/door height. The spacing of the mullions shall not exceed 2000 mm centre to centre. The size of transoms/mullions shall be minimum 115 mm square with 4nos, 8 mm dia. bars and 6mm stirrups at 150 mm centres.
- 10.5 Type, thickness and height of external walling, facing the transformer yard to take care of fire accidents in transformer yard shall be according to the requirements of LPA.
- 10.6 Even where metal cladding is specified for initial 3m height from the ground level, minimum one brick thick masonry wall shall be provided.
- 10.7 All up stands and parapet walls on roof shall be of RCC constructions, minimum height of parapet walls shall be 750 mm and thickness 125 mm.
- 11.0 **DRAINAGE**
- 11.1 **Floor drainage**
- 11.1.1 For all buildings and areas, suitable arrangement for draining out water collected from equipment blow downs, leakage, floor washing, fire fighting, etc., shall be provided on each floor. Gully traps, inspection pits, collecting pits etc., shall be located suitably and designed considering flow volume, easy access, maintenance and safety.
- 11.1.2 All drains inside the building shall have minimum 40 mm thick galvanised grating covers. In areas where heavy equipment loads

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would be coming, pre-cast RCC covers shall be provided in place of grating. These drains shall lead the water to drain sump.

- 11.1.3 Garland drains shall be provided around all buildings to receive the drainage water from roof and floor and lead them to the plant storm water drainage system.

11.2 **Roof drainage**

- 11.2.1 Roof drainage system shall be provided for quick and efficient draining of rain water from roof to avoid seepage and damage to roof. The gradient for the roof shall not be less than 1 in 100. Roof drainage system shall consist of roof drain heads, rain water down comers and fixtures. System shall be designed to handle design rain fall for the specific site and shall be in accordance to stipulations of IS: 1742 and IS: 2527. Roof drains shall conduct water to storm drains through down comers.

- 11.2.2 Rain water down take pipes shall be of UPVC pipe of Class-3 conforming to IS:4985.

11.3 **Sumps**

In case of underground structures, sumps with pumping arrangement shall be provided at suitable location to collect and pump out any incidental water collection to nearest storm water drain.

12.0 **WATER PROOFING OF UNDERGROUND STRUCTURES**

- 12.1 All underground structures like basements, pump houses, water retaining structures etc., shall have plasticiser cum waterproofing cement additives conforming to IS: 9103. In addition, limits on permeability as given in IS: 6494 shall also be met with. The concrete surface of these structures in contact with soil shall be provided with minimum three coats of bituminous painting of grade 85/25 conforming to IS: 702 @ 1.7 kg/sqm (minimum) for water / damp proofing. Also provision shall be made on the inner surface of walls and base slab, so that water proof grout can be injected later in case of leakage.

13.0 **ANTI TERMITE TREATMENT**

Pre-constructional anti termite treatment shall be given to all vulnerable areas susceptible to termite attack and shall include

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column pits, wall trenches, foundations, filling below the floors etc, as per IS 6313 and other relevant Indian standards.

14.0 **PLINTH LEVEL**

14.1 Finished ground floor level (plinth level) of all buildings and pump houses shall be minimum 300 mm above the formation level / grade level.

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

14.3 Finished floor levels of HRSG area / transformer area yard paving shall be kept 150 mm lower than the finished floor level of the turbine building.

15.0 **STATUTORY REQUIREMENTS**

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

15.2 Adequate no. of fire escapes shall be provided in all buildings. Fire proof doors, no. of staircase, fire separation walls, lath plastering on structural steel member (in fire prone areas) shall be made according to the recommendations of LPA. For fire safety requirements of buildings IS: 1641 and IS: 1642 shall be followed in addition to LPA requirements. All masonry or RC fire walls shall satisfy the requirement of LPA.

15.3 Provisions of safety, health and welfare according to Factories act shall be complied with design stage. These shall include provision of continuous walkway (minimum 500mm wide) along crane-girder at the crane girder level on both sides of the building, comfortable approach to EOT crane cabin, railings, fire escape and locker room for workmen, pantry, toilets, rest room etc.

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1.0 **GENERAL**

All structures shall be designed for the most critical combinations of dead loads, imposed loads, equipment loads, crane loads, steam piping (static & dynamic) and other piping loads, wind loads, seismic loads, temperature loads, loads and forces developed due to differential settlement and any other loading conditions which can occur during the design life of the facility.

2.0 **DEAD LOADS**

2.1 Dead loads consist of the weights of the structure complete with finishes, fixtures, partitions, wall panels and all equipment of semi-permanent nature including tanks, partitions, roofing, piping, cable trays, bus ducts etc. The content of tanks, containers etc., shall be measured at full capacity for this purpose.

2.2 The piping loads, cable tray loads and the contents of the tank shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilising load for uplift.

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

Materials	:	Unit weight
Plain cement concrete	:	2.40 t/cum
Reinforced cement concrete	:	2.50 t/cum
Structural steel	:	7.85 t/cum
Brick work	:	1.9 t/cum
Cement plaster	:	2.1 t/cum
Roof Treatment (7 course bituminous):	:	0.03 t/cum
Roof Treatment (9 course bituminous):	:	0.04 t/cum
Floor Finish	:	2.4 t/cum

3.0 **IMPOSED LOADS**

3.1 Imposed loads in different areas shall include live loads, dust loads, minor equipment loads, cable trays, small pipe racks / hanger, erection loads, operation / maintenance loads, etc. The loads considered shall not be less than that specified in IS: 875 (part II). The loads listed here under are the minimum loads for the areas involved. Special use areas shall be investigated and loads shall be revised upward as necessary. Floors and supporting members which may be

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subjected to heavy equipment live loads shall be designed on the basis of the weight of equipment or specifically defined live loads, whichever is greater.

3.2 The specific minimum floor live loads are listed below:

3.2.1 **Roofs :**

a) Flat Roof : 1.5 kN/sqm for accessible roofs
: 0.75 kN/sqm for non-accessible roofs
: 5.0 kN/sqm for accessible roofs with HVAC Equipment etc.

b) Sloped Roof : As per IS: 875

3.2.2 **Steam Turbine and Gas Turbine Building:**

- (a) Ground floor : General area 25 kN/sqm
: Heavy eqpt. Storage area 50 kN/sqm
(b) Operating Floor : Rotor removal Area 30 kN/sqm
: Eqpt. Laydown Area 30 kN/sqm
: Other areas (Corridors etc.) 15 kN/sqm
: Rotor removal area beams shall also be checked for $\frac{1}{2}$ the rotor load at the centre of the beam.
(e) Precast concrete covers : 12 kN/sqm
(f) Mezzanine floors : 10 kN/sqm

3.3 **HRSG area**

- (a) Floor at 0.00 : 15 kN/sqm (under operation) or actual loads specified by HRSG manufacturer.

3.4 **Control buildings** :

- (a) Control Room Floor : 10 kN/sqm
(b) MCC Room : 15 kN/sqm

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- (c) Cable vault floor : 5 kN/sqm
- (d) Battery Rooms : 20 kN/sqm
- (e) AHU, AC & ventilation : 10 kN/sqm
plant floors
- (f) Switchgear room, : 15 kN/sqm
PLCC, relay room

3.5 Pump houses

- (a) Operating floor slab : 15 kN/sqm or as required by
equipment supplier whichever higher.

