

Annexure –3
Technical Specifications
for
Lattice Tower Structure Material



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1.0 STEEL STRUCTURES FOR TRANSMISSION LINE

1.1 General

- a) This section covers the furnishing of galvanized structural steel for transmission towers. It includes supply of all raw materials, fabrication, galvanizing, and delivery of structures with necessary connection bolts, step bolts and other miscellaneous material required to make complete transmission towers structures.
- b) This section is intended for use with complimentary sections and appropriate drawings which outline electrical clearances, loading assumptions and other details pertaining to specified standards.
- c) All raw materials of tower shall be branded new and free of pitting, dents, bends and other defects.

1.2 Materials of Fabrication:-

Materials shall conform to the following specifications:

- a) Rolled Shapes and Plates
 - I. All materials shall be hot rolled of mild structural and/or high-strength structural steel. All structural steel shall be made by the open hearth or electric furnace process.
 - 1) Structural Mild Steel
Structural mild steel shall conform to IS: 2062, 1992, ASTM A36 or BS 15.
 - 2) High Strength Structural Steel
High Strength structural steel shall conform to IS 961, ASTM A441 or BS 4360.
 - 3) Steel Grade Substitution E250 A/B
 - II. Steel rolled for and released as structural grade, shall not be used as a substitute for high-strength grade regardless of test values.
 - III. Steel rolled for high-strength grade may be used for structural grade if it meets the required specifications.
- b) Structural steel other than those specified above may be substituted provided the R-Infra through AEML approves their quality and suitability for the proposed contract. The prospective supplier must furnish with his proposal,

test certificates covering the mechanical properties and chemical composition of any such alternative steel.

- c) Steel shall be purchased by the bidder from either prime manufacturers or reputed re-rollers acceptable to the AEML.
- d) Connection Bolts, U-Bolts and Nuts
 - i) Steel for connection bolts, U-bolts, nuts and locknuts shall be in accordance with IS 6639, IS 1363 & IS 1367 or BS 4190, IS 12427, 1998 or of property class 5.6 conforming to IS 6639. High strength bolts, if used (only with structural steel of IS: 8500) shall conform to property class 8.8 of IS: 3757. Bolts, U-Bolts, nuts and locknuts shall be of uniform quality, either mild steel or high-strength and no combination of both in a tower are permitted. The size of bolts shall be appropriate.
 - ii) Bolts, Nuts & Spring/Pack washers shall be Hot Dip Galvanized.
- e) Step Bolts
Step bolts shall conform to IS: 10238 (1982)
- f) Spring Washers
Spring washers shall be carbon steel conforming to IS 3063 B-type. Washers to be used with high strength bolts and nuts shall conform to IS: 6649.
- g) Plain Washers
Plain washers shall be made of IS 2016, ASTM A 36 or BS 15 steel.
- h) Tower Signs
Tower signs, consisting of number signs, phasing signs and danger signs shall be made of mild steel with enameled finish. The thickness shall not be less than 3 mm. The bolts of tower signs shall have 3mm thick lead washers (relevant IS to be quoted).

2 FABRICATION OF TOWER

2.1 General

- a) All workmanship and finish shall be of best quality, first class throughout and shall conform to the best-approved method of Fabrication. All the pieces shall be finished straight, true to detail drawings. All holes and edges shall be free from burrs. Shearing and chipping, bevel cutting, bending, grinding etc. shall be neatly and accurately done. Unless otherwise directed/approved, reference may be made to the IS: 7215 or American Institute of Steel Construction Manuals for providing standard fabrication tolerances. Material for fabrication shall be kept clean and protected from weather.
- b) All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all towers or structures of which they-form a part.

2.2 Connections

- a) All connections shall be bolted type only.
- b) Bolts shall be full size in shanks. Threads of bolts and nuts shall be clearly rolled or cut and face and head of nut shall be truly at right angle to the axis of bolt. The shank will be round and free of projected fins. The bolt head shall be

hexagonal, properly-centered on the shank and have a bearing surface truly at right angle to the axis of bolt, free from burrs and reasonably smooth.

