



TECHNICAL SPECIFICATION FOR DESIGN, SUPPLY, CONSTRUCTION & COMMISSIONING OF 400 kV D/C TRANSMISSION LINE ASSOCIATED WITH TRANSMISSION SYSTEM STRENGTHENING SCHEME FOR WR & NR

ISSUED BY

JABALPUR TRANSMISSION COMPANY LTD. (JTCL)
(A wholly owned subsidiary of IndiGrid Ltd.)

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TECHNICAL SPECIFICATION
TRANSMISSION LINE

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SCOPE FOR TRANSMISSION LINE

1 Scope

The following transmission line is included in the scope of the Contractor under this package:

- a) Diversion of 765kv d/c hexa zebra Dharamjaigarh-Jabalpur line from AP 66 to AP 67 for shifting / raising height of line between T.No. 222 & 229.

2 This Specification covers the following scope of works but not Limited to:

- (i) Detailed survey including route alignment, profiling, tower spotting, optimization of tower locations, soil resistivity measurement & geotechnical investigation (including special foundation locations viz. pile/well foundation locations, whenever applicable)
- (ii) Check survey including route alignment, finalization of tower spotting/ optimization of tower locations, and pit marking as per Employer approved excavation chart.
- (iii) Arranging of Right of way (ROW) and payment of compensation of crops, trees etc. arranging forest/PTCC, Railway crossing, power line crossing etc. and all other statutory clearances will be as per signed LOA
- (iv) Acquisition of all ROWs, obtaining statutory and other clearances/approvals from Govt. Agencies (Railways, PTCC, power line crossing etc.) and Electrical Inspectorate on behalf of the Employer will be as per signed LOA.
- (v) Dismantling of Existing conductor span between tower no. 222 and Tower no. 29 of both circuit and Dismantling of Tower no. 223,224,225,226,227& 228. Refer BOQ for Erection & Stringing quantity.
- (vi) Fabrication and supply of all types of transmission line towers including River crossing towers (wherever applicable) as per Contractors/Employers design/drawing including fasteners, step bolts, hangers, D-shackles, tower accessories etc.;
- (vii) Supply of all types of tower accessories viz., phase plate, circuit plate (Wherever applicable), number plate, danger plate, anti-climbing device and Bird guard (Wherever applicable);
- (viii) Supply of
 - a) Composite Long rod Insulators & it's Hardware Fittings
 - b) Conductor and Conductor Accessories
 - c) Earth wire and Associated accessories.
 - d) OPGW & associated accessories.
- (ix) For transmission lines, to promote mechanization and safe working conditions, use of crane is being promoted. Erection of towers by using

crane (wherever feasible), tack welding of bolts and nuts including supply and application of zinc rich paint, fixing of insulator strings, stringing of conductors and OPGW along with all necessary line accessories. However, where usage of crane is not possible, erection of towers has to be carried out by conventional method i.e. using Gin pole, Derrick, Centre mast etc. through usage of Power Operated Winch Machines. No tractor shall be allowed for tower erection.

- (x) Classification of foundation based on trial soil pit, backfilling, compaction, curing, for different type of tower and their approval by the owner. Benching, if necessary, Pit excavation, Template fitting, Stub setting, Casting of foundation, (including special foundation locations viz. pile/well foundation locations) for tower footings, revetment wall as per Contractor/Owner's foundation drawing approved by the Owner.
- (xi) Supply & Installation of Tower Earthing.
- (xii) Painting of towers & supply and erection of span markers, obstruction lights (wherever applicable) for aviation requirements (as required).
- (xiii) Testing and commissioning of the erected transmission lines.
- (xiv) Other items not specifically mentioned in this Specification but are required for the successful completion and commissioning of the transmission line, unless specifically excluded in the Specification.

3 The following is the general list of the documents and drawings that are to be approved by the Employer.

- (i) Work Schedule (Master Network) Plan.
- (ii) Detailed survey report and profile drawings showing ground clearance and tower locations (as applicable).
- (iii) Tower schedule and foundation classification for individual tower locations.
- (iv) All drawings/ documents which are developed by the contractor (Editable softcopy and Hardcopies)
- (v) Soil Investigation report.
- (vi) Tower footing earthing drawing.
- (vii) Stringing procedure & charts.
- (viii) Tower accessories drawings like danger plate, name plate etc.
- (ix) Quality plans for fabrication and site activities including Quality System.
- (x) Sub-Vendors approval.
- (xi) Line material drawings.
- (xii) Test report for line materials & Tower.

SPECIFICATION FOR CHECK SURVEY FOR TRANSMISSION LINE

1 General Information

The technical specifications cover detailed survey including route alignment, profiling, tower spotting, optimization of locations, check survey, contouring, and soil investigation for the transmission lines/ part of the transmission lines covered under this specification.

2 The scope of work shall include the following: -

- 2.0** Detailed Survey using Total station, DGPS or alternatively using ALTM (Airborne Laser Terrain Modeling) techniques, inter-alia including:
 - 2.1** Digitized profiling along the selected route along with plan details.
 - 2.2** Computer aided tower spotting & optimization
 - 2.3** Soil resistivity measurement along the route
 - 2.4** Check survey including digitized contouring at undulated / hilly tower locations.
 - 2.5** Soil Investigation
 - 2.6** Preparation of Survey reports including estimation of Bill of Quantities, identification and explanation of route constraints (like Forest, Animal/ Bird sanctuary, reserve coal belt areas, oil pipe line/ underground inflammable pipe lines etc.), infrastructure details available en-route etc.
 - 2.7** Collection of data/ details of ownership of land within the line corridor & tower base.
 - 2.8** The Provisional quantities for the scope of work are indicated in relevant Price Schedules of BPS. The final quantities for route alignment, detailed survey and check survey (quantities in "kms" unit) shall be as approved by Site Engineer-in-charge and shall be along the approved route alignment. For contouring at undulated/hilly tower locations and soil investigations (quantities in "Locs." unit), the actual quantities to be executed shall be decided by Site Engineer-in-charge during execution stage and the final quantities shall be as approved by Site Engineer-in-charge. The route alignment, detailed survey, including profiling & tower spotting, contouring, soil investigation, check survey etc. shall be carried out by the Contractor as per the technical specifications stipulated herein. Contractor shall indemnify the Employer for any loss or damage to properties, trees etc. during the survey work.
 - 2.9** The Contractor should note that Employer will not furnish topographical maps prepared by survey of India but will make available assistance that may be

required in obtaining these by providing letters of recommendation to the concerned authorities. Further, in case the contractor opts for use of ALTM techniques for detailed survey, he shall be responsible for obtaining necessary clearances/ permissions, as may be required from concerned authorities. The Employer will aid that may be required in obtaining these clearances / permissions by providing letters of recommendation to the concerned authorities.

- 2.10** The work shall be carried out by the contractor using modern surveying techniques. The bidder shall indicate in his offer, the detailed description of the procedure to be deployed. The details of the equipment & facilities including software for image processing, computer aided tower spotting etc. available with the bidder or his associates shall also be furnished with the bid.
- 2.11** The Contractor shall also engage services of a reputed geo-technical consultant or experts from independent educational/research institutions for examining stability aspects of the selected transmission line route/locations in hilly terrain wherever required.
- 2.12** After carrying out the detailed survey and soil investigations, the contractor shall submit complete BOQ of the transmission lines, Tower schedule, Profiles, Survey reports and other details as per technical specification requirements to the Employer.

3 Route Alignment

- 3.0** The route Alignment shall be carried out by the contractor using Survey of India topographical maps.
 - (i) Requirement of Transmission Line Routing
 - (ii) The Re-alignment/ routing, if any required, of the transmission line shall be most economical from the point of view of construction and maintenance. The contractor shall identify & examine alternative route alignments and suggest to the Employer the optimal route alignment.
 - (iii) Routing/ Re-routing of transmission line through protected/reserved forest area should be avoided. In case it is not possible to avoid the forests or areas having large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that involvement of forest area and cutting of trees is minimum.

- (iv) The route should have minimum crossings of Major river, Railway lines, National/ State highways, overhead EHV power line and communication lines. The number of angle points shall be kept to minimum. The distance between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.
- (v) Marshy and low-lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.
- (vi) It would be preferable to utilize level ground for the alignment.
- (vii) Crossing of power lines shall be minimum. Alignment of a transmission line with respect to existing line will be kept considering ROW and tower falling distance.
- (viii) Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them.
- (ix) Areas subjected to flooding such as Nala shall be avoided.
- (x) Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.
- (xi) All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.
- (xii) Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens & nurseries which will present the Employer problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided.
- (xiii) Angle points during survey should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.
- (xiv) The line routing should avoid large habitations, densely populated areas, Forest, Animal/Bird sanctuary, reserve coal belt areas, oil pipe line/underground inflammable pipe lines etc. to the extent possible.
- (xv) The areas requiring special foundations and those prone to flooding should be avoided.
- (xvi) For examination of the alternatives & identification of the most appropriate route, besides making use of information/ data/ details available/ extracted through Survey of India Topographical maps, the contractor shall also

carryout reconnaissance/ preliminary survey as may be required for verification & collection of additional information/ data/ details.

- (xvii) The contractor shall submit his preliminary observations & suggestions along with various information/ data /details collected, topographical map data marked with the alternative routes etc. The final evaluation of the alternative routes shall be conducted by the contractor in consultation with Employer's representatives and optimal route alignment shall be proposed by the contractor. Site visit and field verification shall be conducted by the contractor jointly with the Employer's representative for the proposed route alignment.
- (xviii) Final route alignment drawing with latest topographical and other details/ features including all rivers, railway lines, canals, roads etc. up to 8 km on both sides of selected route alignment shall be submitted by the contractor for Employer's approval along with report containing other information/details as mentioned above.
- (xix) Changes in the route alignment, if any, during detail survey, shall be incorporated in the final route alignment drawings.

4 Detailed Survey

- 4.0** The detailed survey shall be carried out using Total stations etc. along the approved route alignment. As an alternative, the contractor may also use ALTM (Airborne Laser Terrain Modeling) techniques of equal or better accuracy for the detailed survey.
- 4.1** Soil resistivity, along the route alignment shall be measured in dry weather by four electrode method keeping inter-electrode spacing of 50 meters. Measurement shall be made at every 2 to 3 km along the length of the route. In case soil characteristics changes within 2 to 3 km, values shall have to be measured at intermediate locations also. Megger reading and soil characteristics should also be indicated in the soil resistivity results.

5 Route Marking

- 5.0** The route of the transmission line shall be recorded using GPS/ DGPS of positional accuracy less than 3m.
- 5.1** The co-ordinates of all the angle points as well as other important crossings, landmarks etc. shall be recorded using GPS for easy relocating.

- 5.2** At the starting point of the commencement of route survey a suitable peg/spike shall be driven firmly into the ground to indicate location of the survey instrument. The co-ordinates of the location of the survey instrument shall also be recorded. Further, the co-ordinates at prominent position at intervals of not more than 750 meters along the transmission line to be surveyed up to the next angle point shall also be recorded. Wooden peg of 50x50x650mm size shall also be driven at prominent position at intervals of not more than 750 meters along the transmission line to be surveyed upto the next angle point. Wire nails of 50 mm length should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to project 100 mm only above ground level. Wherever the line alignment crosses the EHT line, Railway line, P&T line or roads, the contractor shall record co-ordinates on the points of crossing. Wherever line route alignment passes over permanent landmarks such as rock, boulders, culverts etc. suitable white paint marks with directional and DPTL markings shall be made and co-ordinates recorded. At angle positions stone / concrete pillars of 150x150x1000mm in size with DPTL marked on them shall be embedded into the ground for easy identification.

6 Profiling

- 6.0** The complete profiling along the route shall be carried out using modern surveying equipment viz. total stations. Reference levels at every 20 meters along the route are to be recorded. RLs at other undulations along the route as well as in the route plan and other En-route details viz. crossings, building & structures, trees & other infrastructure etc. shall also be recorded. Areas along the route, which in the view of the contractor, are not suitable for tower spotting, shall also be marked in profile. Any undulation keeping conductor location as reference may also be indicated as dotted line in profile.
- 6.1** The complete profiling details shall be digitized and the data shall be prepared & stored in the format compatible to computer-aided tower spotting software.
- 6.2** A printed/ plotted output of the digitized profiling shall be submitted by the contractor to Employer's site-in-charge for review before taking up computer-aided tower spotting.