3.6 Deaerator building

- (a) Deaerator floor : 10 kN/sqm
- (b) Floor around feed water : 20 kN/sqm
tank

3.7 Workshop : 10 kN/sqm :

3.8 Other Areas

- (a) RCC floors : 5 kN/sqm for offices, laboratories,
conference rooms and general floors.
- (b) Stairs and balconies : 5 kN/sqm
- (c) Chequered plate/
gratings : 5 kN/sqm
- (d) Walkways : 3 kN/sqm
- (e) Toilet rooms : 2 kN/sqm

3.9 Culverts and allied structures including RCC pipes shall be designed for Class "AA" loading and checked for Class "A" loading as per IRC standards for two lane road and above.

3.10 Covers for trenches & channels which are not exposed to vehicular traffic shall be designed for Live load of adjoining area or 2 t /sqm whichever is higher. Where channels are likely to be exposed to vehicular traffic, the requirements of Code of practice for road bridges shall be adhered to.

3.11 Piping anchor and restraint forces of major piping shall be obtained from piping analysis results can be considered as live load in the structure design.

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3.12 Ponding effects due to framing deflections for roofs, if any shall be considered.

3.13 In addition to the live loads, a minimum of 1.50 KN/sqm shall be considered as hung loads for electrical, ventilation & air conditioning. A load of 2.5 KN/sqm shall be considered as hung loads for piping unless otherwise mentioned.

3.14 Live load reduction shall be in accordance with the provisions of IS: 875 & IS: 1893 in case of seismic analysis.

4.0 EARTH PRESSURE LOADS

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

4.2 In addition to earth pressure and ground water pressure, etc., a minimum surcharge load of 2.0 t/sqm shall also be considered for the design of all underground structures including channels, sumps, cable & pipe trenches, etc., to take into account the vehicular traffic in the vicinity of the structure.

5.0 WIND LOAD

5.1 Wind load on structures shall be calculated as per provisions of IS: 875 (part 3). The wind shall be assumed to blow in any direction and most unfavourable condition shall be considered for design.

5.2 In design of structures, wind force on equipment supported on frame including all fixtures, piping, staircase, ladders, etc., shall also be considered.

6.0 SEISMIC LOADS

6.1 Seismic forces shall be **Zone III** as per IS: 1893.

6.2 For following structure, the design methods listed below shall be used.

(a)	Turbine Building, control room, HRSG, BFP building	:	Response spectrum method using atleast first five modes of vibration.
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(b) All other buildings : Seismic Coefficient
Method

6.3 The importance factor for all power plant buildings and structures shall be taken as 1.5 and for other minor structures as per IS: 1893.

7.0 TEMPERATURE LOAD

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

7.2 Analysis shall be carried out for the structures where temperature is predominant. The analysis shall be for the ambient temperature variation. The temperature variation shall be considered as 2/3 of 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 temperature during the coldest month of the year and mean of daily maximum temperature during the hottest month of the year. The structure shall be designed to withstand thermal stresses due to 50% of the temperature variation.

7.3 Coefficient of thermal expansion of steel shall be taken as per IS: 800. Coefficient for thermal expansion for concrete shall be taken as per IS: 456.

8.0 EQUIPMENT LOADS

8.1 Static and dynamic loads of major equipment such as deaerator, heaters, feed water tank, BFP, motors, fan drive pulleys, pumps, monorails, cable load, pipe load, tanks, AHU, air washer, HRSG, etc., shall be based on the manufacturer's data of the specified equipment and shall be considered in design in addition to the live load. However, where the uniform floor live load adequately accounts for the equipment moving weight, the weight of such equipment as a dead load shall not be considered e.g.: switchgear and control room floors

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are usually designed for a live load that includes the equipment weight.

8.2 All equipment, tanks and piping design loading shall include hydraulic testing loading. Weight of equipment, ducts, tanks, pipes, conduits, etc., supported by structure shall include maximum possible loading conditions i.e., flooded material contents and associated impacts, test loadings, anchorage's and constraint effects.

8.3 Air and gas duct loads shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads applicable.

9.0 **CRANE, MONORAIL & ELEVATOR LOADS**

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

9.2 **Impact Factor**

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

9.2.1 **Crane loads :**

- (a) For vertical force, an impact factor of 25% of the maximum crane wheel load
- (b) A lateral crane surge of 10% of the weight of the trolley plus lifted load applied at the top of each rail divided in proportion to the relative lateral stiffness of the rail support system
- (c) A horizontal surge of 5% of the maximum static wheel loads of the crane applied at the top of the rail

9.2.2 **Monorail loads**

- (a) Impact factor of 10% of lifted load of hoist for monorail and support design
- (b) Impact factor of 25% of the lifted load for electrical pulley and support design

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9.2.3 Elevator

A 100% of the lifted load including elevator live load plus the cab weight for the elevator support beams.

9.2.4 Pedestals supporting gravity take ups for conveyors and pedestals in elevator pits shall be designed assuming 100% impact factor.

10.0 OTHER LOADS

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

10.2 In order to allow for unusual loading during steel erection or during the construction period, all beams on major column lines acting as column struts or ties are designed to withstand an axial force of 45 t in combination with the dead load of the beam. End connections on these beams are designed to transfer its axial load. A minimum of 12mm thick connection angles are to be provided unless thicker angles are required by design.

10.3 Roof girders / trusses in the service / maintenance bay of Turbine building shall be designed for crane erection loads.

10.4 Columns in turbine building near transformer yard shall also be designed to support tension due to strung conductors and shield wire if the conductors are connected to the Turbine building columns.

11.0 BASIC LOAD CASES

11.1 The following basic load cases shall be considered for the analysis:

(a)Dead load	:	D
(b)Self weight of permanent equipment	:	EL
(c)Live load on floor / walkway	:	L
(d)Live load on roof	:	LR
(e)Crane load with lift	:	CR1
(f) Crane load without lift	:	CR2
(g)Wind load	:	WL
(h)Seismic load	:	SL

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- | | | |
|--------------------------------------|---|-----|
| (i) Load due to soil pressure | : | SP |
| (j) Load due to surcharge | : | SCL |
| (k) Load due to hydrostatic pressure | : | HP |
| (l) Load due to temperature | : | TL |
| (m) Special loads | : | SPL |

12.0 **LOAD COMBINATIONS**

12.1 The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion. Permissible stresses for different load combinations shall be taken as per IS: 875 (Part-V) and other relevant IS codes. Wind and seismic forces shall not be considered to act simultaneously.

12.2 Criticality of erection / maintenance loads shall also be checked separately in combination with other simultaneously occurring loads for possible design loading.

12.3 "Lifted load" of crane shall not be considered during seismic condition.

12.4 In case more than one crane is 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. In case the tandem operation is envisaged, the load shared by the two cranes shall be considered.