- c) Nuts shall be hexagonal of dimensions adequate to develop full strength of bolts. All nuts shall be securely locked by the use of lock-nuts or spring washers or by other means approved by DFCCIL/R-Infra. The nuts and locknut shall fit freely for entire length of bolt threads.

Dimensions of spring washers shall meet the following requirements.

Nominal Diameter (mm)	Basic Inside Diameter (mm)	Maximum Outside diameter(mm)	Average thickness (mm)
12	12.2	21.1	2.5
16	16.2	27.4	3.0
20	20.2	33.5	4.0

- d) In all cases where bearing is critical, the unthreaded bolt shall bear on members assembled. A suitable washer of adequate thickness may be provided to exclude the threads from the bearing thickness, in case a longer grip bolt has to be used for this purpose. As far as possible not more than four thicknesses shall be connected together at any point.

a) Fabrication Procedure

a) Straightening

Rolled material shall be straightened before being worked, unless otherwise specified. The straightening or flattening shall be done without any injury to the Material or its strength. Long plates shall be straightened by passing through leveling rolls and structural shapes by use of mechanical or hydraulic bare/section straightening machines. Heating or forging shall not be resorted to without the prior approval of AEMLin writing.

b) Cutting

- i) Cutting may be by shearing, cropping or sawing. Flame cutting shall be avoided as far as possible.
- ii) All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from burrs and distortions so as to avoid any difficulty of assembly caused by the interference of end sections with other members at the time of assembling the tower.

c) Punching and Drilling

- i) Holes may be punched through material not over 12 mm thickness. Holes for thickness higher than 12 mm shall preferably be drilled and the burrs removed effectively.
- ii) The diameter of bolt hole shall not exceed 1.5 mm over the nominal diameter of bolt used. Special care shall be exercised to ensure exact spacing of holes and their distance from the back of angle and to the end of piece. Any member having holes or cuts more than 1.0 mm from correct position, will be subject rejection. No welding, filling or plugging will be permitted Poor matching, over-drilling and ovality in holes shall be subject to rejection. Burning holes with gas is strictly prohibited.

iii) Holes in bent members affected by bending operation shall be laid out and punched or drilled after bending.

d) Welding

i) Welding shall be avoided as far as possible, however if used, shall be carried out before galvanizing. Electrodes for manual welds shall comply with the requirements of IS 814 or AWS A5.1 and shall be of approved make. Welding shall be continuous unless otherwise specified. Caution shall be exercised to obtain full penetration of weld when welding light members to heavy members.

ii) All welds shall be made only by welders and welding operators who have been properly trained and previously qualified by tests to perform the type of work required and prescribed in the relevant applicable standards.

iii) All welds shall be free from defects like blow holes, slag inclusion, lack of penetration, under cutting, cracks etc. All welds shall be cleaned of slag or flux and show uniform sections, smoothness of weld metal, feather edges without overlap and freedom from porosity.

iv) Fillet welds larger than 8 mm shall be, made with 2 or more passes. Each layer of multiple layer welds, except the root and surface run, may be moderately pined with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from over pinning.

e) Bending

i) All bending of high-strength structural steel must be done hot. Bends of difficult nature on mild steel would be done hot; otherwise cold bending could be employed.

ii) If cold bending is adopted the AEMML shall have the right to make any test in accordance with ASTM A143.

iii) Members bent hot shall be heated in non-oxidizing flame over a sufficient area to prevent excessive deformation. Hot bends shall be cooled by natural air cooling method and not by quenching. In case where bends are near splices, the upset metal shall be forged smooth for full bearing on the contact surface.

iv) All bends shall be finished free from waves, folds, localized reduction in sectional area or reduction in leg length in excess of 5%.

f) Tolerances

i) The acceptable limits for straightness (sweep and camber) for rolled or fabricated members are:

- | | | |
|--|---|--------------------------------------|
| a) Main struts and legs of towers | - | L/1000 or 10 mm whichever is smaller |
| b) For other members not primarily in compression, Such as redundant members | - | L/500 or 15 mm whichever is smaller |

Where L is the axial length of member between points of lateral supports

ii) Tolerances in specified length of finished member shall be as follows:
Finished member without ends finished for contact bearing shall have tolerances ± 1.5 mm for member up to 3 m in length. For members over 3 m long an additional 1 mm for every 3 m length may be allowed, but in no case will a tolerance more than 3 mm be allowed for any structure member.

g) Marking

i) After checking and inspection, all members shall be marked for identification during erection. The mark shall conform to the piece marks on the approved detail drawings. Markings shall be stamped with metal dye prior to galvanizing and the figures and letters shall be at least of 20 mm height and to such optimum depth as to be clearly visible ever after the member is galvanized.

ii) Marking of tower members shall be in A-BB-CC-DDD pattern and as below:-
A = R-Infra's code assigned to the contractor-Alphabet
B = Contractor's Mark-Numerical
CC = Tower type-Alphabet
DDD = Number mark to be assigned by contractor-Numerical

iii) All the erection marks shall be on outer surface and placed preferably near one end in the same relative position on each member so as to be easily seen after assembly of tower. They shall be stamped so as not to reduce the effective net section of the member. Members having length more than 4 meters shall have marking at both ends.

iv) After galvanizing the marking shall be encircled boldly by distinguishable paint to facilitate easy location.

v) Member, having identical size and details, shall have the same marking regardless of its position in the structure.

h) Errors

i) Any error in shop work, which prevents proper assembling and fitting up of parts in the field by moderate use of drift pin or moderate amount of reaming, shall be rejected as defective workmanship. All charges incurred by the aeml either directly or indirectly because of such defective workmanship, will be deducted from the amount due to the contractor before payment is made. The amount of such deduction will consist of the sum total to the cost of labor, direct or indirect material, plant, transportation equipment rental and overhead expenses.

ii) In case the AEML chooses to reject the material because of poor workmanship, the cost of all handling or returning the material to the contractor, if he so desires, shall be entirely to the account of contractor. All the replacement material shall be supplied free and delivered at site in all such cases.

b) Cleaning & Galvanization

- a) **Workmanship**
After all the shop work is complete, all the structural materials shall be stamped with erection mark and is hot-dip galvanized. Before galvanizing, the steel shall be thoroughly cleaned of any paint, grease, rust scale, acid or alkali or such other foreign matters as or likely to interfere with the galvanizing process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.
- b) Galvanizing for structural steel members, bolts, nuts, step bolts and other accessories of tower shall meet the requirements of IS: 2629, IS: 5358 & IS: 6745.
- c) The galvanized surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth, and shall be free from defects like discolored patches, bare spots, unevenness of coating, which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.
- d) There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanized steel member shall withstand minimum number of one minute dips in copper sulphate solution as per tests specified in IS: 2633 or ASTM A-239.
- The minimum repetition times for one minute dip in uniformity tests shall be as follows:
Structural members, gussets : 6
Bolts, nuts & other accessories : 4
- e) Galvanizing of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. However, in case of members over 7.5 m long, the contractor shall take prior approval of AEML for double dipping. When the steel section is removed from the galvanizing kettle excess shall be removed by 'bumping'. The process known as 'wiping' or 'scraping' shall not be used for this purpose.
- f) Wherever galvanized bolts, nuts, locknuts, washers, accessories etc. are specified, they shall be hot dip galvanized. Spring washers shall be electro galvanized. Excess spelter from bolts, nuts, etc. shall be removed by centrifugal spinning. Rehashing of bolt threads after galvanizing shall not be permitted. Nuts however may be tapped, but not to cause appreciable rocking of the nuts on the bolts.
- g) Defects in certain members indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the Specifications, or lack of quality control in any manner in the galvanizing plant, shall render the entire production in the relevant shift liable to rejection.
- h) All galvanized members shall be treated with Sodium Dichromate solution or an approved equivalent after galvanizing, so as to prevent white storage stains.