7 Optimization of Tower Location/ Tower Spotting

- 7.0** Optimization of tower locations including profiling shall be done by the contractor using computer-aided tower spotting software - PLSCADD and shall furnish sample calculations and manual tower spotting drawings for some typical sections.
- 7.1** The sag-tension characteristics of the conductor as well as tower spotting data shall be furnished by the Employer to the contractor during execution stage. Sag template curves, if any required for tower spotting, shall be prepared by the contractor and two sets of sag-template curves shall be given to Employer for checking of profile.
- 7.2** General description of towers is indicated in Section – I of this specification for information of the Contractors.

8 Tower Spotting: While profiling & spotting the towers, the following shall be borne in mind:

8.0 Span

The number of consecutive spans between the section points shall not exceed 15 spans or 5 km in plain terrain and 10 spans or 3km in hilly terrain. A section point shall comprise of tension point with B/DB/QB type or C/DC/QC type or D/DD/QD type towers as applicable.

8.1 Extension/Truncation

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations inground profile, one or both the supports of the span may be extended by inserting standard body/ leg extension. In case of locations where the ground clearance is available, truncated towers may be spotted. The provisions kept in the design of towers w.r.t. body/ leg extensions, truncations shall be intimated to the contractor by the Employer during execution stage.

8.2 Loading

There shall not be any upward force on suspension towers under normal working conditions and the suspension towers shall support at least the minimum weight span as provided in the designs. In case uplift is unavoidable, it shall be examined if the same can be overcome by adding standard body

extensions to the towers failing which tension towers designed for the purpose shall be deployed at such positions.

8.3 Road Crossing

At all important road crossings, the tower shall be fitted with normal suspension and tension insulator strings depending on the type of tower, but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, ground clearance of the conductor from the road surfaces will not be less than specified minimum ground clearances. At all national highways, D/DD/QD type towers tension insulator strings shall be used and crossing span will not be more than 250 meters, unless higher span is permitted by national highways authority in case of highways having more lanes.

8.4 Railway Crossings

All the railway crossings coming En-route the transmission line shall be identified by the Contractor. At the time of detailed survey, the railway crossings shall be finalized based on the following and confirming to the regulation laid down by the Railway Authorities.

- (i) The crossings shall be supported on D/DD/QD type tower on either side.
- (ii) The crossing shall normally be at right angle to the railway track.
- (iii) The minimum horizontal distance measured at right angles from the center of nearest track to any part of a structure (all structures shall be rigid and well founded), carrying electrical conductors crossing a railway shall be equal to the height of the structure in meters above normal ground level plus 6 meters.
- (iv) No crossing shall be located over a booster transformer, traction switching station, traction sub-station, Overlap Section or a track cabin location in an electrified area. 0 % of the normal span for which the structure is designed whichever is less.
- (v) Minimum ground clearance between crossing conductor under condition of maximum sag and railway line shall maximum of following:
 - a) Vertical Clearance for OHE (other than high rise OHE):

Sl. No.	Transmission line voltage level	Minimum clearances from Rail Level
		New Power Line Crossing or Crossing Planned for Alteration
1	110kV	15.56 m
2	132kV	15.56 m
3	220kV	16.46 m
4	400kV	18.26 m
5	765kV	21.86 m

b) Vertical Clearance for high rise OHE:

Sl. No.	Transmission line voltage level	Minimum clearances from Rail Level
		New Power Line Crossing or Crossing Planned for Alteration
1	110kV	17.56 m
2	132kV	17.56 m
3	220kV	18.46 m
4	400kV	20.26 m
5	765kV	23.86 m

Note: Applicable only for electrification of routes where double stack container having maximum height of 6809mm is plying.

c) Minimum Clearances between Highest Traction Conductor & Lowest Crossing Conductor

Sl No.	Transmission line voltage level	Minimum Clearances between Highest Traction Conductor & Lowest Crossing Conductor
1	Above 66 kV & upto 132 kV	3.05 m
2	Above 132 kV & upto 220 kV	4.58 m
3	Above 220 kV & upto 400 kV	5.49 m
4	Above 400 kV & upto 500 kV	7.94 m
5	Above 500 kV & upto 800 kV	7.94 m

9 River Crossings

In case of major river crossing, river crossing towers shall be of suspension type alongwith anchor towers of D/DD/QD type tower on either side of the main river crossing. Alternately on the basis of economics and / or site/ execution constraints crossing of rivers using normal extended angle towers (+18/+25/+30M Extensions) also shall be considered. For navigable rivers, clearance required by navigation authority shall be provided. For non-navigable river, clearance shall be reckoned with respect to highest flood level (HFL).

10 Power line Crossings

- 10.0** Where the line is to cross over another line, towers with suitable extensions may be used, depending upon the merit of the prevailing site condition.
- 10.1** For power line crossing of 400 kV or above voltage level, large angle & dead-end towers (i.e. D/DD/QD) shall be used on either side of power line crossing (i.e. D/DD/QD- D/DD/QD arrangement).
- 10.2** For power line crossing of 132 kV and 220 kV voltage level, angle towers (B/C/D/DB/DC/DD/ QB/QC/QD) shall be used on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.
- 10.3** For power line crossing of 66 kV and below voltage level, suspension/tension towers shall be provided on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.
- 10.4** In case of crossing with B/C/DB/DC/QB/QC towers proper guying shall be provided to facilitate stringing of the power line crossing sections separately on obtaining line shutdowns.
- 10.5** Clearance between lines crossing each other shall be kept in accordance with the CEA (Measures Relating to Safety and Electric Supply) Regulations, 2010 as amended up to date. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground-wire of the line to be crossed (if this is possible and permitted by the Employer of the line to be crossed).
- 10.6** Minimum clearance in meters between lines when crossing each other:

Sl. No.	Voltage Level	110-132 kV	220 kV	400 kV	765 kV	500 kV HVDC	800 kV HVDC	1200 kV
1	110-132KV	3.05	4.58	5.49	7.94	6.86	9.04	10.44
2	220KV	4.58	4.58	5.49	7.94	6.86	9.04	10.44
3	400KV	5.49	5.49	5.49	7.94	6.86	9.04	10.44
4	765KV	7.94	7.94	7.94	7.94	7.94	9.04	10.44
5	500KV HVDC	6.86	6.86	6.86	7.94	7.94	9.04	10.44
6	800KV HVDC	9.04	9.04	9.04	9.04	9.04	9.04	10.44
7	1200 KV	10.44	10.44	10.44	10.44	10.44	10.44	10.44

11 Telecommunication Line Crossings

- 11.0** The angle of crossing shall be as near to 90 degree possible. However, deviation to the extent of 30 degree may be permitted under exceptionally difficult situations.
- 11.1** When the angle of crossing has to be below 60 degree, the matter will be referred to the authority in charge of the telecommunication System. On a request from the Contractor, the permission of the telecommunication authority may be obtained by the Employer.
- 11.2** Also, in the crossing span, power line support will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

12 Oil Pipe-Line Crossings

Wherever transmission line crosses an oil/gas pipeline, the angle of crossing shall be as near to 90 degree possible. Further, a minimum separation of 3m should be maintained between pipeline and transmission line footings & pipe/ counterpoise earthing.

13 Details En-route

All topographical details, permanent features, such as trees, building etc. within following distance on either side of the alignment shall be detailed on the profile plan:

Sl No	Voltage Level	ROW (One side) from center line
1	1200 kV Single Circuit	44.5 m
2	765 kV Double Circuit	33.5 m

3	765kV Single Circuit Delta	32 m
4	765kV Single Circuit Horizontal	42.5 m
5	± 800 kV HVDC	34.5 m
6	400kV Single Circuit	26.0 m
7	400kV Double Circuit	23.0 m
8	± 500 kV HVDC	26.0 m
9	220 kV	17.5 m
10	132 kV	13.5 m

14 Clearance from Ground, Building, Trees etc.

- 14.0** Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the CEA's Regulations 2010 (Measures relating to Safety and Electric Supply).
- 14.1** The Contractor shall count, mark and put proper numbers with suitable quality of paint at his own cost on all the trees that are to be cut by the Employer at the time of actual execution of the work as detailed below. Contractor may please note that Employer shall not pay any compensation for any loss or damage to the properties or for tree cutting due to Contractor's work.
- 14.2** To evaluate and tabulate the trees and bushes coming within following distance on either side of the central line alignment the trees will be numbered and marked with quality paint serially from angle point 1 (I) onwards and the corresponding number will be painted on the stem of trees at a height of 1 meter from ground level. The trees list should contain the following:

Sl No	Voltage Level	ROW (One side) from center line
1	1200 kV Single Circuit	44.5 m
2	765 kV Double Circuit	33.5 m
3	765kV Single Circuit Delta	32 m
4	765kV Single Circuit Horizontal	42.5 m
5	± 800 kV HVDC	34.5 m
6	400kV Single Circuit	26.0 m
7	400kV Double Circuit	23.0 m
8	± 500 kV HVDC	26.0 m
9	220 kV	17.5 m
10	132 kV	13.5

(i) Girth (circumstances) measured at a height of 1 meter from ground level.

(ii) Approximate height of the tree with an accuracy of +2 meters.

(iii) Name of the type of the species/tree.

The bushy and under growth encountered within following distance should also be evaluated with its type, height, girth, and area in square meters, clearly indicating the growth in the tree/bush statement: -

Sl No	Voltage & Circuit	Right of Way (m)
1	1200 kV Single Circuit	89 m
2	765 kV Double Circuit	67 m
3	765kV Single Circuit Delta	64 m
4	765kV Single Circuit Horizontal	85 m
5	± 800 kV HVDC	67 m
6	400kV Single Circuit	52 m
7	400kV Double Circuit	46 m
8	± 500 kV HVDC	46 m
9	220 kV	35 m
10	132 kV	27m

14.3 The contractor shall also intimate the Employer, his assessment about the likely amount of tree & crop compensation etc. required to be paid by the Employer during execution stage. This assessment shall be done considering prevailing practices/guidelines, local regulations, and other enquiries from local authorities.

14.4 The contractor shall also collect data/ details of ownership of land within the line corridor and tower base from the concerned revenue/ local authorities and submit the same to owner as per format enclosed with this technical specification at Annexure-E.

14.5 The Contractor shall also identify the forest/ non-forest areas involved duly authenticated by concerned authorities.

- (i) A statement of forest areas with survey/ compartment Number (all type of forest RF/ PF / Acquired forest/ Revenue forest/ Private forest/ Forest as per dictionary meaning of forest etc.)
 - (ii) A statement of non-forest areas with survey/ compartment nos.
 - (iii) Tree cutting details (Girth wise & specie wise)
 - (iv) Marking of forest areas with category on topo sheets 1:2,50,000 showing complete line route, boundaries of various forest divisions and their areas involved.
 - (v) Village forest maps of affected line and affected forest area and marking of the same.
 - (vi) Forest division map showing line and affected forest area.
- 14.6** The Contractor shall finalize the forest clearance proposal on the prescribed format, as per requirements of the state/ MOE & F, duly completed in all respects for submission by the Employer to the Forest Department.
- 14.7** Preliminary Schedule
- The profile sheets showing the locations of the towers together with preliminary schedules of quantities indicating tower types, wind & weight spans, angle of deviation, crossing & other details etc. shall be submitted by the contractor for review & approval by Employer's site-in-charge.

15 Check Survey of Tower Locations

- 15.0** The check survey shall be conducted to locate tower locations on ground conforming to the approved profile and tower schedule.
- 15.1** The co-ordinates of all the tower locations shall also be recorded using GPS / DGPS of positional accuracy less than 3m for easy relocating. The position of all tower locations shall be marked in the final digitized route alignment drawing with relative distances from any permanent benchmark area.
- 15.2** The contractor shall also collect required data at each tower location in respect of soil strata, ground water level, history of water table in adjacent areas/surface water, distance from permanent bench mark (these details to be furnished in a tabulated form) and classify the suitable type of foundation at each tower location based on the data collected at each location and detailed soil investigations carried out at selected locations etc.

16 Contouring at hilly/ undulated locations

- 16.0** The levels up or down of each pit center with respect to center of tower location shall be recorded at intervals of 2m using total stations/GPS/digital theodolite and digitized contour plans shall be made. Based on the digitized elevation plans, the quantities of benching & protection work vis-à-vis possible unequal leg extensions shall be optimized using suitable computer-aided techniques/software or manual method. Required tower and foundation details, cost data for comparative valuation for benching & protection work vis-à-vis unequal leg extensions shall be provided by the Employer to the Contractor during execution stage.
- 16.1** The changes desired by the Employer in the preliminary tower schedule or as may be required based on detailed survey of tower locations & contouring by the contractor, shall be carried out by the contractor and the final tower schedule shall be submitted for approval of Employer. The tower schedule shall show position of all type of towers, span length, type of foundation for each tower, benching & revetment requirement, unequal leg extensions, deviation at all angles, crossings & other details.