13.0 **LOAD COMBINATIONS FOR UNDERGROUND STRUCTURES**

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

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

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

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

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

14.0 **SPECIAL STRUCTURES**

For the following structures, additional loading criteria as mentioned below in addition to the criteria discussed above shall be considered:

14.1 **Switchyard structures**

14.1.1 The loading for the design of switchyard structures shall be as per IS: 802 Part 1/Sec 1:1995 (latest edition). Following loads shall be considered:

- (i) Dead load due to equipment and dead load due to structure
- (ii) Wind load on towers, conductors, ground wires and insulator strings calculated as per clause 8 and 9 of IS:802
- (iii) Temperature effects consisting of effect of temperature variation and sag tension as per clause 10 of IS:802
- (iv) Climatic loads as per clause 11.2 of IS:802
- (v) Anti cascading loads as per clause 11.3.1 of IS:802
- (vi) Torsional and longitudinal loads caused by breakage of conductor as per clause 11.3.2 and 16 of IS:802
- (vii) Construction and maintenance loads
- (viii) Seismic loads as per IS:1893
- (ix) Short circuit forces including "snap effect" in the case of bundled conductors

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- 14.1.2 Switchyard structure shall be designed for the worst combination of above loads. The factor of safety for design of members shall be considered as 2 for normal and broken wire conditions and 1.5 for combined short circuit and broken wire conditions. Short circuit forces and wind forces shall not be considered simultaneously.
- 14.1.3 Foundation shall be designed for a factor of safety 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire conditions. Design of foundation shall be carried out as per IS: 4091.
- 14.2 **HRSG Support Structures**
- 14.2.1 The supporting structure shall be designed for the following :
- (a) Live / imposed loads
 - (b) Dead loads
 - (c) Static and dynamic loads of piping, movable equipment and maintenance parts
 - (d) Cantilever loads of not less than 500 kg/m at a distance of 1200 mm from the external face of the columns, on both sides of the HRSG, for cable trays and walkways.
 - (e) Seismic or wind loads as specified elsewhere in the specification
 - (f) Temperature variation of ± 25 deg. C for atmospheric temperature variations
 - (g) Temperature variations under HRSG operating conditions
 - (h) The loads listed above indicate the minimum requirements
- 14.2.2 HRSG supporting structures shall be so configured that the temperature of steel does not exceed 60 deg. C unless specified otherwise. Brackets shall be provided on both sides of the outermost row of columns of the HRSG for supporting cable trays and walkways, at a height not exceeding 10 m. The exact levels shall however, be decided during detail engineering.
- 14.2.3 The bracings in the HRSG structure shall be provided such that under no circumstances normal / convenient access to all points in the boiler is blocked or obstructed.

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- 14.2.4 HRSG support structures shall be checked for differential settlement of foundations which shall be restricted to 1 in 1000 of span or 8 mm whichever is less.
- 14.2.5 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.
- 14.2.6 Design criteria for foundations and some other facilities / areas are covered separately in this specification.

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1.0 **GENERAL**

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

2.0 **DESIGN METHODOLOGY**

2.1 **General**

2.1.1 All designs of RCC structures shall be carried out by limit state method as per IS: 456. Unless use of working stress method is specifically mentioned. Design strength of materials and design loads shall be calculated using appropriate partial safety factors over characteristic strength and characteristic loads as per IS: 456.

2.1.2 IS: 11384 shall be followed for design of steel concrete composite beam.

2.1.3 For reinforcement detailing IS: 5525 and SP: 34 shall be followed.

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

2.2 **Foundation and Underground Structures**

2.2.1 **General**

The depth of all the foundations from design consideration shall be reckoned from NGL (Natural ground level) or FGL (Finish ground level) whichever is lower.

2.2.1.1 Type of foundation system, i.e., isolated, strip, raft shall be decided based on the loading arrangement, load intensity and soil strata. Design of foundations at various levels shall be dependent upon the soil bearing capacity at that level.

2.2.1.2 Foundation system adopted shall ensure that settlement / relative settlement is as per provision of IS: 1904 and other Indian Standards. However, the settlement shall be restricted to a lower value, if necessary as per the system requirement.

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2.2.1.3 All foundations including machine / equipment foundations shall be of RCC construction. All foundations shall be designed in accordance with relevant parts of the latest revisions of Indian standards IS: 2974 and IS: 456. Raft foundations shall be designed as per IS: 2950.

2.2.1.4 All underground pits, tunnels, basements, cable and pipe trenches, etc., shall be leak proof RCC structure where specified design depth of ground water table so warrants. Effects of uplift and reduction in bearing capacity due to underground water table shall also be considered.

2.2.1.5 For design of underground structures, subsoil water level shall be assumed at 1.0 m above the normal water table.

2.2.2 Liquid Retaining Structures

2.2.2.1 RCC water retaining structures like storage tanks, reservoirs, cooling tower basin, etc., shall be leak proof and designed as un-cracked section as per IS: 456.

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

2.2.2.3 In all liquid retaining structures, PVC water bar shall be provided at each construction / expansion joint. The sequence of construction shall also be specified on drawings showing construction joints. At joints fillet shall be provided

2.2.2.4 Where anchors are prescribed to resist uplift, the design of the same shall be based on the recommendations of IS: 10270 or the recommendations and parameters furnished below whichever is more critical.

(a) Minimum dia of anchor rod shall be 25 mm & that of anchor hole shall be 75 mm. The dia of anchor hole shall not be less than 2.5 times the dia of anchor rod.

(b) The anchor hole shall be grouted with cement, sand aggregate(of size 6 mm & down) grout 1:1:2 with non-shrink additive & shall be of strength not less than M-30 or one grade higher than the grade of concrete to be used.

(c) Minimum depth of anchor in rock shall be 2 m. Anchor strength in soil layer shall not be accounted. The allowable bond stress

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between grout & rock shall be 0.2 N/sq.mm & 0.5 N/sq.mm for disintegrated rock & hard rock respectively.

(d) The anchor rod shall be protected by corrosion resistant paint as per IS: 10270.

(e) Adequate number of pull-out tests as per IS: 11309 shall be conducted to verify the capacity of the anchors both for test & working anchor.

2.3 **Machine Foundations**

2.3.1 The design of equipment foundation shall be as per IS:456 and IS:2974. The provisions of DIN 4024 shall also be followed for machine foundations.

2.3.2 All machine / equipment foundations and structures subject to vibrations shall suitably be proportioned so that amplitude and frequency of the foundation / structures are within permissible limits.

2.3.3 All block foundations resting on soil shall be designed using the elastic half space theory. The mass of the RCC block shall not be less than the three times mass of the machine. Dynamic analysis shall be carried out to calculate natural frequencies in all modes including coupled modes and to calculate vibration amplitudes. Frequency and amplitude criteria as laid down by the relevant codes or machine manufacturers shall be satisfied. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

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

2.3.5 All variable speed machines shall be supported on vibration isolation system. The vibration isolation system shall consist of helical spring units and viscous dampers supporting the RCC inertia block which support the machine. The spring units shall conform to DIN 2089 and DIN 2096. For other equipments which do not satisfy the foundation design criteria as per IS: 2974 or DIN 4024, then such equipments shall be supported on vibration isolation system.

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- 2.3.6 All such foundation shall be separated from adjoining part of building and other foundations. Joints at floor / slab shall be suitably sealed. All appendages to such foundations shall be reinforced suitably to ensure integral action.

2.4 **Increase in Stresses**

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

- 2.4.2 Bearing capacity of the soil shall be allowed to increase by 25% under seismic / wind load condition.

3.0 **STABILITY OF STRUCTURES**

- 3.1 Design shall be checked against buoyancy due to the ground water during construction and maintenance stages for structures like under ground tanks, pits trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading. For purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area shall be taken in to consideration.

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

- (a) Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum.
- (b) Factor of safety against sliding shall be 1.5 minimum.
- (c) Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5.

