



**ODISHA POWER TRANSMISSION CORPORATION LIMITED**

**TECHNICAL SPECIFICATION**

**FOR**

**SWITCH YARD STRUCTURES**

**STRUCTURES FOR OUTDOOR EQUIPMENT**  
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## **GENERAL**

### **1.1 Design of structures**

Substation structures shall be designed in accordance with the requirements of IS 802. The wind pressures for the substation sites shall be as per data in schedules and wind pressure map of the State of Orissa.

Structures shall be designed to carry the equipment and associated connections, insulator sets, earth conductors and all fittings under all specified conditions of service of operation and loading.

The substation gantry structures shall be designed to carry the down lead spans and the Contractor shall be provided with the details and location of the terminal tower and the type of conductor used on the overhead line in order to do so. All structures intended to carry equipment or materials on more than one side of the structure shall be designed to cater for all possible stages of equipment erection, installation and maintenance. The substation gantry structures shall be designed to terminate the overhead line down lead spans which may enter  $\pm 30$  degrees horizontally and  $\pm 15$  degrees vertically.

### **1.2 Conductor spacing and clearances**

Structures shall be dimensioned to maintain the specified minimum phase to earth, phase to phase and insulation height clearances under conditions of maximum conductor swing and sag. The spacing between individual phase conductors, and the clearance between clamps, arcing horns, jumper loops or other live metal and the structure steelwork and other obstacles, under all specified conditions of temperature and loading shall not be less than the specified values.

### **1.3 Applied loads**

The assumed maximum simultaneous loadings on the substation structures shall be as follows—

#### **1.3.1 Wind loads**

The normal wind load shall be given by the wind pressure, as stated in the Schedules, acting on the whole projected area of the phase and earth conductors and, where applicable, the horizontal resultant of the maximum line and earth conductor tensions, together with the wind pressure, as stated in the Schedules, on 1.5 times the projected area of the members of one face of the structure plus the projected area of the plant being supported.

#### **1.3.2 Vertical loads**

The normal vertical load shall be the mass of the line and earth conductors, insulators, the plant item, insulator fittings, earth conductor fittings, spacers, line traps and ancillary apparatus where applicable. For the overhead line terminating span it shall be assumed that the mass of the conductors and earth wires shall include the actual total mass of the down lead span.

### **1.4 Electro mechanical loads**

Electro dynamic forces due to short circuit conditions, snatch forces, aeolin vibration and other similar loads shall be computed and applied for design of structures. The different mechanical effects due to short circuit current etc. shall be estimated as per IEC 865 and CIGRE guide line No. 7

### **1.5 Construction**

The structures shall be of an approved design and construction. All stressed members (tension and compression) of steel structures shall consist of rolled steel sections unless otherwise approved.

The material used for the members shall not be less than 6 mm thick except for unstressed members where the thickness may be reduced to 4 mm.

No bolt hole shall be more than 1.5 mm larger than the corresponding bolt diameter. As far as possible, bolt heads, rather than nuts, shall be on the outer or upper faces of structure connections.

To facilitate inspection and maintenance, all tall structures shall be provided with step bolts and ladders complete with hoops. Handrails, screens, guards and other appropriate facilities shall also be provided.

Where the structure is to terminate overhead transmission lines supplied under another contract, suitable provisions shall be made to accept the transmission line insulator fittings and earth conductor clamps.

Means shall be provided for fixing and bonding GI flat strip to the steelwork at a minimum of two points. Earth connections shall be made to a vertical face, clear of the ground. Foundation bolts shall not be used for their attachment. GI flats for earth connections, bolts, nuts washers etc.. shall be included in the structures.

Gantry type structures which support more than one three phase circuit shall have suitable interbay screens installed to prevent access along the beam from a dead to an energised circuit. The location of the screens shall be agreed with the Engg Incharge (Divisional Engr.).

## **1.6 Material**

All rolled steel sections, flats, plates and bolt and nut bars used shall consist of steel manufactured by an approved process and shall be to the requirements of ISO 630 (minimum yield strength 255 N/mm<sup>2</sup>). The steel shall be free from blisters, scales, laminations and other defects. Steel sections shall preferably be British Standard or metric standard sections chosen with a view to avoiding delays in obtaining material.

All members shall be cut to jig and all holes shall be drilled or punched to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite to each other before being bolted up. Drifting or reaming of holes will not be allowed.

Built members shall, when finished, be true and free from all kinks, twists and open joints, and the material shall not be defective or strained in any way.

