

## CHAPTER - STRUCTURES

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## **SECTION: STRUCTURES**

### **1.0 GENERAL**

- 1.1 The scope of specification covers design (excepting design of those structures which have been standardised and enclosed with the specification), fabrication, pre-assembly, supply and erection of galvanised steel structures for towers, girders, lightning masts and equipment support structures. Towers, girders, lightning masts shall be lattice type structure fabricated from structural steel conforming to IS 2062 (latest). All equipment support structure shall be fabricated from GI pipe conforming to YST 22 (Kg/mm<sup>2</sup>) or of higher grade as per IS 806. Support structure for circuit breaker is not standardised and shall be designed by the Contractor. Support structure for 132/66/33kV equipments shall be of lattice type.

It is the intent of the Purchaser to provide structures, which allow interchangeability of equipments at a later stage. Accordingly equipment support structure standardization has been carried out with the provision of stool. Stools shall be provided between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, hangers, shackles, clamps and climbing devices, bird guards, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be by base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 0.610 kg/m<sup>2</sup> for anchor bolts / foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of leveling.

## 2.0 DESIGN REQUIREMENTS FOR STRUCTURES NOT COVERED IN STANDARDISED LIST

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS: 875, Parts I to V.

2.2 For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.  
In case platform is envisaged for series capacitor and other allied equipments, it shall be designed as per IS-800.

2.3 Minimum thickness of galvanized tower member shall be as follows:

Members	Minimum thickness (mm)
Leg members, Ground wire	
Peak members/Main members	5
Other members	4
Redundant members	4

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.

2.5 Minimum distance from hole center to edge shall be  $1.5 \times$  bolt diameter. Minimum distance between center to center of holes shall be  $2.5 \times$  bolt diameter.

2.6 The minimum bolt diameter shall be 16 mm.

### 2.7 Step Bolts

In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each tower shall be provided with step bolts not less than 16mm diameter & 175mm long spaced not more than 450mm apart, staggered on faces on one leg extending from about 0.5 meters above ground level to the top of the tower. The step bolt shall conform to IS: 10238. Ladders on towers with lighting appliances shall be provided with safety guards.

**Design Criteria**

- a) All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS: 875, seismic forces as per code IS: 1893 (latest), Importance factor of 1.5, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40.0 kA. IEC-865 may be followed for evaluation of short circuit forces.
- b) Switchyard gantry structures shall be designed for the two conditions i.e. normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e. all the three (phase) conductors broken on the other side. Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures, which are of lattice type.
- c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.
- d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 metric tones per phase for 400 kv and 2 metric tones per phase for 220 kv, 1 tone per phase for 132 kV or as per requirements whichever is higher. The distance between terminal gantry and dead end tower shall be taken as 200 meters. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.
- e) The girders shall be connected with lattice columns by bolted joints.
- f) All Pipe support used for supporting equipments shall be

designed for the worst combination of dead loads, erection load. Wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS: 806. The material specification shall be as per IS: 1161 read in conjunction with IS: 806.

- g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.
- h) Foundation bolts shall be designed for the loads for which the structures are designed.
- i) Lightning Mast shall be 50m in height (47.5m lattice structure plus 2.5m pipes) and designed for diagonal wind condition. Lightning masts shall be provided with a structural steel ladder within its base up to a height of 25 meter. The ladder shall be provided with protection rings. Two platforms shall be provided one each at 12.5m and 25.0m height for mounting of lighting fixture. The platforms shall also have protection railing. The details of lighting fixtures would be as per the approved drawings.

### **3.0 DESIGN DRAWINGS, BILL OF MATERIALS AND DOCUMENTS**

- 3.1 The Contractor shall furnish design, drawing and BOMs and shop manufacturing drawings for every member to the Purchaser after award of the Contract. However, Contractor shall have to prepare and submit any other drawings, bill of materials (BOM) additionally required during design and construction stage which the Purchaser feels necessary. In case Purchaser feels that any design drawing, BOM are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the design drawing, BOM as required in the specification.
- 3.2 The fabrication drawings to be prepared and furnished by the Contractor shall be based on the design approved by the Purchaser or standard drawing provided. These fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the Purchaser. The fabrication drawings

shall be submitted to the Purchaser. Proto shall be made only after approval of fabrication drawings.

3.3 The fabrication work shall start only after the Purchaser accords the final approval to the Fabrication drawing. The design drawing should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints.