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

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

4.0 **MINIMUM THICKNESS OF STRUCTURAL ELEMENTS**

- 4.1 The following minimum thickness shall be followed:

- | | |
|---|---------------|
| (a) Suspended floor/slab/walkways/
Canopy slabs, etc | 125 mm |
| (b) Ground floor slab (non-suspended) | 150 mm |
| (c) Water Retaining slabs / walls | 200 mm |
| (d) Cable / pipe trenches / underground pits /
Launder walls and base slab | 125 mm |
| (e) All footings (including raft foundations) | 300 mm |
| (f) Parapets | 125 mm |
| (g) Sunshades | 75 mm at edge |
| (h) Precast louvers / fins | 50 mm |
| (i) Precast trench cover slabs / floor slabs /
louvers | 75 mm |
| (j) Paving | 100 mm |
| (l) Basement walls and base slab | 200 mm |
| (m) Underground reservoir | |
| • Below ground water table | 200 mm |
| • Above ground water table | 150 mm |

- 4.2 From fire resistance point of view minimum thickness of reinforced concrete members shall be as per fig.1 of IS: 456. Minimum fire rating of 2 hours shall be considered where fire hazard is expected.

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5.0 **MINIMUM HEIGHTS FOR PEDESTALS OF STEEL COLUMNS**

5.1 Pedestals to Steel Columns for building structures:

Top of RCC foundations (pedestals) shall normally be kept at a lower level so that the column base plates together with gussets and stiffeners remain below finished floor level (FFL) unless specified otherwise. Foundation levels for some columns shall be changed suitable to accommodate underground services, pits trenches, etc.

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

5.3 Pedestals to Steel Columns for Equipment structure:

- (a) Equipment in open area : as required (300mm min)
- (b) Equipment in covered area : as required (150 mm min)
- (c) Structures and equipment : as per vendor data
subject to minimum as
specified above

6.0 **MINIMUM HEIGHTS FOR ENCASEMENT OF STEEL COLUMNS**

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

- (a) Open area : 300 mm above paved level
- (b) Covered area : 150 mm above FFL

7.0 **CONCRETE MIX**

7.1 Cement used shall be ordinary Portland cement of grade 43 conforming to IS 8112, unless the chemical nature of the soil warrants special cement for structures below ground level. The proportions for nominal mix of concrete shall be as per Table 9 of IS: 456. The following minimum grades of concrete used for different structures shall be as follows.

M10 : Back filling of over excavation

M15 : Foundation below brick wall / Concrete block wall, RR masonry walls, blinding layer below

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foundations, trenches and underground structures. Minimum thickness of the layer shall be 100 mm.

M20 : Base plate encasement, Pavement around building including plinth protection work, damp proof course below concrete block work, encasement of structural steel work, screed concrete, etc.,

All RCC members except where other grades are specified example foundation & super structure, grade beams, pedestals, ground floor slabs, roof slabs, cable & pipe trenches, pre-cast concrete work, TG raft etc.

7.2 Minimum cement content, maximum water cement ratio, and minimum grade of concrete shall be considered as per IS: 456 for mild exposure condition. Minimum fire rating of 2 hours shall be considered where fire hazard is expected and accordingly minimum cover shall be taken as per Table 16A of IS: 456. For structures below ground level which are exposed to sulphate attack, requirement of cement shall be as per Table 4 of IS: 456. Intermixing of different grades of concrete in the same structure shall not be allowed in a particular structural element.

7.3 Minimum grade of concrete for reinforced concrete work shall be M20. Minimum grade of concrete for water retaining structure, TG foundations, BFP foundations, fan foundations, GT foundations and underground structures including foundations shall be M30. However higher grade of concrete may also be used than the minimum specified to satisfy the design requirement.

8.0 **REINFORCEMENT**

8.1 Reinforcement bars shall be as per the following codes:

(a) High Yield Strength

Deformed bars : IS: 1786

(b) Mild steel bars : Grade I of IS: 432

(c) Welded wire fabric : IS: 1566

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8.2 Inter mixing of different grades of rebars or rebars of different material composition in same structure shall not be allowed.

9.0 **GROUTING**

9.1 Non-shrink flowable grout shall be used for under pinning work below base plate of columns. Non-shrink cum plasticiser admixture shall be added in the grout. For grouting of base of machine foundation high strength flowable ready mixed non-shrink grout shall be used.

9.2 Crushing strength of the grout shall generally be one grade higher than the base concrete. Minimum grade of grout shall be M25.

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

10.0 **MINIMUM COVER TO FOUNDATION BOLTS**

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

- (a) Clear distance from the edge of base plate/base frames to the outer edge of the pedestal shall be minimum 50 mm.
- (b) Clear distance from the face of pocket to the outer edge of pedestal shall be 75 mm.
- (c) Clear distance from the edge of sleeve or anchor plate to the edge of pedestal shall be 75 mm.

11.0 **MISCELLANEOUS REQUIREMENT**

11.1 Fillets at the junction of roof and vertical walls shall be provided with cast in situ cement concrete 1:2:4 (nominal mix) followed by 12 mm thick 1:4 cement mortar.

11.2 A screed layer not less than 100 mm thick of cast in situ concrete of nominal mix 1:3:6 shall be provided below all water retaining structures. A sliding layer of craft paper or bitumen paper shall be provided over the screed layer to destroy the bond between screed and base slab.

11.3 All under ground structures such as CW sumps, etc, shall be designed as un-cracked section as per IS: 456. In case of leakage in the above

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structures injection grouting method shall be applied to repair the structure according to the requirement of IS: 6494.

- 11.4 For switchyard foundations anchor bolt with mechanical anchorage shall be provided and cast along with foundation concrete. Bolts in pockets shall not be adopted. Foundation for all switchyard towers shall be designed as per IS: 4091. Contact between foundation and the soil strata shall be ensured for all conditions and combinations of loading
- 11.5 Plywood formwork shall be used for all water retaining / conveying structures and for all over ground concrete works. For other areas steel / plywood formwork shall be used.
- 11.6 Unless specified 20mm and down graded aggregates shall be used for all structural concrete works. However 40mm and downgraded aggregates may also be used under special conditions for foundation.
- 11.7 Tolerance for formed and concrete dimension shall be as per IS: 456

12.0 **MAJOR EQUIPMENT FOUNDATIONS**

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

12.1 **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 of high percentage of reactive silica content, aggregate may be allowed where low alkali cement shall be used. Lime stone aggregate shall not generally be used for foundations which are subjected to high temperature and repeated temperature cycles (like in the case of all machine foundations).

12.2 **Temperature control of concrete**

The temperature of fresh concrete shall not exceed 23 deg. C when placed. For maintaining the temperature of 23 deg. C in the top decks of machine foundations, crushed ice shall be used in mixing water.

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12.3 **Admixture**

Plasticizer cum retarder type admixture shall generally be added to the concrete for promoting workability in addition to retarding the setting time for mass concreting work. The slumps shall generally be in the range given below:

TG Top deck	: 100 mm to 150 mm
BFP	: 80 mm to 150 mm
Block foundation	: 80 mm to 150 mm
Column	: 80 mm to 150 mm

12.4 **Form work**

Plywood formwork shall be used for the top decks of all machine foundations and also for columns of TG foundation. Steel trestles shall be used in staging for concreting of the TG columns / Decks

12.5 **Scheme for concreting**

Weigh batching plants shall be mobilized for all machine foundations. Concrete pump shall be mobilized for gas turbine generator foundations, steam turbine generator foundation, BFP foundations. Arrangements for stand-by plant and equipment shall also be made.