- i) Prior approval shall be secured from AEML if galvanizing is done outside contractor's plant or place other than that indicated in his bid offer.
- j) Contractor shall ensure that galvanizing is not damaged in transit and shall at his cost replace such members as are damaged in transit. If, AEML accepts repair of minor damages, contractor shall furnish sufficient quantity of appropriate paint, free of cost, for repairing galvanized surfaces damaged in transit.
- c) Minor Repairs
 - a) Material on which galvanizing has been damaged shall be re-dipped unless in the option of the AEML, the damage is local and can be repaired by applying zinc rich/galvanizing repair paint.
 - b) Where such repair is authorized, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits of xylene, followed by wire brushing. Subsequently, the area shall be re-cleaned with solvent to remove residue, and shall be given one heavy coat of zinc rich/galvanizing regular paint. The percentage of pure zinc by weight in dry film shall not be less than 85%.
- d) Shop Assembly–Proto Inspection
 - a) One tower of each type and height, including every combination of leg extensions, shall be assembled in shop and shall be offered to AEML for inspection to ensure proper field erection. Reaming of holes not properly matching will not be permitted. A moderate amount of drifting will be allowed.
 - b) If any errors on the drawings or fabrication are discovered in such assembly all the corrections or modifications shall be incorporated in the drawings and correct part re- fabricated and assembled. All revised drawings shall be resubmitted for approval from AEML.
 - c) Fabrication of the tower shall be carried out only after approval of Proto Assembly Inspection for each type of tower as well as after satisfactory type testing of Tower at approved testing station.
 - d) The successful bidder shall give the AEML not less than 15 days advance notice, in writing or by e-mail, of the date when Proto model assembly of towers will be ready for inspection. The AEML reserves the right to waive the requirement for performing any or all inspections. The expenditure of proto-model inspection by AEML shall be borne by the bidder.
 - e) The successful bidder shall also arrange for tack welding of bolts & nuts up to the bottom cross arm including supply and application of zinc rich primer and two coats of enamel paint.

3.0 TOWER ACCESSORIES

3.1 Step Bolt Ladders

- 3.1.1 Each tower shall be provided with step bolts on one of the main legs, of not less

than 16mm diameter and 175 mm long, spaced not more than 450 mm apart and extending from about 3.5 meters above the ground level to the top of the tower. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN and shall be used as a ladder for climbing. The step bolts shall conform to IS: 10238 and shall have a hexagonal head.

3.1.2 Each tower accessories shall be supplied as per the below mentioned standards and DFCCIL/R-Infra general practices.

Number Plate	IS 5613 (Part 2/Sec-1)-1985
Danger Notice Plates	IS 2551 – 1983
Phase Plate	IS 5613 (Part 2/Sec-1) - 1985
Circuit Plate	IS 5613 (Part 2/Sec-1) - 1985
Anti-climbing Device	IS 5613 (Part 2/Sec-1) - 1985
Bird Guard (for suspension insulator string)	IS 5613 (Part 2/Sec-1) - 1985

3.2 Anti-Climbing Devices

Fully galvanized barbed wire type anti-climbing device shall be provided at a height of approximately 3 meters as an anti-climbing measure. Four layers of barbed wires will be provided each inside and outside the tower in horizontal plane, spacing between the layers being 140 to 150 mm. The angle pieces with 12mm x 12mm notches for accommodating barbed wire shall be supplied with the towers along with provision for suitable bolt holes on leg members for fitting the angles. The barbed wire shall conform to IS-378 (1978). The anti-climbing devices shall in general conform to fig.8 of IS: 5613 (Part-II/Sec-I).

3.3 Insulator String hangers

For the attachment of suspension insulator strings a suitable swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditions and free swinging of the string. The hanger shall be designed to withstand an ultimate tensile strength of more than 120 KN.