3.4 Such approval shall, however, not relieve the Contractor of his responsibility for the safety of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

#### **4.0 FABRICATION OF STEEL MEMBERS**

4.1 The fabrication and erection works shall be carried out generally in accordance with IS 802. A reference however may be made to IS 800 in case of non-stipulation of some particular provision in IS 802. All materials shall be completely shop fabricated and finished with proper connection material and erection marks for ready assembly in the field.

#### **5.0 PROTO-ASSEMBLY**

- i) The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.
- ii) Sample towers, beams and lightning masts and equipment support structures shall be trial assembled in the fabrication shop and shall be inspected and cleared by Contractor based on the approved fabrication drawing before mass fabrication.

Pursuant to above the B.O.Ms along with proto-corrected fabrication drawings and shop manufacturing drawings for

every member shall be prepared and submitted by the main vendor to Purchaser as document for information. Such BOM, which shall be duly certified by the main vendor for its conformity to the approved design, shall be the basis for Purchaser to carry out inspection.

## **6.0 BOLTING**

- i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- ii) All steel items, bolts nuts and washers shall be hot dip galvanised.
- iii) 2.0% extra nuts and bolts shall be supplied for erection.

## **7.0 WELDING**

The work shall be done as per approved fabrication drawings which clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld etc. Symbols for welding on erection and shop drawings shall be according to IS: 813. Efforts shall be made to reduce site welding so as to avoid improper joints due to constructional difficulties.

## **8.0 FOUNDATION BOLTS**

- 8.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.
- 8.2 The Contractor shall be responsible for the correct alignment and leveling of all steel work on site to ensure that the towers/structures are plumb.
- 8.3 All foundation bolts for lattice structure, pipe structure is to be supplied by the Contractor.
- 8.4 All foundation bolts shall be fully galvanised so as to achieve 0.61 kg. per Sq.m. of Zinc Coating as per specifications.

- 8.5 All foundation bolts shall conform to IS 5624 but the material, however shall be MS conforming to IS: 2062

## **9.0 STABILITY OF STRUCTURE**

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

## **10.0 GROUTING**

The method of grouting the column bases shall be subject to approval of Purchaser and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. The Contractor will be fully responsible for the grouting operations.

## **11.0 GALVANISING**

- 11.1 All structural steel works and pipe supports shall be galvanised after fabrication.

- 11.2 Zinc required for galvanising shall have to be arranged by the manufacturer. Purity of zinc to be used shall be 99.95% as per IS: 209.

- 11.3 The Contractor shall be required to make arrangement for frequent inspection by the Purchaser as well as continuous inspection by a resident representative of the Purchaser, if so desired for fabrication work.

## **12.0 TOUCH-UP PAINTING**

The touch up primers and paints shall consist of Red Oxide / Zinc chromate conforming to the requirements of IS: 2074 with a pigment to be specified by the Purchaser.

## **13.0 INSPECTION BEFORE DISPATCH**

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by the Purchaser or his authorised representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor



of his responsibility regarding adequacy and completeness of fabrication.

#### **14.0 TEST CERTIFICATE**

Copies of all test certificates relating to material procured by the Contractor for the works shall be forwarded to the Purchaser.

#### **15.0 ERECTION**

The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipments and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage.

#### **16.0 SAFETY PRECAUTIONS**

The Contractor shall strictly follow at all stages of fabrication, transportation and erection of steel structures, raw materials and other tools and tackles, the stipulations contained in Indian Standard Code for Safety during erection of structural steel work-IS: 7205.

#### **17.0 STANDARD GANTRY AND EQUIPMENT SUPPORT STRUCTURES**

The Purchaser has standardised certain equipment and gantry structures. Copies of the design - drawings of such structures are enclosed, which also indicate main parameters for which the designs have been made. It is intended that only standard structures shall be used in the switchyard to the maximum extent. However, if necessary, as per site requirement, different designs may be adopted. Structures other than those standardised, if required, are to be designed, supplied and erected, as described in preceding paragraphs, without any extra financial implication to the Purchaser.

#### **18.0**

All tests mentioned in standard field quality plans have to be carried out and conformity of materials and workmanship shall be ascertained.

## CHAPTER - CIVIL (CVL)

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## **SECTION: CIVIL**

### **1.0 GENERAL**

The intent of specification covers the following:

Design, engineering, and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of this Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per National/ International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant Indian Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of Purchaser.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the purchaser based on Tender Drawings Supplied to the Contractor by the Purchaser. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance based on the input provided by the Purchaser. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

### **2.0 GEOTECHNICAL INVESTIGATION**

- 2.1 Fairly levelled site shall be handed over to the Contractor. If required, the contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the site in order that the foundation of various structures can be designed and constructed safely and rationally.