12.6 **Placing of concrete**

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

12.7 **Ultrasonic testing**

12.7.1 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 cum of concrete subject to a minimum of six cubes) shall be taken to carry out Ultrasonic Pulse velocity (UPV) testing on the cubes to serve as reference UPV values

12.7.2 Testing shall be done as per IS: 13311 (Part-1). In case of any defects, the Contractor shall rectify the defects suitably using cement / epoxy grout etc.

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1.0 **DRAINAGE AND SEWERAGE**

All drainage lines for storm water, sewage and waste drainage etc. shall preferably be laid in service aisles close to the road. Separate network shall be provided for lines of storm water, sewage, and waste drainage.

1.1 **Surface Drainage**

1.1.1 All the paved and unpaved areas shall be adequately drained. The surface drainage system shall be designed for surface washings and / or rain / fire water as the case may be. Unpaved open areas shall be drained through RCC drains and connected to main storm drains.

1.1.2 The paved area shall be sloped towards the drains with a minimum slope of 1 in 100. The maximum drainage travel extent shall be limited to 10 metres.

1.1.3 The surface drainage from uncontaminated area shall be connected to nearest open storm water drains through rectangular drains. Contaminated area surface drainage shall be collected through separate network.

1.1.4 The interconnecting pipes and rectangular drains shall be sized for carrying the design discharge when running full.

1.1.5 The rectangular drains shall be minimum 600 mm wide of RCC construction. The pipes for water drainage system shall be of RCC class NP2 conforming to IS: 458 with minimum size of 150 mm NB. However for road crossings etc. only RCC box culverts shall be provided. For rail crossings, pipes conforming to railway loading standards shall be provided. If sufficient clearance cannot be provided between the top of the pipe and road top, the pipes shall be encased in RCC.

1.1.6 The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However minimum velocity for self cleaning of 0.6 m/sec shall be ensured. Slope of drain shall not be milder than 1 in 1000.

1.1.7 Minimum earth cover of 450 mm shall be provided over drainage pipes in paved areas.

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- 1.1.8 Garland drains minimum 300 mm wide shall be provided all-round the building to lead away roof drainage to plant drainage system. These drains shall be of RCC construction. Plinth protection in PCC grade M15 shall be provided between building wall and drain with appropriate slope.
- 1.2 **Storm Water Drainage System**
- 1.2.1 The plant storm water drainage system shall take into account the topography of the plant area, area drainage patterns and intensity of rainfall etc. The drainage system shall be designed for a precipitation intensity equal to hourly rainfall of 75 mm indicated vide Clause 3.8.1, Sheet 7 of 30, Section D4.5, Volume-III of technical specification.
- 1.2.2 All storm water drainage shall preferably be through open storm water drains. These shall be provided on both sides of the roads and shall be designed to drain the appropriate catchment area including road surface, open and covered area etc. The drains shall be minimum 600 mm wide.
- 1.2.3 All open drains rectangular in cross section shall be in RCC. In the main plant block, rectangular section RCC drains in minimum **M25** grade concrete shall be provided. The thickness of side and bottom shall be minimum of 125 mm or as per design considerations whichever is higher.
- 1.2.4 The pipes for water drainage system shall be concrete pipes of class NP2 conforming to IS: 458. However for road crossings etc. higher strength pipe of class NP3 shall be provided. Diameter of pipes used for drainage / culverts shall be between 300 mm to 600 mm. Beyond 600 mm, box drains / culverts shall be provided.
- 1.2.5 Surface drains shall normally have a bed slope not milder than 1 in 1000 along longitudinal direction and RCC pipes shall have such slopes so as to have effective discharge. The maximum velocity for pipe drains and open drains shall be limited to 2.4 m/sec and 1.8 m/sec respectively. However, minimum velocity for self cleaning of 0.6 m/sec shall be ensured at peak flow condition (i.e. 3 times average flow) for pipes flowing at half full.
- 1.2.6 Suitable manholes shall be provided to piped drainage lines at every 30 m intervals, at junctions and at change of gradient, alignment and diameter of pipe and shall be of masonry or RCC construction. Minimum size of manholes shall be 1.0m x 1.0m or circular manhole of 1 m dia. All manholes shall be designed considering maintenance,

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inspection and cleaning of pipes. Easy accessibility and safety shall also be given due consideration.

1.2.7 The cushion over the pipes for storm culverts shall be minimum 600 mm. Where less cushion is available, pipe shall be encased in RCC M-20. Suitable RCC structures shall be provided at drops / falls to prevent scouring or damage to surface.

1.2.8 Invert of drainage pipe / drain shall be decided in such a way that the water can easily be discharged above the high water level in water course outside the plant boundary to which the storm water is to be led.

1.3 Plant Effluent Drainage (Oily Waste/Process Waster Drainage)

1.3.1 The oily / process waste shall be drained / collected through a separate sewer system consisting of underground HDPE Pipes. Catch pits shall be provided at the source location and they shall be interconnected by buried pipes. No bends and branches shall be provided in the pipe line. Manholes shall be provided at all junctions of pipes. Catch pits shall have a minimum internal dimension of 600 mm x 600 mm. They shall be of RCC construction and provided with CI grills.

1.3.2 The main and branch connection pipes shall be sized for the expected maximum discharge subject to a minimum of 250 mm NB and 100 mm NB respectively. The pipes shall be adequately sloped for drainage and shall carry flow to neutralisation pit / ETP / Oil water separator as required.

1.4 Sewerage system

1.4.1 HDPE pipes shall be used below ground level for sewage disposal. Pipes connecting toilet facilities to manholes shall be minimum 100 mm NB. Pipes connecting various manholes shall be minimum 150 mm NB.

1.4.2 Sewers shall have such slopes so as to have effective discharge. Sewers shall be designed for a minimum self cleaning velocity of 0.75 m/sec for peak flow condition (assumed as 3 times the average flow) and pipes flowing half full. The maximum velocity shall not exceed 2.4 m/sec.

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1.4.3 Suitable manholes shall be provided to piped sewage lines at every 30 m intervals, at junctions and at change of gradient, alignment & diameter of pipe and shall be of masonry or RCC construction. Details of manholes shall be as per IS: 4111 (Part-I). Minimum size of manholes shall be 1.0m x 1.0 m or circular manhole of 1 m dia. All manholes shall be designed considering maintenance, inspection and cleaning of pipes. Easy accessibility and safety shall also be given due consideration.

1.4.4 Common Septic tanks shall be provided at suitable locations for all buildings. Overflow from septic tanks shall be led to the soak pit.

2.0 INTER PLANT TRENCHES

2.1 All cable and pipe trenches shall be of RCC with minimum M20 grade. Trenches located outside buildings shall be projecting at least 150 mm above finished formation level to avoid entry of storm water into the trenches. The bottom of trench shall be provided with suitable slope for draining out collected water into a sump pit.

2.2 Trenches shall be covered using precast RCC cover of minimum M20 grade, each not weighing more than 65 kg and shall be provided with lifting hooks.

2.3 As far as possible in the open area trenches shall not be provided for running cables. Instead cables may be run in stacks above ground.

3.0 ROADS AND PARKING AREA

3.1 Roads and parking areas shall be of rigid pavement type of construction and shall be designed in accordance with the provision of the relevant IRC Codes of Practice. Top level of parking area shall be flushed with crown of the connecting roads with a cross slope.

3.2 Roads shall be designed as per IRC: 58 (latest edition) "Guidelines for the design of rigid pavements" and as per standard and good engineering practice, which shall be subject to review and approval by the Owner during execution stage.