17 Survey Methodology & Precision

- 17.0** All elevations shall be referenced to benchmarks established by the survey of India. Survey operations shall begin and end at benchmarks approved by the Employer.
- 17.1** During the leveling of the profile, check surveys will be affected at intervals not exceeding 50kms. with benchmarks of known elevations. The difference in elevations as surveyed by the contractor and as declared by Survey of India for these benchmarks shall not exceed the precision required for 3rd order surveys $e \leq 24k$ where k is the distance between benchmarks in km and e is the difference between elevations in mm.
- 17.2** In the absence of suitable benchmarks, the leveling shall be done by two independent leveling parties working in opposite directions along the same line. The difference in elevations between the two surveys shall not exceed the precision required for 3rd order surveys as stated above.
- 17.3** All-important objects and features along the transmission line centerline (railways,

- 17.4** highways, roads, canals, rivers, transmission lines, distribution lines, telephone lines etc.) shall be surveyed and located with a positional accuracy of 1:2000 between points of known horizontal position.

18 Survey Report

- 18.0** Complete BOQ of the transmission lines as per format enclosed with this technical specification at Annexure-A shall be furnished in the survey report.
- 18.1** Each angle point locations shall be shown with detailed sketches showing existing close by permanent landmarks such as specific tree(s), cattle shed, homes, tube wells, temples, electric pole/ tower, telephone pole, canal, roads, railway lines etc. The relative distance of land marks from the angle points and their bearings shall be indicated in the sketch. These details shall be included in the survey report.
- 18.2** Information w.r.t infrastructure details available en-route, identification, and explanation of route constraints, etc. shall also be furnished in the Survey report and shall inter-alia include the following:
- 18.3** Information regarding infrastructural facilities available along the final route alignment like access to roads, railway stations, construction material sources (like quarry points for stone, sand and availability of construction water), labour, existing transport facilities, fuel availability etc. shall be furnished in the survey report.
- 18.4** All observations which the Contractor thinks would be useful to the construction of the transmission lines mentioned under scope of work are to be reported.
- 18.5** Suggestions regarding the number of convenient zones (line segments/ portions) in which the entire alignment can be divided keeping in view the convenience of construction/project implementation are to be given.
- 18.6** Suggestions regarding location for setting up stores during line construction in consultation with Employer's representative shall also be provided by the contractor.
- 18.7** Working months available during various seasons along the final route alignment, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.

- 18.8** Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc.
- 18.9** All the requisite data for processing the case for statutory clearances such as PTCC, Forest and Railway shall be provided along with the report.
- 18.10** The contractor shall also collect & report (as per Formats enclosed at B) details pertaining to pollution levels envisaged along the transmission line.
- 18.11** Four copies of survey reports shall be furnished by the contractor to the Employer.

TECHNICAL SPECIFICATION FOR GEOTECHNICAL INVESTIGATION (Transmission Lines Tower Foundations)

1 General

Geotechnical investigation shall be carried out at various tower locations to provide the designer with sufficiently accurate information, both general and specific, about the substrata profile and relevant soil and rock parameters at site based on which the foundation of transmission line towers can be classified and designed rationally. This specification provides general guidelines for geotechnical investigation of normal soils. Cases of marshy locations and locations affected by salt water or saltpeter shall be treated as special locations and the corresponding description in these specifications shall apply. Any other information required for such locations shall be obtained by Contractor and furnished to Employer.

2 Scope

- 2.0** The scope of work includes detail soil investigations and furnishing bore log data at various tower locations. The provisional quantities have been indicated in Bill of Quantities. However, during actual execution of work, the quantities shall be decided by the Engineer- in-Charge, depending upon the soil strata and terrain. Based on the bore log data/soil parameter/soil investigation results, the Contractor shall recommend the type of foundations suitable for each location and the same shall be approved by the Employer. For other locations, trial pit is to be done in every location for foundation classification up to foundation depth. No separate payment for trial pit shall be done.
- 2.1** These specifications cover the technical requirements for a detailed Geotechnical investigation and submission of a detailed Geotechnical Report. The work shall include mobilization of all necessary tools and equipment, provision of necessary engineering supervision and technical personnel, skilled and unskilled labor, etc. as required to carry out the entire field investigation as well as laboratory tests, analysis and interpretation of data collected and preparation of the Geotechnical Report. Contractor shall also collect data regarding variation of subsoil water table along the proposed line route. The work shall be supervised by a graduate in civil Engineering having at least 5 years of site experience/ Diploma in civil Engineering having at least 8 years of site experience in geotechnical investigation work.
- 2.2** Contractor shall make his own arrangements to establish the co-ordinate system required to position boreholes, test pits and other field test

locations as per the drawings/sketches supplied by Employer. Contractor shall determine the reduced levels (R. L's) at these locations with respect to benchmarks used in the detailed survey. Two reference lines shall be established based on survey data/details. Contractor shall provide at site all required survey instruments to the satisfactions of Employer so that the work can be carried out accurately according to specifications and drawings. Contractor shall arrange to collect the data regarding change of course of rivers, major natural streams and nalas, etc., encountered along the transmission line route from the best available sources and shall furnish complete hydrological details at the tower location including maximum velocity discharge, highest flood level (H.F.L), scour depth etc. of the concerned rivers, major streams and nalas (canals).

- 2.3** Field and laboratory data shall be recorded on the proforma recommended in relevant Indian Standards. Contractor shall submit to Employer, two copies of field bore logs (one copy each to Employer's site and Corporate Office) and all the field records (countersigned by Employer) soon after the completion of each boreholes/test.
- 2.4** Whenever Contractor is unable to extract undisturbed samples, he shall immediately inform Employer. Payment for boring charges shall be subject to Employer being satisfied that adequate effort has been made to extract undisturbed samples. Special care shall be taken for locations where marshy soils are encountered and Contractor in such cases shall ensure that specified number of vane shear tests are performed, and the results correlated with other soil parameters.
- 2.5** All the laboratory tests shall be carried out in the Govt. Engineering College/ NABL approved labs only. One copy of all field records and laboratory test results along with soil investigation reports shall be sent to Employer. Employer may witness the laboratory testing procedures.
- 2.6** The Contractor shall interact with Employer to get acquainted with the different types of structures envisaged and in assessing the load intensities on the foundation for the various types of towers in order to enable him to make specific recommendation for the depth, founding strata, type of foundation and the allowable bearing pressure.
- 2.7** After reviewing Contractor's geotechnical investigation draft report, Employer will call for discussions, to be held normally within one week at Employer's site Office, in order to comment on the report in the presence

of Contractor's Geotechnical Engineer. Any expenditure associated with the redrafting and finalizing the report, traveling etc. shall be deemed included in the rates quoted for the geotechnical investigations.

- 2.8** Contractor shall carry out all work expressed and implied in these specifications in accordance with requirements of the specification.
- 2.9** The contractor shall prepare and submit soil profile along the transmission line route (in digitized form, with digitized route alignment drawing as base) indicating salient soil characteristics / features, water table etc. based on detailed soil investigations and other details / information collected during detailed survey.

3 General Requirements

- 3.0** Wherever possible, Contractor shall research and review existing local knowledge, records of test pits, boreholes, etc., types of foundations adopted and the behavior of existing structures, particularly those like the present project.
- 3.1** Contractor shall make use of information gathered from nearby quarries, unlined wells excavation etc. Study of the general topography of the surrounding areas will often help in the delineation of different soil types.
- 3.2** Contractor shall gather data regarding the removal of overburden at the tower location area either by performing test excavations, or by observing soil erosion or landslides to estimate reconsolidation of the soil strata. Similarly, data regarding recent landfills shall be studied to determine the characteristics of such land fill as well as the original soil strata.
- 3.3** The water level in neighboring streams and water courses shall be noted. Contractor shall make enquiries and shall verify whether there are abandoned underground works

e.g. worked out ballast pits, quarries, old brick fields, mines, mineral workings etc.
- 3.4** It is essential that equipment and instruments be properly calibrated at the commencement of the work. If Employer so desires, the contractor shall arrange for having the instruments tested at an approved laboratory at its cost and shall submit the test reports to the Employer. If Employer desires to witness such tests, Contractor shall arrange for the same.

4 Codes and Standards for Geotechnical Investigations

4.0 All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of conflict between the present specifications and those referred to herein, the former shall prevail. Internationally accepted standards which ensure equal or higher performance than those specified shall also be accepted.

All work shall be carried out in accordance with the following Indian Standards and Codes:

Indian Standard (Latest)	Title	International Standard / Code
IS:1080	Codes of Practice for Design and Construction of Simple Spread Foundations.	
IS:1498	Classification and Identification of Soils for General Engineering purposes.	ASTM D 2487 ASTM D2488
IS:1892	Code of Practice for Subsurface Investigation for Foundation	
IS:1904	Code of Practice for Design and Construction of foundation in Soils: General Requirements	
IS:2131	Method of Standard Penetration Test for Soils	ASTM D 1586
IS:2132	Code of Practice for Thin Walled Tube Sampling of Soils	ASTM D 1587
IS:2720	Method of Test for Soils (Relevant Parts)	ASTM D 420
IS:2809	Glossary of Terms and symbols Relating to Soil Engineering	ASTM D 653
IS:2911	Code of Practice for Design and construction of Pile Foundations (Relevant Parts).	
IS:3025	Methods of Sampling and Testing (Physical and Chemical) for water used in Industry	
IS:3043	Code of Practice for Earthing	
IS:4078	Code of Practice for Indexing and Storage of Drill Cores.	

Indian Standard (Latest)	Title	International Standard / Code
IS:4091	Code of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles.	
IS:4434	Code of Practice for In-situ Vane Shear Test for Soil	ASTM D 2573
IS:4453	Code of Practice for Exploration by Pits, Trenches Drifts and Shafts.	
IS:4464	Code of Practice for Presentation of Drilling information and core description in Foundation investigation	
IS:4968-Part II	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry.	
IS:5313	Guide for Core Drilling observations.	
IS:6403	Code of Practice for Determination of Allowable Bearing Pressure on Shallow Foundation.	ASTM D 194
IS:6926	Code of Practice for Diamond Core Drilling for Site Investigation for River Valley Projects.	
IS:6935	Method of Determination of Water level in a Bore Hole.	
IS:7422	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant parts).	
IS:8009-Part I	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS:8764	Method of Determination of Point Load Strength Index of Rocks.	
IS:9143	Method of Determination of Unconfined Compressive Strength of Rock Materials.	ASTM D 2938
IS:9179	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS:9259	Specification for Liquid Limit Apparatus.	ASTM D 4318
IS:9640	Specification for Split Spoon Sampler.	ASTM D 1586

Indian Standard (Latest)	Title	International Standard / Code
IS:10050	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS:11315 -Part II	Description of Discontinuities in Rock Mass - Core Recovery and Rock Quality.	

5 Field Investigation for Soils

5.0 Boring

Boreholes are required for detailed soil investigations. Boreholes shall be made at every tower location.

5.1 Terrain types

- (i) Different types of terrain where towers are expected to be erected are listed below:
 - a) Cultivated field, on plain terrain
 - Rice producing
 - Non rice producing
 - b) Barron lands, non-cultivated fields (but not hills)
 - c) Forests on plain terrain
 - d) Hilly terrain
 - Having greenery (Forests)
 - Cultivated fields (Paddy or non-paddy)
 - Barron land on fill
 - Snow
 - e) Underwater
 - Within river/nallah/dam
 - Riverbanks getting submerged during rainy season
 - Creek area/Pond

- Canal crossing
- f) Marshy land
- g) Area having black cotton soil
- h) Normal land within the vicinity (1 Km) of sea
- i) Rocky area
- j) Any other location not covered above

6 General Requirements

- 6.0** Boreholes shall be made to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and for conducting laboratory tests. The minimum diameter of the borehole shall be 150mm and boring shall be carried out in accordance with the provisions of IS:1892 and the present specification.
- 6.1** All boreholes shall be 15m deep for normal soil conditions. The depth of boreholes at river crossings and special locations shall be 40m. If a stratum is encountered where the Standard Penetration Test Records N values greater than 100, with characteristics of rock, the borehole shall be advanced by coring at least 3m further in normal locations and at least 7m further for the case of river crossing locations with prior approval of Employer. When the boreholes are to be terminated in soil strata an additional Standard Penetration Test shall be carried out at the termination depth. No extra payment shall be made for carrying out Standard Penetration Tests.
- 6.2** Casing pipe shall be used when collapse of a borehole wall is probable. The bottom of the casing pipe shall at all times be above the test of sampling level but not more than 15cm above the borehole bottom. In case of cohesionless soils, the advancement of the casing pipe shall be such that it does not disturb the soil to be tested or sampled. The casing shall preferably be advanced by slowly rotating the casing pipe and not by driving.
- 6.3** In-situ tests shall be conducted, and undisturbed samples shall be obtained in the boreholes at intervals specified hereafter. Representative disturbed samples shall be preserved for conducting various identification tests in the laboratory. Water table in the bore hole shall be carefully

recorded and reported following IS:6935. No water or drilling mud shall be used while boring above ground water table. For cohesion less soil below water table, the water level in the borehole shall always be maintained slightly above the water table.