If the structures are fabricated or galvanised by subcontractors, the Contractor shall, if required by the Engg Incharge (Divisional Engr.), provide a resident inspector at the works of each subcontractor during the time that the steelwork is being fabricated or galvanised.

All bolts and screwed rods shall be galvanised, including the threaded portions; all nuts shall be galvanised with the exception of the threads, which shall be oiled.

Except where specified to the contrary, all iron and steel used in the construction of the Contract works shall be galvanised after all sawing, shearing, drilling, punching, filing, bending and machining are completed.

Galvanising of all material shall be in accordance with the requirements of this Specification. The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated material.

Sherardizing or other similar process shall not be used.

## **2. 0 SUPPORT STRUCTURES OF SWITCHYARD**

### **2.1 General**

The scope of works covers design, fabrication, proto -assembly, supply and erection of galvanised steel structure for portals (columns, girders), lightning masts and equipment support structures.

Portals (columns, girders), lightning masts, and equipment support structures shall be lattice type structures fabricated from structural steel conforming to IS 226/2062. The design of all support structures for 220kV, 132kV and 33kV equipment. The column and beam and lightning cum lighting mast of 400 KV side shall be of lattice type. The equipment support structure for 400 KV shall be GI Tubular pipe of adequate height and strength confirming to the latest IS. All the structural materials are within the scope of the Contractor. The use of GI pipes conforming to IS 806 to support certain equipment will also be considered. However approval of the Engg Incharge (Divisional Engr.) should be obtained for the same before commencement of detailed design.

It is the intent of the Employer to provide structures which allow inter changeability of equipment at a later stage. Keeping this in view, the height of all the structures must be maintained as per approved drawings. It is stressed that the Contractor has to provide minimum steel sections as per the standard

drawings. However, if a higher section is required from design point of view the same shall be acceptable. Additional structures called stools shall be connected to the equipment and the bottom of the stool shall be connected to the support structure where required.

The scope shall include the supply of all types of bolts, nuts, hangers, shackles, clamps, anticleimbing devices, bird guards, climbing systems, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, angles and bolts for structure mounted or ground mounted marshalling boxes (ACDC marshalling box and equipment control cabinets), and any other items as required to complete the works.

The connection of all structures to their foundations shall be by base plates and embedded anchor and foundation bolts. All steel structures and anchor or foundation bolts shall be fully galvanised. The weight of the zinc coating shall in accordance with this Specification. One additional nut shall be provided below the base plate which may be used for the purpose of levelling.

## **2.2 Design requirements**

The minimum bolt diameter shall be 16 mm.

In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each substation gantry structure shall be provided with step bolts not less than 16mm diameter and 175mm long spaced not more than 450mm apart, staggered on faces of one leg extending from about 2.5 metres above ground level to the top of the tower. The step bolts shall conform to IS 10238. Ladders on lighting masts and other tall structures shall be provided with safety guards.

All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS 802, seismic forces as per code IS 1893, 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 40kA. IEC 865 and CIGRE Guide No. 7 may be followed to estimate the various forces of conductor for structural design.

Substation gantry structures shall be designed in accordance with IS 802 for the three conditions i.e. normal conditions, three conductors on one side broken, and broken wire condition and short circuit force. The design of all structures shall be based on the condition where stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

A factor of safety of 2.0 under normal and broken wire conditions and 1.5 under combined short circuit and broken wire conditions shall be considered for the design of switch yard structures. For purpose of design 110% of static tension pull and transverse reaction on the gantries as calculated for each span shall be considered.

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. The weight of a man with tools shall be considered as 150 kg for the design of structures.

Torsional effect on towers and beams due to unbalanced forces may be taken care of as per American Code DS-10.

Terminal line take off gantries shall be designed for a minimum conductor tension of four metric tonnes per phase for 400kV and two metric tonnes per phase for 220kV & 132 kV. The distance between terminal gantry and dead end tower shall be taken as 200 metres. The design of these terminal gantries shall also be checked considering  $\pm 30$  degree horizontal and  $\pm 15$  degree vertical deviation of conductor. The transmission line conductors would be either single ACSR conductor per phase on AC side for all lines except for 400kV. For 400kV the line side conductor shall be twin ACSR.

The girders shall be connected with lattice columns by bolted joints.