A report to the effect will be submitted by the Contractor for Purchaser's specific approval giving details regarding data proposed to be utilised for civil structures design.

- 2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract.

### **3.0 SITE PREPARATION:**

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the Purchaser. The Contractor shall give all help in instruments, materials and personnel to the Purchaser for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

#### **3.1 SCOPE**

This clause covers execution of the work for site preparation, such as clearing of the site, the supply and compaction of fill material, excavation and compaction of backfill for foundation, road construction, drainage, trenches and final topping by stone (broken hard stone).

#### **3.2 GENERAL**

- 1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of standard specifications.
- 2) If fill material is required the fill material shall be suitable for the above requirement. The fill shall be such a material and the site so designed as to prevent the erosion by wind and water of material from its final compacted position or the in-situ position of undisturbed soil.
- 3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material and to be approved by the Purchaser.
- 4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill, shall be disposed off in area's as directed by purchaser upto a maximum lead of 2 km.

#### **3.3 EXCAVATION AND BACKFILL.**

1. Excavation and backfill for foundations shall be in accordance with the relevant code.
2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.
3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.
4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.
5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

### **3.4**

#### **COMPACTION**

1. The density to which fill materials shall be compacted shall be as per relevant IS and as per direction of Purchaser. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The subgrade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesionless material subgrade shall be compacted to 70% relative density (minimum).
2. At all times unfinished construction shall have adequate drainage. Upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.
3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling

shall begin at the edges overlapping half the width of the roller each time and progress to the center of the road or towards the building as applicable. Rolling will also be required on rockfills. No compaction shall be carried out in rainy weather.

### **3.5 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION**

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. The fill materials and other protections etc. to be used under the foundation is to be got approved by the Purchaser.

## **4.0 ANTIWEED TREATMENT & STONE SPREADING**

### **4.1 SCOPE OF WORK**

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification and direction of the Purchaser.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work.

### **4.2 GENERAL REQUIREMENT**

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Purchaser.

- 4.2.1 The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to Table 2 of IS:383 – 1970. Hardness, flakiness shall be as required for wearing courses are given below :

- (a) Sieve Analysis limits (Gradation)  
(IS : 383 – Table – 2)

Sieve Size	% passing by weight
63mm	100
40mm	85-100
20mm	0-20
10mm	0-5

"One Test" shall be conducted for every 500 cu.m.

(b) Hardness

Abrasion value (IS:2386 Part-IV) – not more than 40%

Impact value (IS:2386 Part-IV) – not more than 30% and frequency shall be one test per 500 cu.m. with a minimum of one test per source.

(c) Flakiness Index

One test shall be conducted per 500 cu.m. of aggregate as per IS:2386 Part – I and maximum value is 25%.

- 4.2.2 After all the structures/equipments are erected, antiweed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The antiweed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx) and shall be sprinkled with water at least once in the afternoon everyday after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Engineer – in- charge. The final approval shall be given by Engineer – in –charge based on the results.
- 4.2.3 Engineer-in-charge shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.
- 4.2.4 After antiweed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by Engineer-in-charge. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.
- 4.2.5 In areas that are considered by the Engineer-in-Charge to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.
- 4.2.6 The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the

surface.

- 4.2.7 Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement : 5 fine sand : 10 burnt brick aggregate) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement : 6 fine sand ) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.
- 4.2.8 A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

## 5. SITE DRAINAGE

Providing rain water drainage system within the switchyard fencing under the present scope including connection at One or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from Engineer- in- charge before commencement of construction. While designing the drainage system following points shall taken care of:

- (a) The surface of the switchyard shall be sloped to prevent accumulation of water.
- (b) Drain shall be constructed on both sides of roads. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left undrained.
- (c) Open surface trapezoidal drains having 300mm bottom width and sides having slope of 1horizontal: 1.5 vertical with 300mm depth at starting point of drain shall be provided.
- (d) Longitudinal slope shall not be less than 1 in 1000.
- (e) Open surface drains shall be constructed with 100mm thick plain cement concrete 1:2:4 (1cement: 2 coarse sand: 4 stone aggregate 20mm nominal size). PCC 1:2:4 shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size )
- (f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..
- (g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured
- (h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation
- (i) For pipe drains, concrete pipe of class NP2 shall be used. However, for road



crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, IS:456 and IS:783 shall be followed.