- 6.4** The borehole shall be cleaned using suitable tools to the depth of testing or sampling, ensuring least or minimum disturbance of the soil at the bottom of the borehole. The process of jetting through an open tube sampler shall not be permitted. In cohesive soils, the borehole may be cleaned by using a bailer with a flap valve. Gentle circulation of drilling fluid shall be done when rotary mud circulation boring is adopted.
- 6.5** On completion of the drilling, Contractor shall back fill all bore holes as directed by Employer.

7 Auger Boring

Auger boring may be employed in soft to stiff cohesive soils above the water table. Augers shall be of helical or post hole type and the cuttings brought up by the auger shall be carefully examined in the field and the description of all strata shall be duly recorded in the field bore log as per IS:1498. No water shall be introduced from the top while conducting auger boring.

8 Shell and Auger Boring

Shell and auger boring may be used in all types of soil which are free from boulders. For cohesion less soil below ground water table, the water level in the borehole shall always be maintained at or above ground water level. The use of chisel bits shall be permitted in hard strata having SPT-N value greater than 100. Chisel bits may also be used to extend the bore hole through local obstructions such as old construction. Boulders rocky formations, etc. The requirements in Clause 5.1.2 shall apply for this type of boring.

9 Rotary Drilling with mud circulation

- 9.0** Rotary drilling with mud circulation may be used in all types of soil below water table. In this method the boring is carried out by rotating the bit fixed at the lower end of the drill rod. Proper care shall be taken to maintain firm contact between the bit and the bottom of the borehole. Bentonite or drilling mud shall be used as drilling fluid to stabilize and protect the inside surface of the borehole.

- 9.1** Any other proposed method of boring other than the specified methods herein may be acceptable in case found suitable for the type of soils encountered at site but only after approval by Employer's Design Engineer/Engineer in-charge.

10 Standard Penetration Test (SPT)

- 10.0** This test shall be conducted in all types of soil deposits encountered within a borehole, to find the variation in the soil stratification by correlating with the number of blows required for unit penetration of a standard penetrometer. Structure sensitive engineering properties of cohesive soils and silts such as strength and compressibility shall not be inferred based on SPT values.

- 10.1** The test shall be conducted at depths as follows:

Location	Depths (m)
Normal locations	2.0, 3.0, 5.0, 7.0, 10.0, 13.0, 15.0
River Crossings and Special locations	2.0, 3.0, 5.0, 7.0, 10.0 and thereafter at the rate of 3m intervals to 40m

- 10.2** The spacing between the levels of standard penetration test and next undisturbed sampling shall not be less than 1.0m. Equipment, accessories, and procedures for conducting the test and for the collection of the disturbed soil samples shall conform to IS:2131 and IS:9640 respectively. The test shall be conducted immediately after reaching to the test depth and cleaning of bore hole.
- 10.3** The test shall be carried out by driving a standard split spoon sampler in the bore hole by means of a 650N hammer having a free fall of 0.75 m. The sample shall be driven using the hammer for 450mm recording the number of blows for every 150mm. The number of blows for the last 300mm drive shall be reported as N value.
- 10.4** This test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25 mm for 50 blows after confirmation from Employer Design Engineer/Engineer in-charge. At the level where the test is discontinued, the number of blows and the corresponding penetration shall be reported. Enough quantity of disturbed soil samples shall be collected from the split spoon sampler for identification and laboratory testing. The sample shall be visually classified and recorded at the site as well as properly preserved without loss of moisture content and labelled.

11 Sampling

11.0 General

- (i) Sufficient soil samples shall be collected. Disturbed soil samples shall be collected for soil identification and for conducting tests such as sieve analysis, index properties, specific gravity, chemical analysis etc. Undisturbed samples shall be collected to estimate the physical bearing capacity and settlement properties of the soil.
- (ii) All accessories and sampling methods shall conform to IS:2132: all disturbed and undisturbed samples collected in the field shall be classified at site as per IS:1498.
- (iii) All samples shall be identified with date, borehole or test pit number, depth of sampling, etc. The top surface of the sample in-situ shall also be marked. Care shall be taken to keep the core and box samples vertical, with the mark directing upwards. The tube samples shall be properly trimmed at one end and suitably capped and sealed with molten paraffin wax. The Contractor shall be responsible for packing, storing in a cool place and transporting all the samples from site to the laboratory within seven days after sampling with probe, protection against loss and damage.

11.1 Disturbed Samples

- (i) Disturbed soil samples shall be collected in boreholes at regular intervals. Jar samples weighing approximately 1 kg shall be collected at 0.5m intervals starting from a depth of 0.5m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be stored immediately in airtight jars which shall be filled as much as possible.
- (ii) In designated borrow areas, bulk samples, from a depth of about 0.5m below ground level shall be collected to establish the required properties for use as a fill material. Disturbed samples weighing about 25kg (250N) shall be collected at shallow depths and immediately stored in polythene bags as per IS:1892. The bags shall be sealed properly to preserve the natural moisture content of the sample and placed in wooden boxes for transportation.

11.2 Undisturbed Samples

- (i) In each borehole undisturbed samples shall be collected at every change of strata and at depths as follows:

Location	Depths (m)
Normal locations	1.0, 4.0, 6.0, 8.0, 11.0, 14.0
River Crossings and Special locations	1.0, 4.0, 6.0, 8.0, 11.0 and thereafter at the rate of 3m intervals to 38m

- (ii) The spacing between the top levels of undisturbed sampling and standard penetration testing shall not be less than 1.0m. Undisturbed samples shall be of 100mm diameter and 450mm in length. Samples shall be collected in a manner to preserve the structure and moisture content of the soil. Accessories and sampling procedures shall conform to IS:1892 and IS:2132

- a) Undisturbed sampling in cohesive soil:

Undisturbed samples in soft to stiff cohesive soils shall be obtained using a thin walled sampler. To reduce the wall friction, suitable precautions, such as oiling the surfaces shall be taken. The sampling tube shall have a smooth finish on both surfaces and a minimum effective length of 450mm. The area ratio of sampling tubes shall be less than 12.5%. However, in case of very stiff soils area ratio up to 20% shall be permitted.

- b) Undisturbed sampling in very loose, saturated, sandy and silty soils and very soft clays: Samples shall be obtained using a piston sampler consisting of a cylinder and piston system. In soft clays and silty clays, with water standing in the casing pipe, piston sampler shall be used to collect undisturbed samples in the presence of expert supervision.

- c) Accurate measurements of the sampling depth, dimensions of sampler, stroke and length of sample recovery shall be recorded. After the sampler is pushed to the required depth, the cylinder and piston system shall be drawn up together, preventing disturbance and changes in moisture content of the sample.

- d) Undisturbed sampling in cohesion less soils:

Undisturbed samples in cohesion less soils shall be obtained in accordance with IS:8763. Sampler operated by compressed air

shall be used to sample cohesion less soils below ground water table.

12 Ground Water

12.0 One of the following methods shall be adopted for determining the elevation of ground water table in boreholes as per IS:6935 and the instructions of Employer:

- (i) In permeable soils, the water level in the borehole shall be allowed to stabilize after depressing it adequately by bailing before recording its level. Stability of sides and bottom of the boreholes shall always be ensured.
- (ii) For both permeable and impermeable soils, the following method shall be suitable. The borehole shall be filled with water and then bailed out to various depths. Observations on the rise or fall of water level shall be made at each depth. The level at which neither fall nor rise is observed shall be considered the water table elevation and confirmed by three successive readings of water level taken at two hours interval.

12.1 If any variation of the ground water level is observed in any specific boreholes, the water level in these boreholes shall be recorded during the field investigation. Levels in nearby wells, streams, etc., if any, shall also be noted in parallel.

12.2 Subsoil water samples

- (i) Subsoil water samples shall be collected for performing chemical analysis. Representative ground water samples shall be collected when first encountered in boreholes and before the addition of water to aid boring or drilling.
- (ii) Chemical analysis of water samples shall include determination of pH value, turbidity, sulphate, carbonate, nitrate and chloride contents, presence of organic matter and suspended solids as per IS:456. Chemical preservatives may be added to the sample for cases as specified in the test methods or in applicable Indian Standards. This shall only be done if analysis cannot be conducted within an hour of collection and shall have the prior written permission and approval of Employer.

13 Dynamic Cone Penetration Test (only at Special locations)

13.0 With bentonite slurry

- (i) Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity of granular soils, etc. The test shall be conducted to the specified depth or refusal, whichever comes first. Refusal shall be considered when the blow count exceeds 100 for 300mm penetration. Equipment, accessories test procedures, field observations and reporting of results shall conform to IS:4968, Part-II. The driving system shall comprise of a 650 N weight hammer having a free fall of 750mm. The cone shall be of 60° and of 65mm diameter provided with vents for continuous flow of bentonite slurry through the cone and rods to avoid friction between the rods and soil. On completion of the test the results shall be presented as a continuous record of the number of blows required for every 300mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300mm penetration vs. depth. On completion of the test, the results shall be presented on the proforma approved by Employer.

13.1 Without bentonite slurry

- (i) This test shall be conducted with 50mm diameter 60° cone fitted loosely to the driving rod through a cone adapter. The cone shall be driven into the soil by allowing 650 N weight hammer top fall freely through a height of 750mm each time. The number of blows for every 75mm penetration shall be recorded. The process shall be repeated till the cone is driven to the required depth. The penetration depth shall be limited to 5m in cohesion less soil and 10m in mixed soil with some binding material. The cone driving rods, driving head, hoisting equipment shall conform to IS: 10589. The test report should be prepared as per guidelines of IS: 4968 (Part I).

13.2 Vane Shear Test. (required for boreholes where UDS is not possible) (Only at Special Locations)

Field vane shear test shall be performed inside the borehole to determine the shear strength and bearing capacity of cohesive soils, especially of soft and sensitive clays, which are highly susceptible to sampling disturbance. Equipment, accessories, test procedures, field observations shall correspond to IS:4434. Tests may also be conducted by direct penetration from ground surface. If the cuttings at the test depth in the borehole show any presence of gravel, sand shells,

decomposed wood, etc., which are likely to influence the test results substantially, the test at that depth may be omitted with the permission of Employer. However, the test shall be conducted at a depth where these obstructions cease to occur. On completion of the test, the results shall be reported in an approved proforma as specified in IS:4434

14 Field Investigation for Rock

14.0 Rock drilling

- (i) If, during the investigations, large hard fragments or natural rock beds are encountered, work shall proceed with core drilling methods. The equipment and procedures for this operation shall conform to IS:1892. The starting depth of drilling in rock shall be certified by Employer. At the end of the investigation, the hole drilled in rock shall be backfilled with grout consisting of 1-part cement and 3 parts sand by weight.
- (ii) Drilling shall be carried out with NX size tungsten carbide (TC) or diamond tipped drill bits, depending on the type of rock and according to IS:6926. Suitable type of drill bit (TC/Diamond) and core catchers shall be used to ensure continuous and good core recovery. Core barrels and core catchers shall be used for breaking off the core and retaining it when the rods are withdrawn. Double tube core barrels shall be used to ensure better core recovery and to retrieve cores from layers of bedrock. Water shall be circulated continuously in the hollow rods and the sludge conveying the rock cuttings to the surface shall be collected. A very high core recovery ratio shall be aimed at to obtain a satisfactory undisturbed sample. Attempt shall be made to recover cores of 1.5m in length. Normally TC bit shall be used. Change over to a diamond bit shall require the specific written approval of Employer, and his decision as to whether a TC or a diamond bit is to be used shall be final and binding on Contractor.
- (iii) No drilling run shall exceed 1.5 m in depth. If the core recovery is less than 80% in any run, the length of the subsequent run shall be reduced to 0.75m. During drilling operations observations on return water, rate of penetration etc. shall be made recorded and recorded as per IS:5313.
- (iv) The color of return water at regular intervals, the depth at which any change of color of return water is observed, the depth of occurrence and amount of flow of hot water, if encountered, shall be recorded.