All pipe supports used for supporting equipment 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 busbars as per IS 806 and IS 1161. Minimum sections for 400kV, 220kV and 132kV & 33kV structures shall be as per standard drawings approved by the Engg Incharge (Divisional Engr.). However, the Contractor can increase the sections if required. The height of the structures shall be as per standard drawings.

If lighting fittings are proposed to be fixed on gantries or towers, the proper loading for these shall be considered in the design. Holes for fixing the brackets for lighting fittings should be provided wherever required.

Foundation bolts and stubs shall be designed for the loads for which the structures are designed.

Lightning masts shall be designed as per IS 802 for diagonal wind condition for a height of 47.5 m for lattice structures and 2.5m for MS pipe with conical head at top.

Lightning masts shall be provided with a structural steel ladder within its base up to a height of 25 metres. The ladder shall be provided with protection rings. Two platforms shall be provided one each at 12.5m and 25m height for mounting of lighting fittings. The platforms shall also have protection railing.

### **2.3 Design drawings, bill of materials and documents.**

The fabrication drawings to be prepared and furnished by the Contractor shall be based on the design approved by the Engg Incharge (Divisional Engr.). These fabrications 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, bill of materials in the proforma approved by the Engg Incharge (Divisional Engr.), bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the Contractor.

Fabrication work shall start only after the final approval of the design and fabrication drawings is accorded by the Engg Incharge (Divisional Engr.).

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

### **2.4 Fabrication of steel**

The Contractor shall bear all the expenditure at all stages on account of loading and unloading, transportation and other miscellaneous expenses and losses and damages for all materials up to the fabrication yard/shop and thereafter to the erection site including all other expenses till the erection of work has been completed and accepted. His unit rates shall be deemed to be inclusive of all such incidental expenses and no extra shall be payable on any account in this regard.

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.

### **2.5 Assembly**

#### **2.5.1 General**

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 minimise distortion in members the component parts shall be positioned by using clamps, clips, dogs, jigs and other suitable means. Fasteners (bolts and welds) shall be placed in a balanced pattern if the individual components are to be bolted, paralleled and tapered.

Sample towers, beams and lightning mast shall be trial assembled keeping in view the actual site conditions, before erection in the fabrication shop and shall be inspected and approved by Engg Incharge (Divisional Engr.) before mass fabrication. Necessary erection marks shall be made on these components in the shop before disassembly and despatching.

#### **2.5.2 Bolting**

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.

- All steel items, bolts, nuts and washers shall be hot dip galvanised.

- 2.0% extra nuts and bolts shall be supplied for erection.

### **2.5.3 Welding**

The works shall be done in accordance with the General Technical Clauses (TS-GTC) and as per approved fabrication drawing which shall clearly indicate various details such as joints to be welded, type of weld, length and size of weld, and whether shop or site welded. 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 welding due to constructional difficulties.

Those welds which are considered to be critical to the design and the integrity of the construction of the structure shall be subject to radiographic inspection.

The Contractor shall carry out non- destructive testing of all butt welds subject to tensile stresses. Testing shall be carried out in the fabrication shop or on site as the case may be.

Unless otherwise approved, non- destructive testing shall be by radiographic examination.

## **2.6 Foundation bolts**

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.

The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers and structures are plumb.

All foundation bolts for all structures and supports are to be supplied by the Contractor.

All foundation bolts shall be fully galvanised in accordance with the General Technical Clauses of this specification.

The contractor shall provide templates for all stanchion bolt spacing. Holding down bolts, assemblies, templates, tubes and washers shall be delivered to the site in sufficient time to position and build them into the foundations. Boxing out for bolts shall not be permitted. The projection of threaded portions of bolts above the foundation level shall be adequate to properly secure the nuts.

## **2.7 Stub setting**

Stub for towers and lightning mast shall be set in such a manner that the distance between the stubs and their alignment and slope shall be exactly as shown in the fabrication drawings.

## **2.8 Stability of structure**

The Contractor 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 bracing's and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

## **2.9 Grouting**

The method of grouting the column bases shall be subject to approval of Engg Incharge (Divisional Engr.) 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. The mix for the grouting shall contain one part of cement and two parts of coarse sand. Non shrinkage admixtures of approved quality and of standard make shall also be added in adequate proportion as specified by the manufacturers of the admixtures.

## **2.10 Galvanising**

All structural steel works and single pipe supports shall be galvanised after fabrication in accordance with this Specification. The galvanising of structures having length not exceeding 6m for lattice type, and 5m along with base plate size of 750x 750mm for other type, shall be made in one dip only.