- (j) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.
  - (k) Pipe drains shall be connected through manholes at an interval of max. 30m.
  - (l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed within the substation boundary.
- (m) The drainage scheme and associated drawings shall be got approved from the employer before commencement of construction.

## **6.0 ROADS AND CULVERTS**

- a). All the roads within the substation fencing under the present scope is in the scope of contract. Layout of the roads are as shown in the General detail & Arrangement drawing for the substation issued along with the tender documents. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Autotransformer/Reactor shall be as short and straight as possible.
- b) The double lane road shall have 7.0m black topping with 1.6 m wide earthen shoulder on either side of the road. Other roads shall be with 3.75 m black topping and 1.3 m wide earthen shoulder on either side of the road.
- c) All roads shall be designed for class "C" traffic as per IRC- 37 (Guidelines for design of flexible pavements).
- d) CPWD specification shall be followed for construction of Roads.
- e) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed for class AA loading as per IRC standard / IS code and should be checked for Autotransformer / Reactor loading.

## **7.0 CABLE & PIPE TRENCHES**

- a). The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M20 grade.
- b). The cable trench walls shall be designed for the following loads.
  - (i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier
  - (ii) Earth pressure + uniform surcharge pressure of 2T/m<sup>2</sup>.

- c). Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at center of span on each panel.
- d). Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.
- e). The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.
- f). All metal parts inside the trench shall be connected to the earthing system.
- g). Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- h). The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.
- i). Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

## **8.0 FOUNDATION /RCC CONSTRUCTION**

### **8.1 GENERAL**

1. Work covered under this Clause of the Specification comprises the design and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, pulling block, control cubicles, bus supports, Autotransformer/Reactors, marshalling kiosks, auxiliary equipments & systems buildings, tanks or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.
2. Concrete shall conform to the requirements mentioned in IS:456 and all the tests shall be conducted as per relevant Indian Standard Codes as mentioned in Standard field quality plan appended with the specification

A minimum grade of M20 concrete (1: 1.5: 3 mix) shall be used for all structural/load bearing members as per latest IS 456 (draft revision)

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.
4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.
5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.
6. Concrete made with portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.
7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
8. If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre-cast or under reamed type as per relevant parts of IS Code 2911. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles have been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

## 8.2

### DESIGN

1. All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS:456 and minimum grade of concrete shall be M-20. Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Purchaser.
2. Limit state method of design shall be adopted unless specified otherwise in the specification.

3. For detailing of reinforcement IS:2502 and SP:34 shall be followed. Cold twisted deformed bars ( $F_y=415 \text{ N/mm}^2$ ) conforming to IS:1786 or TMT bars as per CPWD specifications shall be used as reinforcement. However, in specific areas, mild steel (Grade I) conforming to IS:432 can also be used. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per IS:456 (latest).
4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with IS:3370 (Part I to IV) by working stress method. However, water channels shall be designed as cracked section with limited steel stresses as per IS:3370 (Part I to IV) by working stress method.
5. The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and/or superstructure and other conditions which produces the maximum stresses in the foundation or the foundation component and as per the relevant IS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.
6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.
7. Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/harmful to the concrete foundations.
8. RCC columns shall be provided with rigid connection at the base.
9. All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications. For checking against overturning weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.
10. Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures earth pressure at rest shall be considered.

11. In addition to earth pressure and ground water pressure etc., a surcharge load of  $2T/Sq\ m$  shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.
12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:
  - a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).
  - b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
  - c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.
14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.
15. The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.
16. The foundations of transformer and other enclosures shall be of block type foundation. Minimum reinforcement shall be governed by IS 2074 and IS 456.
17. The tower and equipment foundations shall be checked for a factor

of safety of 2.2 for normal condition and 1.65 for short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

## **0. ADMIXTURES & ADDITIVES**

1. Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.
2. Admixtures in concrete shall conform to IS:9103. The water proofing cement additives shall conform to IS:2645. Concrete Admixtures/Additives shall be approved by Purchaser.
3. The Contractor may propose and the Purchaser may approve the use of a water-reducing set-retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.
4. The water-reducing set-retarding admixture shall be an approved brand of Ligno-sulphonate type admixture.
5. The water proofing cement additives shall be used as required/advised by the Purchaser.

## **9.0 CHAINLINK FENCING AND GATE**

### **9.1 General**

Fencing and gate shall be provided as per details given below :

### **9.2 Areas requiring Fencing**

1. Fencing shall be provided for complete switchyard as per drawing. Separate gate shall be provided for men and equipment.
2. Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

### **9.3 Product materials**

The minimum requirements are as follows :

Chain link fence fabric (without galvanization) in accordance to IS:2721.