3.3 Sub base shall be of granular material i.e. laterites, murrum, natural sand, gravel, crushed stone (grading-1) or combination thereof laid over well compacted subgrade. Shoulder provided on either side shall be in murrum construction of 150 mm compacted thickness. The shoulders shall be paved with factory made interlocking cement

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paving blocks of approved design and colour or with cobble stones. Kerbs of PCC or stone shall be provided to distinguish carriage way.

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

3.5 Minimum radius of curvature along the inner side of the carriage way shall be generally 12m. However for minor roads this shall be reduced suitably as per layout requirements and site conditions. Road width and turning radii shall also be checked for to take largest foreseeable vehicles and equipment which can reasonably be expected.

3.6 All service and utility lines crossing under roads shall be taken through concrete pipes / ducts and designed for imposed loadings. Number of such crossings shall however be kept to a minimum.

4.0 **PAVING**

4.1 **R.C.C paving**

4.1.1 R.C.C paving of grade M20, minimum 125 mm thick laid to a slope of 1 in 100 towards the nearest drain, with reinforcement placed 50 mm from the top surface, shall be provided in the following areas.

(i) Entire backside of the main Turbine building up to the farther edge of main stack. The paving shall extend to a minimum of 5 m on either side from the outer most face of equipment structures in the other direction or upto the edge of the road whichever is higher.

(ii) 5 m wide corridor all along the entire width of Turbine building at both gable ends.

4.1.2 The under bed shall consist of well compacted ground supporting dry rubble soling of compacted thickness 225 mm with interstices properly filled with grits, followed by a layer of M 15, 50 mm thick.

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4.2 **P.C.C. paving**

4.2.1 PCC paving of nominal mix of grade M15, 100 mm thick laid over 150 mm thick compacted rubble soling shall be provided in the following area.

- (i) Complete Transformer Yard, covering area between turbine building upto the fencing of the Transformer yard.
- (ii) Plinth protection around all building to a width of 750 mm or the distance between the brick wall to the garland drain.

4.2.2 PCC paving of nominal mix M10, 100 mm thick shall be provided as paving inside fuel oil tank farm. The paving shall be laid over well compacted ground and laid to slope towards peripheral drain.

4.3 **Stone aggregate paving**

- (a) Entire switchyard area shall be provided with 75 mm thick paving using 20 to 40 mm size stone aggregate on top and 75 mm paving of 20 mm stone aggregate below. Before laying the paving, the ground surface shall be treated with anti-weed chemicals as per manufacturer recommendations.
- (b) For auxiliary transformer yard, paving of stone aggregate of 100mm thick using 20 mm size aggregate shall be provided after compacting the under bed and treating with anti-weed chemicals.

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1.0 **IS CODES & REFERENCES**

- 1.1 Reference to only some of the codes in this document and various clauses of design criteria shall not limit or restrict the scope or applicability of other relevant codes. It shall be ensured that all other codes relevant to a specific job, in addition to those already mentioned, are followed wherever applicable.
- 1.2 Where Indian Standards and codes are not available, reference shall be made to British / American / DIN codes and standards.
- 1.3 In case of any deviation / conflict between provisions of IS codes and the design criteria, the provisions that are more stringent shall be followed unless specifically directed otherwise.
- 1.5 The Codes and Standards listed below are applicable for the design and construction of structures and buildings in general. Codes and Standards applicable for specific design and construction are listed elsewhere in reference sections.
- 1.6 Specifications for materials supplied from India shall follow the Indian Standard Specifications.
- 1.7 Field and laboratory testing procedures for materials shall follow Indian Standard Specifications.
- 1.8 Working stress design can be used as alternative but the approval of Owner is a prerequisite.
- 2.0 The following Indian codes and standards shall be used for analysis, design and construction and quality control system of all civil and structural works. In all cases latest revisions with amendments, if any shall be followed. Apart from the specific codes mentioned herein, all other relevant and related codes concerning the specific jobs under consideration and/or referred to in these codes and technical specification shall be followed wherever applicable. (All codes shall be latest as on the date of issuing the Tender/Bid document).

(A)	Excavation and filling
IS: 2720	(Part-II, IV to VIII, XIV, XXI, XXIII, XXIV, XXVII TO XXIX, XL) Methods of test for soils-determination for water content etc.
IS: 9758	Guide lines for Dewatering during construction

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IS: 10379	Code of practice for field control of moisture and compaction of soils for embankment and sub-grade
(B)	PROPERTIES, STORAGE AND HANDLING OF COMMON BUILDING MATERIALS
IS: 383	Specification for coarse and fine aggregates from natural sources for concrete
IS: 455	Specification for Portland Slag Cement
IS: 432	Specification for mild steel and (Parts 1&2) medium tensile steel bars and hard-drawn steel wires for concrete reinforcement
IS: 702	Specification for Industrial bitumen
IS: 712	Specification for building limes
IS: 808	Rolled steel Beam channel and angle sections
IS: 1077	Specification for common burnt clay building bricks
IS: 1161	Specification of steel tubes for structural purposes
IS: 1363	Hexagon head Bolts, Screws and nuts of production grade C
IS: 1364	Hexagon head Bolts, Screws and Nuts of Production grade A & B
IS: 1367	Technical supply conditions for Threaded fasteners
IS: 1489 (Part I)	Specification for Portland Pozzolona Cement Fly ash based
IS: 1542	Specification for sand for plaster
IS: 1566	Specification for hard-drawn steel wire fabric for concrete reinforcement
IS: 1786	Specification for high strength deformed bars for concrete reinforcement
IS: 2062	Specification for steel for general structural purposes
IS: 2116	Specification for sand for masonry mortars
IS : 2185 Part I	Specification for Concrete Masonry, Hollow and Solid concrete blocks
IS : 2185 Part II	Specification for Concrete Masonry, Hollow and solid Light weight Solid concrete blocks
IS: 2386 (Parts-I to VIII)	Testing of aggregates for concrete
IS: 3150	Hexagonal wire netting for general purpose.
IS: 3495	Methods of tests of burnt clay building bricks

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(Parts-I to IV)	
IS: 3812 (Part I & II)	Specification for Pulverised Fuel Ash Part I –for use as Pozzolona in Cement, Cement Mortar and Concrete; Part II – for use as Admixture in Cement Mortar and Concrete
IS: 4031 (All Parts)	Methods of physical tests for hydraulic cement
IS: 4032	Methods of chemical analysis of hydraulic cement
IS: 4082	Recommendations on stacking and storage of construction materials at site
IS: 8112	Specification for 43 grade ordinary Portland cement
IS: 8500	Medium and high strength structural steel.
IS: 12269	53 grade ordinary Portland cement
IS: 12894	Specification for Fly ash lime bricks
(C)	CAST-IN-SITU CONCRETE AND ALLIED WORKS
IS: 280	Specification for mild steel wire for general Engineering purposes
IS: 456	Code of practice for plain and reinforced concrete
IS: 457	Code of practice for general construction of plain & reinforced concrete for dams & other massive structures
IS: 516	Method of test for strength of concrete
IS: 650	Specification for standard sand for testing of cement
IS: 1199	Methods of sampling and analysis of concrete
IS: 1791	General requirements for batch type concrete mixers
IS: 1838	Specification for preformed fillers for expansion
(Part-I)	Joints in concrete pavements and structures (non-extruding and resilient type).
IS: 2438	Specification for roller pan mixer
IS: 2502	Code of practice for bending and fixing of bars for concrete reinforcement
IS: 2505	General requirements for concrete vibrators, immersion type
IS: 2506	General requirements for concrete vibrators, screed board type
IS: 2514	Specification for concrete vibrating tables
IS: 2645	Specification for Integral cement water proofing