- (v) The depth through which a uniform rate of penetration was maintained, the depth at which marked change in rate of penetration or sudden fail on drill rod occurs, the depth at which any blockage of drill bit causing core loss, if any, shall be recorded.
- (vi) Any heavy vibration or torque noticed during the drilling should be recorded together with the depth of occurrence.
- (vii) Special conditions like the depth at which grouting was done during, drilling, presence of artesian conditions, loss of drilling fluid, observations of gas discharge with return water, etc., shall also be observed and recorded.
- (viii) All the observations and other details shall be recorded as per daily drill and reported in a proforma as given in IS:5313, Appendix A.

14.1 Core Sampling

- (i) Core samples shall be extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration. Friable cores shall be extracted from the barrel directly into a suitably sized half round plastic channel section. Care shall be taken to extrude the samples in the direction of coring to avoid stress reversal.
- (ii) Immediately after withdrawal from the core barrel, the cores shall be placed in a tray and transferred to boxes specially prepared for this purpose. The boxes shall be made from seasoned timber or any other durably material and shall be indexed on top of the lid according to IS:4078. The cores shall be numbered serially and arranged in the boxes in a sequential order. The description of the core samples shall be recorded as instructed in IS:4464. Where no core is recovered, it shall be recorded as specified in the standard. Continuous record of core recovery and rock quality designation (RD/DD/QD) are to be mentioned in the bore log in accordance with IS:11315(Part-II).

15 Laboratory Testing

15.0 Essential Requirements

- (i) Depending on the types of substrata encountered, appropriate laboratory tests shall be conducted on soil and rock samples collected in the field. Laboratory tests shall be scheduled and performed by qualified and experienced personnel who are thoroughly conversant with the work.

Tests indicated in the schedule of items shall be performed on soil, water and rock samples as per relevant IS codes.

One copy of all laboratory test data records shall be submitted to Employer progressively every week. Laboratory tests shall be carried out concurrently with the field investigations as initial laboratory test results could be useful in planning the later stages of field work. A schedule of laboratory tests shall be established by Contractor to the satisfaction of Employer within one week of completion of the first borehole.

- (ii) Laboratory tests shall be conducted using approved apparatus complying with the requirements and specification of Indian Standards or other approved standards for this type of work. It shall be checked that the apparatus is in good working condition before starting the laboratory tests. Calibration of all the instruments and their accessories shall be done carefully and precisely at an approved laboratory.
- (iii) All samples, whether undisturbed or disturbed shall be extracted, prepared, and examined by competent personnel properly trained and experienced in soil sampling. examination, testing and in using the apparatus in conformance with the specified standards.
- (iv) Undisturbed soil samples retained in liners or seamless tube samplers shall be removed, without causing any disturbance to the samples, using suitably designed extruders just prior to actual testing. If the extruder is horizontal, proper support shall be provided to prevent the sample from breaking. For screw tube extruders, the pushing head shall be free from the screw shaft so that no torque is applied to the soil sample in contact with the pushing head. For soft clay samples, the sample tube shall be cut by means of a high-speed hacksaw to proper test length and placed over the mold before pushing the sample into it with a suitable piston.
- (v) While extracting a sample from a liner or tube, care shall be taken to assure that its direction of movement is the same as that during sampling to avoid stress reversal.

15.1 Tests

- (i) Tests as indicated in these specifications and as may be requested by Employer, shall be conducted. These tests shall include but may not be limited to the following:

- a) Tests of undisturbed and disturbed samples
 - Visual and engineering classification.
 - Sieve analysis and hydrometric analysis.
 - Liquid, plastic and shrinkage limits.
 - Specific gravity.
 - Chemical analysis
 - Swell pressure and free swell index determination
 - Proctor compaction test.
- b) Tests of undisturbed samples:
 - Bulk density and moisture content;
 - Relative density (for sand),
 - Unconfined compression test;
 - Box shear test (for sand);
 - Triaxial shear tests (depending on the type of soil and field conditions on undisturbed or remolded samples):
 - Unconsolidated undrained.
 - Consolidated drained test.
 - Consolidation.
- c) Tests on rock samples
 - Visual classification.
 - Moisture content, porosity and density.
 - Specific gravity.
 - Hardness
 - Stake durability
 - Unconfined compression test (both saturated and at in-situ water content);
 - Point load strength index.

- Deformability test (both saturated and dry samples).
- d) Chemical analysis of sub soil water.

15.2 Salient Test Requirement

- (i) Triaxial shear tests shall be conducted on undisturbed soil samples, saturated by the application of back pressure. Only if the water table is at enough depth so that chances of its rising to the base of the footing are small or nil, the triaxial tests shall be performed on specimens at natural moisture content. Each test shall be carried out on a set of three test specimens from one sample at cell pressures equal to 100, 200 and 300 KPa respectively or as required depending on the soil conditions.
- (ii) Direct shear test shall be conducted on undisturbed soil samples. The three normal vertical stresses for each test shall be 100, 200 and 300 KPa or as required for the soil conditions.
- (iii) Consolidation test shall have loading stages of 10, 25, 50, 75, 100, 200, 400 and 800 KPa. Rebound curve shall be recorded for all samples by unloading the specimen at its in-situ stress. Additional rebound curves shall also be recorded wherever desired by Employer.
- (iv) Chemical analysis of subsoil shall include determination of PH value, carbonate, sulphate (both SO₃ and SO₄), chloride and nitrate contents, organic matter, salinity and any other chemicals which may be harmful to the foundation material. Their contents in the soil shall be indicated as percentage (%).
- (v) Chemical analysis of subsoil water samples shall include the determination of properties such as color, odor, turbidity, PH value and specific conductivity, the last two chlorides, nitrates, organic matter and any other chemical harmful to the foundation material. The chemical contents shall be indicated as parts per million (PPM) based on weight.

16 Geotechnical Investigation Report

16.0 General

- (i) Contractor shall submit a formal report containing geological information of the region, procedures adopted for geotechnical investigation, field observations, summarized test data, conclusions and recommendations. The report shall also include detailed bore logs,

subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, supporting calculations for the conclusions drawn, etc. Initially, Contractor shall submit three copies of the report in draft form for Employer's review.

- a) Contractor's Geotechnical engineer shall visit Employer's Office for a detailed review based on Employer's comments to discuss the nature of modifications, if any, to be done in the draft report. Contractor shall incorporate in the report the agreed modifications and resubmit the revised draft report for approval. Ten copies of the detailed final approved report shall be submitted to Employer together with one set of reproducible of the graphs, tables etc.
- b) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures.

16.1 Data to be furnished

- (i) The report shall also include the following:
 - a) A location plan showing the locations and reduced levels of all field test e.g. bore holes, trial pits, static cone penetration tests, dynamic cone penetration tests, etc., properly drawn to scale and dimensioned with reference to the established grid lines.
 - b) A true cross section of all individual boreholes and test pits with reduced levels and co-ordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted, samples collected at different depths and the rock stratum, if encountered;
 - c) Geological information of the area including geomorphology, geological structure, lithology, stratigraphy and tectonics, core recovery and rock quality designation (RD/DD/QD), etc.
 - d) Observations and data regarding change of course of rivers, velocity, scour depths, silt factor, etc., and history of flood details for mid-stream and riverbank locations.

- e) Past observations and historical data, if available, for the area or for other areas with similar soil profile, or with similar structures in the surrounding areas;
- f) Plot of Standard Penetration Test (uncorrected and corrected N values) with depth for each test site;
- g) Results of all laboratory test summarized according to Table (i) for each sample as well as (ii) for each layer, along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions, and photographs of representative rock cores.
- h) For all triaxial shear tests, stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity

(E) shall be furnished for all tests along with relevant calculations.
- i) For all consolidation tests, the following curves shall be furnished
 - e vs. $\log p$.
 - e vs. p .
 - Compression vs $\log t$ or vs t depending upon the shape of the plot, for proper determination of coefficient of consolidation.

The point showing the initial condition (e_0 , p_0) of the soil shall be marked on the curves.

- j) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements shall also be calculated.

Table – Summary of Results (But not limited to number as shown) of laboratory tests on soil

Date of Boring:						Name of the Project:														Bore hole no.:							
Ground elevation: (R.L. in m.)						Co-ordinates:						Termination Depth:								Water table:							
Soil details						Grain Distribution				Size		Atterberg limits		Soil density Kg/m ³				Moisture content		Triaxial / Direct Shear Test							
Depth	Sample nos. & type	IS Classification of soil	Description of layers	N – Value (observed)	N – Value (corrected)	Specific Gravity	Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity index	Bulk / Natural Density	Dry Density	Submerged Density	Proctor Density	Relative Density	Natural	Optimum	Confining Pressure	Cohesion	Angle of Repose	Compression Index	Swell Pressure	Free swelling index %	Remarks

Following additional information should also be provided:

- Maximum expected yearly rise / fall of water table
- General topography of the location: whether cultivated or barren, hilly / plain location, river bank location etc.

Note: wherever undisturbed sampling is not possible, reasons must be clearly indicated, and all the tests shall be conducted on re-moulded samples.

Signature

Signature

Signature

Dated: 20/04/2021

Document type: Restricted

Document no. IGT/D&E/TL/CIVIL/TS/001

Location no.	Foundation Classification	Depth of footing considered for bearing capacity calculation	Size of footing considered for bearing capacity calculation	Ultimate bearing capacity	
				Based on settlement criteria (for 50mm total settlement)	Based on shear failure criteria
		3.0 m	3.0m x 3.0m x 3.0m		
		3.0 m	4.0m x 4.0m x 4.0m		
		3.0 m	5.0m x 5.0m x 5.0m		
		3.0 m	6.0m x 6.0m x 6.0m		
		3.0 m	7.0m x 7.0m x 7.0m		
		3.0 m	8.0m x 8.0m x 8.0m		
		3.0 m	9.0m x 9.0m x 9.0m		
		3.0 m	10.0m x 10.0m x10.0m		
		3.5 m	3.0m x 3.0m x 3.0m		
		3.5 m	4.0m x 4.0m x 4.0m		
		3.5 m	5.0m x 5.0m x 5.0m		
		3.5 m	6.0m x 6.0m x 6.0m		
		3.5 m	7.0m x 7.0m x 7.0m		
		3.5 m	8.0m x 8.0m x 8.0m		
		3.5 m	9.0m x 9.0m x 9.0m		
		3.5 m	10.0m x 10.0m x10.0m		

Signature

Signature

Signature

Location no.	Foundation Classification	Depth of footing considered for bearing capacity calculation	Size of footing considered for bearing capacity calculation	Net Safe bearing Capacity	
				Based on settlement criteria (for 50mm total settlement)	Based on shear failure criteria
		3.0 m	3.0m x 3.0m x 3.0m		
		3.0 m	4.0m x 4.0m x 4.0m		
		3.0 m	5.0m x 5.0m x 5.0m		
		3.0 m	6.0m x 6.0m x 6.0m		
		3.0 m	7.0m x 7.0m x 7.0m		
		3.0 m	8.0m x 8.0m x 8.0m		
		3.0 m	9.0m x 9.0m x 9.0m		
		3.0 m	10.0m x 10.0m x10.0m		
		3.5 m	3.0m x 3.0m x 3.0m		
		3.5 m	4.0m x 4.0m x 4.0m		
		3.5 m	5.0m x 5.0m x 5.0m		
		3.5 m	6.0m x 6.0m x 6.0m		
		3.5 m	7.0m x 7.0m x 7.0m		
		3.5 m	8.0m x 8.0m x 8.0m		
		3.5 m	9.0m x 9.0m x 9.0m		
		3.5 m	10.0m x 10.0m x10.0m		

*Detailed calculations of all the bearing capacities should be enclosed with soil investigation reports.

Signature

Signature

Signature

**SUMMARY OF SAFE LOAD CARRYING CAPACITIES FOR PILE FOUNDATION
TABLE**

Safe Load Carrying Capacity for Pile Foundation (tons)						
BH- No.	Location	Diameter of Pile (m)	Length of Pile (m)	Vertical Pile Capacity (T)	Lateral Pile Capacity (T)	Uplift Pile Capacity (T)
		0.6				
		0.75				
		0.9				
		1.0				
		1.2				
		1.5				
		1.8				

16.2 Chemical Test

- (i) As per Specifications - Clause 8.4 below.