3.4 At tension towers, horizontal strain plates of suitable dimensions on the underside of each power cross-arm tip and at the top ground wire peak shall be provided for taking the 'D' shackles of the tension insulator strings or ground wire tension clamps, as the case may be.

3.5 Caution Plates, Number Plates, Circuit Plates and Bird Guards:

3.5.1 Each tower shall be fitted with Number Plates, Caution Plates (Danger Boards), Circuit plates and phase plates. These shall be provided at appropriate level from the ground level (about 2.5m to 3.5 m from ground level) so that the man standing at the foot ground tower will be able to clearly identify the same. These plates shall be 2 mm thick and vitreous enameled on both back and front.

3.5.2 The letters, figures and the conventional skull and bones on danger plates are in signal red on the front side. On the number plate, the number of the tower location preceded by the letters defining the type of the tower shall be inscribed. Phase plates shall be coloured red, yellow and blue to indicate the phase of the conductor. The letter on number plates shall be in red against white back ground. The number plates shall confirm to Fig.-5 of IS: 5613 (Part-

I/Sec-I). Similarly, the plates and circuit plates to Fig.6 & 7 in the said IS. The danger notice plates shall confirm to IS: 2551. Bird guards shall be of the saw tooth type and confirm to Fig.10 of IS (5613 Part-II/Sec-I).

4. OTOWER EARTHING (COUNTER POISE TYPE/SOLID ROD TYPE)

4.1 Scope

- a) The bidder shall supply the counter poise/solid rod earthing material as per drawings, documents in accordance with relevant codes, standards & local rules by law.
- b) The footing resistance of all towers shall be measured by the contractor in dry weather after tower erection but before the stringing of earth wire. All the towers are to be earthed; however, in no case tower footing resistance shall exceed 10 ohms. Solid rod (Pipe) type earthing and counterpoise type earthing wherever required shall be provided in accordance with the stipulations made in IS:3043-1987 and IS:5613 (part-II/section-2) 1985. The details for pipe and counterpoise type earthing are given in drawing enclosed with the specification
- c) The scope of supply for earthing system shall include transportation, loading/unloading of earthing material at site.

4.2 Codes, Standards & Regulations

All earthing work shall be in accordance with the following codes.

- IS: 3043 – Code of practice for earthing.
- Indian Electricity rules 1956
- IEEE Std. 524: Guide for installing the Overhead Transmission Line Conductor.
- IEEE Std. 1048: Guide for Protective grounding of Power lines.
- IS 5613

4.3 Technical Specification

- a) Counterpoise earthing
Counterpoise earthing consists of four lengths of galvanized steel stranded wires, each fitted with a lug for connection to the tower leg at one end. The wires are connected to arch of the legs and taken radially away from the tower and embedded horizontally 450 Mtr. Below ground level. The length of earth wire is normally limited to 15 M. The size of the galvanized steel stranded wire may be taken equal to sizes of the earth conductor. The counterpoise type earthing of tower shall be in accordance with IS 5613.
- b) Solid rod type Earthing :
Solid rod type earthing system shall consist of MS 40mm Dia. solid rod of 3000mm length which shall be hot deep galvanized. This rod shall be install inside earth pit of depth 3000mm and filled with treated material like charcoal, salt etc. which shall further lower the earth resistance. Entire Solid rod arrangement shall connect to Tower leg using Galvanized MS flat of size 50x6mm.
Earthing arrangement provided at tower locations shall have earth resistance less than 5 ohms after installation.

4.4 Acceptance Tests

Inspection of materials & Acceptance tests shall be conducted as per relevant standards in the presence of the AEML representative. The expenditure towards witnessing of acceptance test shall be borne by the successful bidder.

4.4.1 Tower Accessories

- Anti-Climbing Device
- Danger Plate
- Tower Phase Plate
- Tower Circuit Plate
- Tower Number Plate

4.4.2 Earthing of Tower

- Counter Poise Type Earthing
- Solid MS Rod Type Earthing