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	compounds
IS: 2722	Specification for portable swing weigh batches for concrete. (single and double bucket type)
IS: 2750	Specification for Steel scaffolding
IS: 2751	Code of practice for welding of mild steel plain and deformed bars for reinforced concrete construction
IS: 3025	Methods of sampling and test waste water
IS: 3366	Specification for Pan vibrators
IS: 3370 (Part I to IV)	Code of practice for concrete structures for the storage of liquids
IS: 3414	Code of practice for design and installation of joints in buildings
IS: 3550	Methods of test for routine control for water used in industry
IS: 3558	Code of practice for use of immersion vibrators for consolidating concrete
IS:3935	Code of Practice for composite construction
IS: 4014 (Parts I & II)	Code of practice for steel tubular scaffolding
IS: 4326	Code of practice for earthquake resistant design and construction of buildings
IS: 4656	Specification for form vibrators for concrete
IS: 4925	Specification for batching and mixing plant
IS: 4990	Specification for plywood for concrete shuttering work
IS: 5525	Recommendations for detailing of reinforcement in reinforced concrete work
IS: 5624	Specification for foundation bolts
IS: 6461	Glossary of terms relating to cement concrete
IS: 6494	Code of practice for water proofing of underground water reservoirs and swimming pools
IS: 6509	Code of practice for installation of joints in concrete pavements
IS: 7861	Code of practice for extreme weather concreting.(Parts I & II)
IS: 9012	Recommended practice for shot concreting
IS: 9103	Specification for admixtures for concrete

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IS: 9417	Recommendations for welding cold worked steel 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	Specification for two-parts poly sulphide
IS: 12200	Code of practice for provision of water stops at transverse contraction joints in masonry and concrete dams
IS: 13311	Method of non-destructive testing of concrete
Part-1	Ultrasonic pulse velocity
Part-2	Rebound hammer
SP:16	Design Aids for reinforced concrete to IS:456-1978
SP:22	Explanatory handbook on codes for earthquake engineering (IS:1982-1975 and IS:4326-1976)
SP:23	Handbook of concrete mixes
SP: 24	Explanatory Handbook on IS: 456-1978
SP:25	Handbook on causes and prevention of cracks in buildings
SP:32	Handbook on functional requirements of industrial buildings
SP: 34	Handbook on concrete reinforcement and detailing
IS:13920	Code of Practice for ductile detailing of reinforced concrete structures subjected to seismic forces.
BS:4485	Structural design of cooling Towers(part 4)
(D)	PRECAST CONCRETE WORKS
SP: 7(Part VI/ Sec.7)	National Building Code- Structural design of prefabrication and systems 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 units
(E)	MASONRY AND ALLIED WORKS
IS: 1905	Code of Practice for Structural Safety of Buildings-Masonry walls
IS: 2212	Code of Practice for Brickwork
IS: 2250	Code of Practice for Preparation and use of Masonry Mortar

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SP: 20	Explanatory hand book on masonry code
(F)	SHEETING WORKS
IS:277	Galvanised steel sheets (plain or corrugated).
IS: 513	Cold-rolled carbon steel sheets
IS: 730	Specification for fixing accessories for corrugated sheet roofing
IS: 2527	Code of practice for fixing rain water gutters and down pipe for roof drainage
IS: 7178	Technical supply conditions 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: 12866	Plastic translucent sheets made from thermosetting polyester resin (glass fibre reinforced).
IS: 14246	Specification for continuously pre-painted galvanised steel sheets and coils
(G)	FABRICATION AND ERECTION OF STRUCTURAL STEEL WORK
IS: 2016	Specification for plain washers
IS: 814	Specification for covered Electrodes for Metal Arc Welding for weld steel
IS: 1852	Specification for Rolling and Cutting Tolerances for Hot rolled steel products
IS: 3502	Specifications for chequered plate
IS: 6911	Specification for stainless steel plate, sheet and strip
IS: 3757	Specification for high strength structural bolts
IS: 6623	Specification for high strength structural nuts
IS: 6649	High Tensile friction grip washers
IS: 800	Code of practice for use of structural steel in general building construction
IS:802	Code of Practice for use of structural steel in overhead transmission line towers: (All parts
IS:806	Code of Practice for use of steel tubes in general building construction
IS:813	Scheme of symbols for welding
IS: 816	Code of practice for use of Metal Arc Welding for General

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	Construction
IS: 4000	Code of practice for assembly of structural joints using high tensile friction grip fasteners
IS: 9595	Code of procedure of Manual Metal Arc Welding of Mild Steel
IS: 817	Code of practice for Training and Testing of Metal Arc Welders
IS: 1811	Qualifying tests for Metal Arc Welders (engaged in welding structures other than pipes).
IS: 7215	Tolerances for fabrication steel structures
IS: 12843	Tolerance for erection of structural steel
IS: 4353	Recommendations for submerged arc welding of mild steel and low alloy steels
SP: 6 (Part 1 to 7)	ISI Hand book for structural Engineers
IS: 1608	Method of Tensile Testing of Steel products other than sheets, strip, wire and tube
IS: 1599	Method of Bend Tests for Steel products other than sheet, strip, wire and tube
IS : 228	Methods of chemical Analysis of pig iron, cast iron and plain carbon and low alloy steel
IS : 2595	Code of Practice for Radio graphic testing
IS : 1182	Recommended practice for Radiographic Examination of fusion welded butt joints in steel plates
IS : 3664	Code of practice for Ultra sonic Testing by pulse echo method
IS : 3613	Acceptance tests for wire flux combination for submerged Arc Welding
IS : 3658	Code of practice for Liquid penetrant Flaw Detection
IS : 5334	Code of practice for Magnetic Particle Flaw Detection of Welds
IS:1024	Code of Practice for use of welding in bridges and structures subjected to dynamic loading
IS:6533	Code of practice for design and construction of steel chimney
IS:8640	Recommendations for dimensional parameters for industrial building
IS:9595	Recommendation for Metal arc welding of carbon

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	and carbon manganese steel
IS:12843	Tolerances for erection of steel structures
(H)	PLASTERING AND ALLIED WORKS
IS : 1635	Code of practice for field slaking of Building lime and preparation of putty
IS : 1661	Application of cement and cement lime plaster finishes
IS : 2333	Plaster-of-paris
IS : 2402	Code of practice for external rendered finishes
IS : 2547	Gypsum building plaster
IS : 3150	Hexagonal wire netting for general purpose
(I)	WATER SUPPLY, DRAINAGE AND SANITATION
IS : 458	Specification for concrete pipes
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 and stop valves for water services
IS : 782	Caulking lead
IS : 783	Code of practice for laying of concrete pipes
IS : 1172	Basic requirements for water supply, drainage and sanitation
IS : 1538	Cast iron fittings for pressure pipe for water, gas and sewage
IS : 1703	Ball valves (horizontal plunger type) including float for water supply purposes
IS : 1726	Cast iron manhole covers and frames
IS : 1729	Sand cast iron spigot and socket, soil, water and ventilating pipes, fittings and accessories
IS : 1742	Code of practice for building drainage
IS : 1795	Pillar taps for water supply purposes
IS : 1879	Malleable cast iron pipe fittings
IS : 2064	Code of practice for selection, installation and maintenance of sanitary appliances
IS : 2065	Code of practice for water supply in building
IS : 2326	Automatic flushing cisterns for urinals