16.3 Recommendations

- (i) Recommendations shall be provided for each borehole location duly considering soil type and tower spotting data. The recommendations shall provide all design parameters and considerations required for proper selection, dimensioning and future performance of tower foundations.
- (ii) Movement of the foundation, including short- and long-term components under transient and permanent loading, shall be strictly controlled with regard to settlement, uplift, lateral translation and rotation.
- (iii) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

Core resistance, frictional resistance total resistance, relation between core resistance, Standard Penetration Test N value, and settlement analysis for different sizes of foundation shall be based on static cone penetration test.

- (iv) For shallow foundation the following shall be indicated with comprehensive supporting calculations:
 - a) Net Safe allowable bearing pressure for isolated square footing of sizes 4.0, 5.0, 6.0 & 7. m at three different founding depths of 1,2 and 3 & 3.5m below ground level considering both shear failure and settlement criteria giving reasons for type of shear failure adopted in the calculation.
 - b) Net safe allowable bearing pressure for raft foundations of widths greater than 5m at 2.0, 3.0 and 4.0m below ground level considering both shear failure and settlement criteria.
 - c) Rate and magnitude of settlement expected of the structure.
 - d) Net safe bearing capacity for foundation sizes mentioned in para (i) above, modulus of sub grade reaction, modules of elasticity from plate load test results along with time settlement curves and load settlement curve in both natural and log graph, variation of Modulus of sub grade reaction with size, shape and depth of foundation.
- (v) The stable slopes for shallow and deep excavations, active and passive earth pressure at rest and angle of repose for sandy soils shall be furnished. The loading of the foundations shall not compromise the stability of the surrounding subsurface materials and the stability of the foundation shall be ensured against sliding or overturning.
- (vi) Depending on the subsurface material, water table level and tower type, either reinforced concrete isolated pad and chimney, cast-in-situ bored pile of special foundations shall be installed at a given location.
- (vii) Net Safe allowable bearing pressure and uplift resistance shall be provided for the various sizes of isolated square footings founded at various depths below ground level considering both shear failure and movement criteria; rate and magnitude of movement expected of the structure (settlement, uplift, rotation) shall also be given.

- (viii) In cases where normal open cast/pile foundations appear to be impractical, special pile foundations shall be given due consideration along with the following:
- a) Type of pile foundation and reasons for recommending the same duly considering the soil characteristics.
 - b) Suitable founding strata for the pile.
 - c) Estimated length of pile for 100 KN, 200 KN, 300 KN, 400 KN, 500 KN, 750 KN and 1000 KN and 4500 KN capacities; end bearing, and frictional resistance shall be indicated separately.
 - d) Magnitude of negative skin friction or uplift forces due to soil swelling.
- (ix) Where the subsoil water and soil properties are found to be chemically Aggressive, report shall provide suitable recommendations for construction including any protective coating to be applied on the foundations; susceptibility of soil to termite action and remedial measures for the same shall be dealt with; Suitability of locally available soils at site for filling, backfilling and adequate compaction shall be investigated.
- (x) If expansive soil such as black cotton soil is encountered recommendation of removal or retainment of the same shall be given, in the latter case, detailed specifications of special requirements shall also be given.
- (xi) Susceptibility of subsoil strata to liquefaction in the event of earthquake and remedial measures, if required, shall be considered.
- (xii) Dewatering schemes and any other information of special significance which a bearing on the design and construction may have shall be provided.
- (xiii) Recommendations for additional soil investigations, beyond the scope of the present work, shall be given if the agency considers such investigations necessary.

16.4 Hydrogeological Conditions

- (i) The maximum elevation of ground water table, amplitudes of its fluctuations and data on water aggressivity about foundation structure materials shall be reported. While preparing ground water characteristics the following parameters should be specified for each aquifer:
- a) Bicarbonate alkalinity mg-eq/(deg)

- b) pH value
- c) content of aggressive carbon dioxide, mg/l;
- d) content of magnesia salts. mg/l, recalculated in terms of ions Mg^{+2} ;
- e) content of ammonia salts, mg/l, recalculated in terms of ions NH_4^{+}
- f) content of caustic alkalis, mg/l, recalculated in terms of ions Na^{+} and K^{+}
- g) contents of chlorides, mg/l recalculated in terms of ions Cl^{-}
- h) contents of sulphates, mg/l, recalculated in terms of ions SO_4^{-2}
- i) aggregate content of chlorides, sulphates, nitrates, carbonates and other salts, mg/l.

16.5 In-situ Permeability Test

In-situ permeability test shall be conducted to determine the water percolation capacity of overburden soil. This test shall be performed inside the bore hole/trial pit at specified depths or in each layer or as per the directions of the engineer-in-charge. The type of test shall be either pump-in or pump- out test depending on the subsoil and ground water conditions. Pump-in test shall be conducted whether ground water in borehole exists or not. Pump-out test shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole. The specification for equipment required for the test and the procedure of testing shall be in accordance with IS: 5529, Part-1. When it is required to carry out the permeability test for a particular section of the soil strata above ground water table, bentonite slurry shall not be used while boring.

16.6 Pump-in-Test

Pump-in test shall be conducted in the bore hole/trial pit by allowing water to percolate into the soil. Choice of the method of testing shall depend on the soil permeability and prevailing ground water level. Only clear water shall be used for conducting the test. Before conducting the test, the borehole shall be cleaned as specified in clause 5.1.2 (e) Water shall be allowed to percolate through the test section for enough period to saturate the soil before starting the observation.

16.7 Constant Head Method (In Bore Hole)

This test shall be conducted in boreholes where soil has a high permeability. Water shall be allowed into the borehole through a metering system ensuring gravity flow at constant head to maintain a steady water level in the borehole. A reference mark shall be made at a convenient level which can be easily seen in the casing pipe to note down the fluctuations of water level. The fluctuations shall be counteracted by varying the quantity of water flowing into the borehole. The elevation of water shall be observed at every 5-minute interval. When three consecutive readings show constant value, the necessary observations such as flow rate, elevation of water surface above test depth, diameter of casing pipe etc. shall be made and recorded as per the proforma recommended in IS: 5529, Part-1.

16.8 Falling Head Method (In Bore Hole)

This method shall be adopted for soils of low permeability and which can stand without casing. The test section shall be sealed at the bottom of the borehole and a packer at the top of the test section. If the test must be conducted at an intermediate section of a pre-bored hole, then double packers shall be used. Access to the test section through the packer shall be by means of a pipe which shall extend above the ground level. Water shall be filled into the pipe up to the level marked just below the top of the pipe and water be allowed to drain into the test section. The water level in the pipe shall be recorded at regular intervals as mentioned in IS: 5529, Part-1, Appendix-B. The test shall be repeated till constant records of water level are achieved.

16.9 Pump-Out Test

This test shall be carried out at site to determine the co-efficient of permeability of soil below water table. This test shall be conducted by continuous pumping out of water from a well to maintain a steady water level at the desired depth in the well. The fluctuations in the water level shall be counteracted by varying the quantity of water pumped out of the well. The specification for the equipment & accessories required for performing the test, the procedure of testing, field observations and reporting of results shall conform to IS: 5529, Part-1. The well shall be of 400mm in diameter to be installed with a 250mm diameter perforated GI/MS pipe. Observation pipes of 50mm diameter shall be installed at regular intervals along three radial lines extending from the well at 120 degrees to each other. Length of these pipes shall depend upon the ground level, estimated depth of lowering the

ground water and the distance from the well. Enough observation pipes shall be installed along each of the radial lines to assess the zones of influence due to dewatering. Draw down depth in the well shall be as specified in the drawing.

17 Rates and Measurements

17.0 Rates

The contractor's quoted rates shall be inclusive of making observations, establishing the ground level and co-ordinates at the location of each borehole, test pit etc. No extra payments shall be made for conducting Standard Penetration Test, collecting, packing, transporting of all samples and cores, recording and submittal of results on approved formats.

18 Specific Requirements for Geotechnical Investigation at River Crossings.

18.0 The entire soil investigation work at river crossing locations (if required) shall be carried out in accordance with the relevant parts of the specifications for geotechnical investigation modified to the extent given below.

18.1 Requirements

- (i) Boreholes shall be executed to specified depth of 40m (refer clause 5.2.2). If refusal strata are reached (i.e. SPT-N value is greater than 100 continuously for 5m depth) with characteristics of rock the borehole may be terminated at shallower depth i.e. at 5m in refusal strata, with prior approval of Employer.
- (ii) Laboratory testing shall be conducted on all soil samples to determine grain size distribution, liquid limit and plastic limit of the different soil strata encountered.
- (iii) Geotechnical Report must furnish the following:
 - a) Geotechnical investigation scheme.
 - b) Bore-logs indicating soil stratification, with IS classification, sampling details and SPI 'N' values.
 - c) Soil cross-sections along various boreholes in two orthogonal directions indicating soil stratification based on field and laboratory tests.
 - d) Grain size distribution curves.

- e) IS classification of soils.
- f) Shear tests (UU) to be done on saturated soil samples.
- g) Bearing capacity of soil at different levels.
- h) Highest flood level (HFL) Historical data from Govt. authority for last 50 years
- i) Maximum discharge, scour depth, velocity etc. (from authenticated source such as CWC or appropriate State authorities)
- j) Recommendations regarding type of foundation to be adopted at the location.

A check list for reporting results of river crossing locational details, detailed soil investigation and river values for river crossing locations is enclosed at Annexure-A.

19 Special Terms and conditions for Geotechnical Investigation in the Riverbed

- 19.0** Contractor is required to mobilize a suitable arrangement (floating pontoon, plant, equipment etc.) to carry out geotechnical investigation work in creek/river locations identified by Employer.
- 19.1** In the event of storm or stoppage of work, etc., Contractor shall not be paid extra for mobilization / remobilization of floating pontoon, plant, equipment, etc.
- 19.2** Contractor shall fully satisfy himself about the conditions of creek/river (depth of water, wave currents, wind conditions, etc.) prevailing in proposed investigation and plan the necessary tools and plant to be deployed before quoting.
- 19.3** Any claim resulting from lack of data collection in this respect shall not be entertained.
- 19.4** Contractor shall make his own arrangements for locating the coordinates and position of boreholes in creek/river with respect to two gridlines indicated by Employer.
- 19.5** Boring in creek or river shall be payable only below the bed level and no payment shall be made for lowering the casing in water.

- 19.6** Contractor shall arrange for necessary transportation on water (e.g. motorboat) to facilitate the supervision of work by officials of Employer at its own cost.
- 19.7** Full details of the construction plant proposed working method for boring and sampling in water shall be submitted along with the Tender. The unit rate quoted for underwater boring shall include complete work required as per specification and no separate payment shall be made on any account.

20 STATUTORY REGULATIONS AND STANDARDS

- 20.0** Contractor is required to follow statutory regulations stipulated in Electricity Act 2003, Indian Electricity Rules and other local rules & regulations.
- 20.1** The codes and standards referred to in these specifications shall govern. In case of a conflict between such codes/standards and these specifications, the provisions of the specifications shall prevail. Such codes, standards referred to shall mean latest revisions, amendments, changes adopted and published by relevant agencies.
- 20.2** Other Internationally acceptable standards which ensure equivalent or better performance than those specified shall also be acceptable.

Annexure-A

FORMAT FOR REPORTING RESULTS OF SURVEY OF RIVER CROSSING STRETCH OF TRANSMISSION LINE

Inputs:

River crossing profile, ground profile, GL, HFL, Tower type, Reference benchmark details:

Base width

- Slope
- Loads
- Stub sections/ Leg sections

Soil Report (up to 40m. depth)

- N Value
- Cohesion © and friction angle (ϕ)
- Dry Density & Submerged density of soil
- Soil composition including bore log data.
- Soil Strata distribution details depth wise
- R.L of ground (Soil investigation and foundation location)
- Mean grain size
- Silt factor calculations
- Scour depth calculations
- Special Recommendations, if any.
- River crossing profile showing the position of R.C towers and Anchor towers with span details.
- Any other details like bunds, roads, bridges etc. with their R.L.S.