The Contractor shall be required to make arrangements for frequent inspection by the Engg Incharge (Divisional Engr.) as well as continuous inspection by a resident representative of the Engg Incharge (Divisional Engr.), if so desired for this fabrication work.

## **2.11 Painting**

Where members of steel structures are required to be painted it shall meet the requirements as specified in relevant sections of this Specification.

The preparation, protection and painting systems selected for ferrous surfaces provided inside the switchyard shall provide a life to first maintenance of 20 years and for doors, windows, louvres etc., it shall provide life to first maintenance of 10 years. Finish colour will be selected as per relevant sections of this Specification.

## **3. 0 INSPECTION BEFORE DESPATCH**

Each part of the fabricated steel work shall be inspected for correctness of physical parameters, welding, joints, erection marks etc.. before it is despatched to the erection site. In any case the Contractor shall be fully responsible for correctness, quality, adequacy and completeness of structures being erected under the scope of this contract.

### **3.1 Testing and inspection**

The Contractor shall give full access to the Engg Incharge (Divisional Engr.) at all times to the place of fabrication and storage for the purpose of inspection and testing. Mill test certificates relating to the material procured by the Contractor for works shall be forwarded to the Engg Incharge (Divisional Engr.).

When so instructed by the Engg Incharge (Divisional Engr.), the Contractor shall provide samples of the steel to be used in the works for tests to be carried out at an independent laboratory approved by the Engg Incharge (Divisional Engr.). The cost of these independent tests shall be paid for by the Contractor.

Should the works or any part thereof fail to pass any test or in the opinion of the Engg Incharge (Divisional Engr.) fail to comply with the specification, the Contractor shall immediately take such action as is necessary to ensure that the works comply with the specification at no extra cost to the Employer.

All defective material and workmanship will be rejected and shall be replaced and reconstructed at the Contractor's expense.

No splice welding of members between connections shall be permitted without the prior approval of the Engg Incharge (Divisional Engr.).

### **3.2 Despatch, handling and storage.**

All bolts, nuts, washers, plates etc. shall be transported to site in properly marked and sealed containers, suitably protected to prevent damage during transportation.

### **3.3 Test certificate.**

Copies of all test certificate relating to material procured by the Contractor for the works shall be forwarded to the Engg Incharge (Divisional Engr.).

## **4. 0 ERECTION.**

The Contractor should arrange his own erection plant and equipment, welding sets, tools and tackles, scaffolding, trestles equipment etc. and any other accessories and ancillaries required for the work.

Finished structures shall be plumb, level and true to dimensions, within the tolerances specified.

### **4.1 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 erection for structural steel work, IS 7205.



#### 4.2 Fire protection to steelwork.

The fire protection to steelwork shall be an approved luminescent paint, spray or board system to give two hours fire protection when tested. Fire protection shall only be required in the immediate vicinity of potential fire sources.

If applicable, fire protection coatings shall be sprayed or painted onto previously primed steelwork. Application to be made in strict accordance with product loading rates for base coat and top sealer specified for two hours fire resistance in manufacturers product application notes. Suitable mesh reinforcement shall be incorporated to prevent loss of insulation when subject to mechanical damage.

The coatings shall be applied by a specialist applicator strictly in accordance with the product manufacturers recommendations. The whole of the fire protection proposals and application shall be in accordance with the current Building Regulations and to the satisfaction of the Local Authority and the Fire Authority.

Surfaces which are to receive a fire protective coating shall be delivered to site with travel coatings applied and shall be suitably protected until immediately prior to the fire protective coatings or casings being applied. The latter shall be applied as late as possible in the construction programme subject to other trades and operations. Primer and travel coat shall be compatible with the fire protection coating.

#### 5. 0 WIDTH AND HEIGHT OF THE BUS AT SUB-STATION

<u>VOLTAGE LEVEL</u>	<u>BAY EIDTH</u>	<u>BOTTOM BUS HEIGHT</u>	<u>TOP BUS HEIGHT</u>
132 KV	11MTRS / 13.1 MTRS	8.5 MTRS	13.5 MTRS
220KV	18MTRS	10.5 MTRS	16.0 MTRS
33KV	5.5MTRS	5.5 MTRS	9.5 MTRS
400KV	27 MTRS	>15	>23 MTRS

Remarks: The structure height shall be maintained as per data provided for getting mnimum clearance and sectional clearance and as OPTCL standard. Contractors to furnish the drawings of all the structural items to the owner for according approval.