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IS : 2470 (Part-I & II)	Code of practice for installation of septic tanks
IS : 2501	Copper tubes for general Engineering purposes
IS : 2548	Plastic seat and cover for water-closets
IS : 2556 (Part 1 to 15)	Vitreous sanitary appliances (vitreous china).
IS : 2963	Non-ferrous waste fittings for wash basins and sinks
IS : 3311	Waste plug and its accessories for sinks and wash basins
IS : 3438	Silvered glass mirrors for general purposes
IS : 3589	Electrically welded steel pipes for water, gas and sewage (200mm to 2000mm nominal diameter).
IS : 4111 (Part I to IV)	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	Electro plated 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 welded steel pipes for water supply
IS : 5961	Cast iron grating for drainage purpose
IS : 7740	Code of practice for road gullies
IS : 8931	Cast copper alloy fancy bib taps and stop valves for water services
IS : 8934	Cast copper alloy fancy pillar taps for water services
IS : 9762	Polyethylene floats for ball valves
IS : 10446	Glossary of terms for water supply and sanitation
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

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SP: 35	Hand book on water supply and drainage – Manual on Sewerage and sewage treatment (Published by CPH & EEO) As updated
(I)	DOORS, WINDOWS AND ALLIED WORKS
IS : 204	Tower Bolts
Part-I	Ferrous metals
Part-II	Nonferrous metals
IS : 208	Door Handles
IS : 281	Mild steel sliding door bolts for use with padlocks
IS : 362	Parliament Hinges
IS : 420	Specification for putty, for use on metal frames
IS : 1003 (Part-I)	Specification for timber panelled and glazed shutters-Part-I 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 : 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 (Part-II)	Specification for wooden flush door shutters (solid core type); particle board face panels and hard board face panels
IS:2209	Mortise locks (vertical type).
IS:2553	Safety glass
IS:2835	Flat transparent sheet glass
IS:3548	Code of practice for glazing in buildings
IS:3564	Door closers (Hydraulically regulated).
IS : 3614	Fire check doors; plate, metal covered and rolling type
IS:4351	Steel door frames
IS:5187	Flush bolts
IS:5437	Wired and figured glass
IS:6248	Metal rolling shutters and rolling grills
IS:6315	Floor springs (hydraulically regulated) for heavy doors
IS:7196	Hold fasts

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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:10521	Collapsible gates
(J)	ROOF WATER PROOFING AND ALLIED WORKS
IS:1203	Methods of testing tar and bitumen
IS:1322	Specification for bitumen felts for water proofing and damp proofing
IS:1346	Code of practice for water proofing of roofs with bitumen felts
IS:1580	Specification for bituminous compound for water proofing and caulking purposes
IS:3067	Code of practice for general design details and preparatory work for damp proofing and water proofing of buildings
IS:3384	Specification for bitumen primer for use in water proofing and damp proofing
(K)	FLOOR FINISHES AND ALLIED WORKS
IS:1237	Specification for cement concrete flooring tiles
IS:1443	Code of practice for laying and finishing of cement concrete flooring tiles
IS:2114	Code of practice for laying in-situ terrazzo floor finish
IS:2571	Code of practice for laying in-situ cement concrete flooring
IS:3462	Specification for unbaked flexible PVC flooring
IS:4971	Recommendations for selection of industrial floor finishes
IS:5318	Code of practice for laying of flexible PVC sheet and tile flooring
IS:8042	Specification for white Portland cement
IS:13801	Specification for chequered cement concrete flooring tiles
(L)	PAINTING AND ALLIED WORKS
IS:162	Specification for fire resisting silicate type, brushing, for use on wood, colour as required.
IS:1477	Code of practice for painting of ferrous metals in buildings
Part-I	Pre-treatment
Part-II	Painting
IS:1650	Specification for colours for building and decorative finishes

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IS:2074	Specification for red oxide-zinc chrome, priming, ready mixed paint air drying
IS:2338	Code of practice for finishing of wood and wood based materials
Part-I	Operations and workmanship
Part-II	Schedules
IS:2395	Code of practice for painting concrete, masonry and plaster surfaces
Part-I	Operations and workmanship
Part-II	Schedule
IS:2524	Code of practice for painting of nonferrous metals in buildings
Part-I	Pre-treatment
Part-II	Painting
IS:2932	Specification of synthetic enamel paint, exterior, under-coating and finishing
IS:2933	Specification enamel paint, under coating and finishing
IS:4759	Code of practice for hot dip zinc coating on structural steel and other allied products
IS:5410	Specification for cement paint
IS:5411 (Part-I)	Specification for plastic emulsion paint-for exterior use
IS:6278	Code of practices for white washing and colour washing
IS:10403	Glossary of terms relating to building finishes
(M)	PILING AND FOUNDATION
IS:1080	Code of practice for design and construction of Shallow foundations in Soils(Other than Raft, Ring & Shell)
IS:1904	Code of practice for design and construction of foundations in Soils; General Requirements
IS:2950 (Part-I)	Code of practice for designs and construction of Raft foundation
IS:2974 (Part-I to V)	Code of practice for design and construction of machine foundations
IS:6403	Code of practice for determination of Allowable Bearing pressure on Shallow foundation
IS:8009	Code of practice for calculation of settlement of foundation

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	subjected to symmetrical vertical loads
Part-I	Shallow foundations
Part-II	Deep foundations
IS:12070	Code of practice for design and construction of shallow foundations on rocks
DIN:4024	Flexible supporting structures for machines with rotating machines
VDI:2056	Criteria for assessing mechanical vibrations of machines
VDI:2060	Criteria for assessing rotating imbalances in machines
(N)	ROADS
IRC:5	Standard specifications and Code of practice for road bridges, section-I general Features of Design.
IRC:14	Recommended practice of 2cm thick bitumen and tar carpets
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:37	Guidelines for the Design of flexible pavements
IRC:86	Geometric Design standards for urban roads in plains
IRC:SP:13	Guidelines for the design of small bridges & culverts
IRC - Publication	Ministry of Surface Transport (Roads Wing), Specifications for Road and Bridge works
IS:73	Specification for paving bitumen
(O)	LOADING
IS:875 (Pt. I to V)	Code of practice for design loads other than earthquake) for 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 & poles
IRC:6	Standard specifications & code of practice for road bridges, Section-II Loads and stresses

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IS:11089	Code of Practice for design and construction of ring foundation
IS:13301	Guidelines for vibration isolation for machine foundations
IS:1911	Schedule of unit weights of building materials
(P)	SAFETY
IS:3696 (Part I & II)	Safety code for scaffolds and ladders
IS:3764	Safety code for excavation work
IS:4081	Safety code for blasting and related drilling operations
IS:4130	Safety code for demolition of buildings
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 on structural steelwork
IS:7293	Safety code for working with construction machinery
IS:7969	Safety code for handling and storage of building materials
IS:11769	Guidelines for safe use of products containing asbestos
	Indian Explosives Act. 1940 as updated
(Q)	OVERHEAD TANK
IS:11682	Criteria for design of RCC staging for overhead water tanks

6.0 Miscellaneous

IS:2210 Criteria for design of reinforced concrete shell structures and folded plates

IS:2470 Code of Practice for installation of septic tank:(part 1)
Design criteria and construction (part 2) Secondary
treatment and disposal of septic tank effluent

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