River Values

- Max. discharge
- Max. velocity (V_{max})

- HFL
- Clear water way during max Discharge
- River Meandering history (50 Years).
- Navigable/ Non-Navigable
- Location reference of above River values for crossing details.
- Riverbed level. (RL)

SPECIFICATION FOR
SUPPLY OF TOWER, FOUNDATION, ERECTION, STRINGING, TESTING AND
COMMISSIONING OF TRANSMISSION LINE

1.0 SCOPE

- 1.1 This Specification covers technical requirements for transmission line tower superstructure and accessories intended to be used in the following 765 kV Overhead Transmission Line apart from tower and foundation design which covers in separate chapter

2.0 SUPPLY & ERECTION:

- 2.1 This includes fabrication, galvanizing, packing, and forwarding, transportation, delivery and unloading at destination stores of all types of towers & its extensions, stub, stub setting templates, including bolts, nuts, washers, hangers, D-shackle etc.
- 2.2 All type of tower accessories like circuit plate, phase plate, number plate, danger plate; bird guard (wherever applicable); anti-climbing device; earthing.
- 2.3 Conductor, Earth-wire, Insulator and OPGW with accessories.
- 2.4 Preparing construction drawings for earthing.
- 2.5 Constructing tower foundations.
- 2.6 Erection of towers, tack welding of bolts & nuts including supply and application of zinc rich primer & two coats of enamel paint, tower earthing; hoisting of insulator strings, stringing/sagging of conductors, earth-wire/OPGW along with all necessary line accessories.
- 2.7 Providing benching and revetment walls, etc all complete.
- 2.8 Painting of towers & supply and erection of span markers, obstruction lights (wherever applicable) for aviation requirements (as required).
- 2.9 Testing and commissioning of the erected transmission lines.
- 2.10 Other items not specifically mentioned in this specification which are required for the successful commissioning of the transmission line shall be supplied by contractor as per requirement.
- 2.11 Along with conventional designs for tower and foundations, special designs like raised chimney, shallow foundation etc. are in the scope of contractor. Same is to be submitted for owner's approval prior to construction of foundation at site.

3.0 TRANSMISSION TOWER

3.1 Tower Description

The towers shall be of self-supporting lattice steel type, which shall be designed to carry the line conductors with necessary insulators, earth wires/OPGW and all the fittings/accessories under all the specified loading conditions.

The towers shall be hot-dipped galvanized using mild steel and high tensile steel sections using PG grade material as per IS 2062:2011. Bolts and nuts with spring washers shall be used for connections.

The Numbers & location of transposition tower shall be fixed with the approval of Project Head in case of requirement.

3.2 Tower Drawings (Shall be provided by Owner)

The relevant drawings for all the towers and their extensions shall be furnished by the contractor which shall include structural drawings and shop drawings, Bill of Materials.

The Contractor shall arrange for proto assembly for each tower type, which shall be inspected by the Owner. After successful proto-assembly inspection, the drawings and bill of materials shall be modified, if/as necessary. The final drawings and bill of materials shall be updated with the next revision number and shall be approved by the Owner, before taking up the mass fabrication.

The mass fabrication shall be taken up from the proto corrected shop drawings. The overall responsibility of correctness lies with the Contractor and he shall ensure that all the tower members can be assembled/fitted while erecting without any undue strain on them.

All the drawings shall have a proper Title Box displaying the name of M/s DPTL on the right-hand bottom corner. All the drawings shall carry the following statement and shall be displayed conspicuously on the drawings:

WARNING: THIS IS PRIOPRIETORY ITEM AND ALL RIGHT IS STRICTLY RESERVED WITH M/s DPTL.

While submitting the structural drawings, bill of materials, shop drawings and any other drawings pertaining to the subject transmission line, the contractor shall clearly indicate on each drawing below mentioned items:

- Name of the specific transmission line

- Name of the project
- Drawing description
- Revision No.
- Date

The same practice is also to be followed while submitting distribution copies & other drawings.

3.3 The Contractor shall also prepare the detailed drawings for all the tower accessories like Number plate, Danger plate, Circuit plate, Phase plate, bird guard, Anti-climbing device, Step bolt, D-shackle, etc. including earthing drawings, benching, Revetment & Retaining wall drawings. These shall be submitted to the Owner for review and approval. The further execution shall be based on the approved drawings.

3.4 After development, these drawing shall be submitted to the Employer in triplicate for approval. In ordinary circumstances, the contractor should submit these drawings as per L2 schedule/Design & drawing deliverable schedule.

Such drawings/ documents developed by the Contractor shall necessarily have sufficient detail to indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component break- up for packing and shipment, fixing arrangement required, the dimensions required for installation and any other information specifically requested in the specifications.

3.5 Each drawing developed by the Contractor shall be clearly marked with the name of the Employer, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.

3.6 The drawing shall be modified by the Contractor if any modifications and/or corrections are required by the Employer. The Contractor shall incorporate such modifications and/or corrections and submit the final drawings for approval. Any delays arising out of failure by the Contractor to rectify the drawings in good time shall not alter the contract completion date.

3.7 The drawings submitted for approval to the Employer shall be in triplicate. One print of such drawings shall be returned to the Contractor by the Employer marked "approved/ approved with corrections". The contractor shall there upon

furnish the Employer additional prints as may be required along with soft copy (in PDF/AutoCAD format) of the drawings after incorporating all corrections.

3.8 The work shall be performed by the Contractor strictly in accordance with the standard/approved drawings and no deviation shall be permitted without the written approval of the Employer, if so required.

3.9 All manufacturing, fabrication work under the scope of Contractor, prior to the approval of the drawings shall be at the Contractor's risk. The contractor may incorporate any changes in the design, which are necessary to conform to the provisions and intent of the contract and such changes will again be subject to approval by the Employer.

3.10 The approval of the documents and drawings by the Employer shall mean that the Employer is satisfied that:

3.10.1 The Contractor has completed the part of the Works covered by the subject document (i.e. confirmation of progress of work).

3.10.2 The Works appear to comply with requirements of Specifications.

In no case the approval by the Employer of any document does imply compliance with all technical requirements or the absence of errors in such documents.

If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible for consequences.

3.11 All drawings shall be prepared using AutoCAD software version 2000 or later only. Drawings, which are not compatible to AutoCAD software version 2000 or later, shall not be accepted. After final approval all the drawings (structural drawings, BOMs and shop sketches) shall be submitted into the Employer in CDs/USB Drive.

Sl No	Details	Soft copy Submission Format
1.	Final Structural Drawing	AutoCAD & PDF
2	Final BOM	Excel & PDF
3	Final Shop Sketch	AutoCAD & PDF

Note: Design Deliverables are specified in design specification

3.12 All rights of the design/ drawing for all types of towers shall be strictly reserved with the Employer only and any designs/ drawings/ data sheets submitted by the contractor from time to time shall become the property of the Employer. Under no circumstances, the Contractor shall be allowed to user/ offer above designs/ drawings/ data sheets to any other authority without prior written permission of

the Employer. Any deviation to above is not acceptable and may be a cause for rejection of the bid.

3.13 Design Improvements

The Employer or the Contractor may propose changes in the specification and if the parties agree upon any such changes and the cost implication, the specification shall be modified accordingly.

3.14 Design Review Meeting

The contractor may be called upon to attend design review meetings with the Employer, and the consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at the Corporate Office of the Employer or at mutually agreed venue as and when required.

3.15 Engineering Data

The furnishing of engineering data by the Contractor shall be in accordance with the mutually agreed L2 schedule. The review of these data by the Employer will cover only general conformance of the data to the specifications and not a thorough review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the Employer shall not be considered by the Contractor, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.

4.0 TOWER: MATERIALS, FABRICATION, ERECTION & STRINGING

4.1 Transmission Tower Materials

4.1.1 Tower Steel Sections

4.1.1.1 For Non-Snow Regions, IS Steel Sections of any tested quality A, B0 or BR in conformity with IS:2062:2011 corresponding to grade E250 (Designated Yield Strength. 250 MPa) and/ or grade E350 (Designated Yield Strength 350 MPa) may be used in towers, extensions, stubs and stub setting templates. For Snow Regions, IS Steel Sections of tested quality C in conformity with IS:2062:2011 corresponding to grade E250 and/or E350 shall be used. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to latest International Standards viz BSEN 10025. However, use of steel grade having designated yield strength more than that of EN 10025 grade S355 JR/JO

(designated yield strength 355 MPa) is not permitted, unless otherwise indicated in this specification.

4.1.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade-0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS 2062 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to grade E250 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. Flats of equivalent grade meeting mechanical strength/ metallurgical properties may also be used in place of plates for packing plates/ packing washers. The chequered plates shall conform to IS 3502. SAILMA 350HI grade plate can also be accepted in place of HT plates (EN 10025 grade S355 JR/JO / IS 2062:2011– grade E350, as applicable) provided SAILMA 350HI grade plate meet all the mechanical properties of plate as per EN 10025 grade S355 JR/JO (designated yield strength 355 MPa)/ IS 2062:2011– grade E350. While selecting equivalent grade, requirement of IS 2062 for particular grade has to be fully complied. Further, material shall be imported from the manufacturers having valid BIS license.

4.1.1.3 During execution of the project, if any particular section is not available, the same shall be substituted by higher section/ Grade. Any cost on account of the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution and records of such substitutions shall be maintained by the Contractor.

4.1.1.4 During execution of the project, if any particular section is not available, the same shall be substituted by higher section by the Contractor at no extra cost to the Owner. However, the prior design approval for such substitution shall be obtained from the Owner.

4.1.1.5 The source of raw steel and raw steel sections shall be approved by the Owner subject to the following:

4.1.1.6 Vendor shall procure steel billets from primary steel producer only Eg; SAIL, RNIL, JINDAL, TISCO Ltd only.

4.1.1.7 DPTL/MS marking shall be embossed on the rolled MS sections & DPTL/HT shall be embossed on rolled HT sections apart from their own logo and color coded.

4.1.1.8

4.1.2 Fasteners: Bolts, Nuts and Washers

- 4.1.2.1 It shall be ensured that the fasteners always provide positive attachment and under the various conditions as the tower structures are subjected to vibrating loads. All tower members shall be joined by Hexagonal bolts and nuts.
- 4.1.2.2 Spring washer shall be provided under each nut. All Hexagonal head bolts, nuts and spring washers including their galvanizing shall conform to IS: 12427. The bolts shall be of 12/16/20/24 mm dia. and of property class 5.6 as per IS: 1363 (Part-III) and matching nut shall be of property class 5.0 as per IS: 1367 (Part-VI).
- 4.1.2.3 All bolts and nuts shall be galvanized and shall have Hexagonal heads being forged out of the solid, truly concentric and square with the shank, which must be perfectly straight.
- 4.1.2.4 The shear strength of bolts for 5.6 grade should be 310 MPa minimum, as per IS: 12427. Bolts should be provided with washer face in accordance with IS: 1363 (Part-1) to ensure proper bearing.
- 4.1.2.5 Nuts should be double chamfered as per the requirements of IS: 1363 (Part-III). It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4mm oversize on effective diameter for size up to M16.
- 4.1.2.6 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.
- 4.1.2.7 All bolts shall be threaded to take the full depth of the nuts and threaded for enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit tight to the point where the shank of the bolt connects to the head.
- 4.1.2.8 To avoid bending stress in bolts or to reduce the same to a minimum, no bolt shall connect aggregate thickness of more than three times its diameter.
- 4.1.2.9 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.
- 4.1.2.10 To ensure effective quality control during manufacture, it is essential that the manufacturer should have in-house testing facility for all tests like weight of zinc coating, shear strength and other tests, etc. The manufacturer should also have

proper Quality Assurance System, which should be in line with the requirement of this specification and IS: 14000 series Quality System Standard.

4.1.3 Tower Accessories

4.1.3.1 Step Bolts & Ladders

Each tower shall be provided with step bolts as per drawing enclosed in the section of drawing. The step bolts conforming to IS 10238 of not less than 16mm diameter and 175 mm long, spaced not more than 450 mm apart and extending from 2.5 meters above the ground level to the top of the tower. However, the head diameter shall be 35mm as indicated in the enclosed drawing. The step bolt shall be fixed on two diagonally opposite legs up to top of the towers for single, double and multi circuit towers. 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. For special river crossing towers, ladders along with protection rings as per the Employer approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be fixed on two diagonally opposite legs. Suitable platform using 6mm thick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.

4.1.4 Attachment for Insulator Strings Clamps

- 4.1.4.1 For the attachment of suspension insulator string, a suitable swinging hanger on the tower shall be provided so as to obtain specified clearances under respective swinging condition of the strings. The design and supply of D-shackles, strain plate, etc are in the scope of Contractor.
- 4.1.4.2 On tension towers, strain plates of suitable dimensions and adequate strength shall be provided on the underside of each cross-arm for taking the hooks or D-shackles of the tension insulator strings. Complete details of the attachments shall be provided by the Contractor. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate, etc. before connecting the insulator string, the same shall be supplied by the Contractor.

- 4.1.4.3 D shackles, if required for attachment of Insulator strings, shall be supplied by the contractor from the identified and approved sub-vendor/ supplier of Hardware fittings.

4.1.5 Attachment for Earth wire Clamps

- 4.1.5.1 Provision shall be made on the towers for the attachment of ground wire and OPGW clamps.
- 4.1.5.2 Earth wire suspension clamps, tension clamps, U-bolts and D-shackles, all as necessary shall be supplied by the Contractor. The detailed drawings shall be submitted by the Contractor for Owner's approval.