1. Size of mesh : 75mm
2. Nominal wire size : 3.15mm dia meter

3. Width of chain link : 1500mm
4. Painting : Two or more coats of approved standard make synthetic enamel paint over a coat of standard steel primer.

### **Posts**

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade Yst-22 (Kg/mm<sup>2</sup>). The tubes shall also conform to IS : 1161/IS 806. The length of tubular post shall be 2600 mm as shown in the tender drawing enclosed with bid documents.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate as shown in the drawing.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long as shown in the drawing. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per IS:209.

### **Fence Fabric Panel**

Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe as shown in the drawing shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard synthetic enamel paint over approved standard steel primer.

### **Installation**

1. Fence shall be installed along the switchyard line as shown in the approved drawings.
2. Post holes shall be excavated by approved method.
3. All posts shall be 3.0m apart measured parallel to ground surface.
4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum

- 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
5. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12 diameter) on each flat.
7. The painting pattern of fence panels shall be decided by Engineer-in-charge. It shall be preferable to paint the panel in different colour pattern such that it gives better aesthetic look.

#### **Gate**

1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Other details shall be as shown in the drawing.
2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
3. The gates shall be provided with suitable locking arrangement.
4. The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
5. Steel roller shall be provided with the gate.
6. Gate shall be installed in location as shown in approved G.A. drawing.

### **10.0 BUILDINGS (IF REQUIRED)**

Buildings (if required ) shall be designed as per relevant IS Codes and construction shall be done as per CPWD specification. The scope shall include design, engineering and construction including anti-termite treatment, plinth protection DPC of Building including sanitary, water supply, electrification etc. of building.

### **11.0 MISCELLANEOUS GENERAL REQUIREMENTS**

- 11.1 Dense concrete with controlled water cement ratio as per IS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.



- 11.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.
- 11.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti corrosive paint to take care of sea worthiness.
- 11.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with IS:2629 and IS:2633. Galvanizing shall be checked and tested in accordance with IS:2633. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS:3416.
- 11.5 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.
- 11.6 Bricks having minimum 75 kg/cm<sup>2</sup> compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm<sup>2</sup> compressive strength before submitting his offer.
- 11.7 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sunshade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.
- 11.8 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase shall be provided in control buildings.
- 11.9 Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole precast cover and any other place where breakage of corners of concrete is expected.
- 11.10 Anti termite chemical treatment shall be given to column pits, wall

trenches, foundations of buildings, filling below the floors etc. as per IS:6313 and other relevant Indian Standards.

- 11.11 Hand-railing minimum 900mm high shall be provided around all floor/roof openings, projections/balconies walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per IS:277). All rungs for ladder shall also be galvanised as per IS:277 medium class.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

- 11.12 For all civil works covered under this specification, nominal mix by volume batching as per CPWD specification is intended. The relationship of grade of concrete and ratio of ingredients shall be as below :

S.No.	Mix	Cement	Sand	Coarse aggregate of 20 mm down grade as per IS 383
1.	M 10	1	3	6
2.	M 15	1	2	4
3.	M 20	1	1.5	3

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of CPWD specification and approved standard Field Quality Plan.

- 11.13 Items/components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

## 12.0 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedments, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is

reduced to minimum.

### **13.0 WATER SUPPLY**

- (i) Water shall be made available by purchaser at any feasible point near scope boundary at single point to the contractor. Contractor shall state the total water requirement both in terms of quantity and head to the purchaser.
- (ii) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.
- (iii) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by the Purchaser before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works.
- (iv) Bore wells and pumps for water supply is not in the scope of contractor.

### **14.0 STATUTORY RULES**

- 14.1. Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State). Fire Safety Rules of Tariff Advisory Committee. Water Act for pollution control etc.
- 14.2 Provisions for fire proof doors, no. of staircases, fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Tariff Advisory Committee.
- 14.3 Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.
- 14.4 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the Indian Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.
- 14.5 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in IS:1904 and other Indian Standards.
- 14.6 All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with clause no. 10 of IS:3370 (Part-I).
- 14.7 Construction joints shall be as per IS: 456.

- 14.8 All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to IS:9103. In addition, limit on permeability as given in IS:2645 shall also be met with. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, Injection Method shall be applied for repairing the leakage.

- 14.9 All building/construction materials shall conform to the best quality specified in CPWD specifications if not otherwise mentioned in this specification.

- 14.10 All tests as required in the standard field quality plans have to be carried out.