4.1.6 Anti-climbing Device and Bird Guards

- 4.1.6.1 All the towers shall be fitted with barbed wire type anti-climbing devices, which shall be as per enclosed drawing. The height of the anti-climbing device shall be provided approximately at 3 m above the ground level. The barbed wire shall conform to IS: 278 (size designation A1). The barbed wires shall be given chromating dip as per procedure laid down in IS: 1340.
- 4.1.6.2 Necessary holes shall be provided on the tower members for installation of the anti- climbing device.
- 4.1.7 All the suspension towers shall be fitted with bird guards at the cross-arm tips.

4.1.8 Danger, Number, Circuit and Phase Plates

Danger plates, Number plates, Circuit plates and Phase plates shall be provided and installed by the Contractor.

- 4.1.8.1 Each tower shall be fitted with danger plate, number plate, two circuit plates and sets of phase plates. The transposition towers shall have provision of fixing phase plates on both the transverse faces.
- 4.1.8.2 The letters, figures and the conventional skull and bones of danger plates shall conform to IS: 2551 and shall be in single red color on the front of the plate.
- 4.1.8.3 The corners of the number, danger and circuit plates shall be rounded off to remove sharp edges.
- 4.1.8.4 The letters of number plates and circuit plates shall be in red enamel with white enamel background.

4.1.9 Aviation Requirements

Provisions for conformity with aviation requirements shall be in the scope of Contractor. These requirements shall conform to IS: 5613 (Part 3/Sec 1).

4.1.9.1 Night Markers (Obstruction lights)

- (i) The scope of night markers covers the design, manufacture, testing at manufacturers works, if any, supply, delivery, erection, testing and commissioning of medium intensity, low intensity, lights along with storage battery & solar panel, control panel, cables, clamps other accessories etc. as per the provision of IS 5613 (Part-II/Section-I) regarding night & day visual aids for denoting transmission line structures as per the requirement of directorate of flight safety.
- (ii) The detail of each component of medium intensity, low intensity lights & associated accessories to be provided on the towers shall be as per the technical specifications given in the preceding clauses and IS/ICAO, International Standards recommended practices.
- (iii) One set of Aviation Lights shall consist of one medium intensity light & two/four (as applicable) low intensity lights along with all accessories such as solar panel, control panel, batteries, cables etc.

4.1.9.1.1 Medium Intensity Light

Medium Intensity light shall be provided on the top of each tower. The medium light should have nighttime intensity as per ICAO requirements in international Standards Recommended Practices. The light on top of the structure should flash at the rate of 20 sequences per minute. The effective intensity during nighttime for the medium flashing light shall be 1600 CD. The light shall conform to ICAO requirements/ BS 3224a and shall have weather protection conforming to IP 55.

The above lights conforming to ICAO specifications flashing red lights shall be DC operated through a suitably sized battery bank at the operating voltage 12V/24V DC. The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T. live but in no case, it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 burning hours, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires. The light shall be equipped with radio suppression facility conforming to BS800 in order to avoid any interference with signals of PLCC etc.

4.1.9.1.2 Low Intensity Lights

Two/ four (as applicable) nos. of low intensity lights are required to be put on each of the towers. Placement drawing for the same shall be submitted by the bidder Contractor.

The light shall be stationary lamp with minimum effective intensity of 32 CD. of red light. The lamps shall conform to the ICAO requirement/relevant BS and shall have weather protection of minimum IP 55 class.

Two/four nos. of L.I. lamp required for each tower shall be operated through a suitable size common battery bank solar panel as per the requirement of operating voltage and load current of the type of lamps being offered.

The burning life of the lamps shall be maximum possible in view of the maintenance hazard of H.T live line, but in no case, it should be less than 15,000 burning hours. In case of failure of the lamp before 15,000 hours, the same shall have to be replaced by the Contractor free of cost even if the pendency of contract expires.

The low intensity lamp shall not generate any R.F. which can interfere with the PLCC signals.

4.1.9.1.3 Storage Battery

4.1.9.1.4 Storage Battery required for the above purpose shall be sealed maintenance free, valve regulate lead acid and suitable for mounting on the top of the transmission line towers. Contractors shall offer the most optimum capacity of the Battery Bank at 120hour discharge rate (considering 80 % percentage usage) matching with the load requirement of the type of lamps being offered including any power loss in the associated cables. The battery sizing shall conform to JISC 8707/ relevant Indian Standard or any other internationally recognized standard. The battery shall be hermetically sealed explosion proof and self-resealing type and free from orientation constraints. The working temperature ranges shall be minimum 0° C and maximum 50° C. Performance certificate of the offered batteries shall be submitted by the Contractor.

4.1.9.1.5 Battery Box

The battery box suitable for mounting on power transmission tower shall be robust construction suitable to accommodate desired number of storage batteries with proper clearance between the batteries. The sides and the top of the battery box shall be made from MS sheets not less than 14 SWG thickness duly mounted

on MS angle frame. The bottom of the battery box shall have suitably designed MS structure to freely hold the total weight of the batteries. The batteries should be placed on insulated base with proper drainage holes. Lifting lugs shall be provided. Dust and vermin proof lockable doors shall be provided for safety and easy access to the batteries for the maintenance. The battery box should incorporate the design for proper ventilation system in order to prevent a gas concentration inside the box. The ventilation opening shall be protected against rain/ splash water and dust. The inside of the battery box shall be lined with insulating polyurethane plating and the exterior painted with weather proof polyurethane paint. The cable entry into the battery box shall be through suitable cable glands.

4.2 Tower Fabrication

The fabrication of towers shall be in accordance with the provisions made in the following sub-clauses: Except where specified hereinafter, details of fabrication shall conform to the relevant clause of latest IS: 802(Part II) & Approved MQP from owner.

- 4.2.1 The tower members shall be accurately fabricated to assemble easily at site without any undue strain on them or the bolts.
- 4.2.2 No angle member shall have the two leg flanges brought together by closing the angle.
- 4.2.3 The diameter of hole shall be 1.5 mm more than the diameter of bolt up to M20 bolts.
- 4.2.4 All parts of the towers shall be cut to correct lengths and fabricated in accordance with the approved shop drawings. Welding of two or more pieces to obtain the length of member specified will not be allowed. Members shall be straight to the permissible tolerances or better when required to ensure proper fit before being laid off or worked and after galvanizing.
- 4.2.5 Normally butt splices shall be used. The components constituting the joint shall have a total strength greater than the heavier of the members connected. Lap splices may be used for connecting members of unequal sizes. The inside angle of lap splice shall be grinded at the heel to fit the fillet of the outside angle. All splices shall develop full strength of the members connected through bolts. Butt as well as lap splices shall be made above and as close to the main panel points as possible.

- 4.2.6 Joints shall be so designed and detailed as to avoid eccentricity as far as possible. However, where the connections are such that the elimination of gusset plates would result into eccentric joints; gussets plates and spacer plates may be used in conformity with modern practices. The thickness of gusset plates shall not be less than 6 mm.
- 4.2.7 The use of fillers in the connections should be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary, to avoid the use of fillers. Each diagonal shall be in one piece without splices or center gusset and it shall be connected at the point of intersection by one or more bolts.
- 4.2.8 All parts of the towers shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to collect and hold water.
- 4.2.9 All similar parts shall be made strictly interchangeable. No rough edges shall be permitted anywhere throughout the work.

4.2.10 Straightening

Before any cutting work is started all steel section shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled

- 4.2.10.1 The following machines should be used for straightening.
- For angle sections up to 110x110x10 mm: Roller straightening machine
 - For higher angle sections: Beam bending machine and Hydraulic press

4.2.11 Cutting

The cut surfaces shall be clean, smooth, reasonably square and free from any distortion.

4.2.12 Bending

Mild steel angle sections up to 75x75 mm (thickness up to and including 6 mm) shall be bent cold up to and including bend angles of 10 Degrees. Angles above 75x75 mm (thickness up to and including 6mm) and up to and including 100x100 mm (thickness up to 8 mm) may also be bent cold up to bend angles of 5 Deg. All other angle sections and bend angles not covered above shall be bent hot. All plates up to 12 mm thickness shall be cold worked up to a maximum bend angle of 15 Deg. Hot bending shall be employed for greater bend angles and thicker

plates. Bends on HT sections shall be done hot. All hot bent material shall be air-cooled. The bends shall be of even profile and free from any surface damages.

4.2.13 Drilling and Punching

4.2.13.1 Holes in the members shall either be drilled or punched with CNC machines and shall not be formed by flame cutting process. All burrs left by punching or drilling shall be completely removed. Punching may be adopted for sections with thickness up to 16 mm. For thicker sections, drilling shall be done. The holes near the bend line of bent member on both sides of bend line should be punched/drilled after bending and relative position of these holes shall be maintained with the use of proper templates/jigs and fixtures.

4.2.13.2 All burrs left by drills or punch shall be removed completely. When the tower members are in position, the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

4.2.14 Erection Mark

Each individual member shall have unique identification number, mark conforming to the component number given to it in the fabrication drawings. This mark shall be embossed at every two-meter length of the member with the die of 16mm size prior to galvanizing and shall be legible after galvanizing.

P-Q-R-S

P = Code alphabet identifying Owner

Q = Code alphabet identifying Tower type

R = Code alphabet identifying batch of manufacturing

S = Code numerical identifying member number

The above unique number mark shall be prefixed by letter 'H' for high tensile members.

4.2.14.1 The Contractor shall maintain necessary records to facilitate the traceability (upto the source of the raw material) of the members based on this unique identification numbering system.

4.2.14.2 Owner's approval for unique identification marking shall be obtained prior to fabrication of tower.

4.2.15 The contractor shall take prior approval of the Owner in respect of the tower fabrication works.

5.0 Quantities and weights

5.1 The quantities of the following items have been envisaged in Metric Tonne (MT) in the relevant price Schedules for various types of towers: -

- Basic Body.
- Body Extensions.
- Leg Extension.
- Stubs & Cleats
- Bolts & Nuts including spring washers and step bolts etc.

5.2 The contractor shall carry out proto assembly after fabrication for his verification/ satisfaction prior to mass production of the tower.

5.3 The manufacturing of the above items shall be taken up in such a manner that the Equipment/Material offered for inspection to the Employer shall be complete tower basis for each type of tower, Stubs & Cleats set basis so as to facilitate availability of erectable tower of each type and erectable stubs & cleats set for casting of foundation.

5.4 Towers to be supplied by the Contractor/ Tower Manufacturer shall be dispatched Panel wise as per mutually agreed procedure between Employer Quality Assurance & Inspection Department.

5.5 Accordingly, the payment shall be released on completed Tower Basis for each type of tower (comprising the Basic Body, body extensions, wherever applicable, bolts & nuts along with spring washer and step bolts, unequal leg extensions wherever applicable for a completed tower) and on completed Stubs and Cleats set basis for each type of foundation (comprising a set of stubs & cleats, required Bolts and nuts along with Spring Washers) based on the weight of the tower parts.

5.6 Final quantities shall be determined after completion and approval of the detailed route survey by Employer. The final quantities of tower including spare towers shall be confirmed by the Employer/ Site in charge based on the requirement of quantities of various towers furnished by the Contractor after completion of detailed survey. Hence it will be responsibility of the Contractor to intimate the exact requirement of all towers and various line materials required for line immediately after the survey.

The Employer reserves the right to order the final quantities including required quantities of spares for which the rates quoted in the Bid shall be valid.

5.7 The estimated total weight of tower/ tower parts as well as bolts & nuts along with spring washers and step bolts to be supplied by the Contractor under various packages have been envisaged in the BOQ. Though fully galvanized tower parts are to be supplied, the weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. ungalvanized) weight of steel members of the size indicated in the approved fabrication drawings and bill of materials, without taking into consideration the reduction in weights due to holes, notches and bevel cuts etc. but taking into consideration the weight of the D shackles, hangers, strain plates, pack plates, gusset plates, extension link/plates and pack washers etc. The weight of stub and cleats also shall be calculated in similar manner. The weight of strain plates, pack plates, extension link and gusset plates shall mean the weight of its circumscribing rectangle, without taking into consideration the reductions in weight due to holes, notches etc. The weight of D-shackles, hangers and pack washers shall be net actual weight taking into consideration reduction due to holes. For bolts and nuts along with spring washers and step bolts, the weight per tower shall be calculated from the bolt schedule applicable to each type of towers and body extensions as approved by the Employer. The rate quoted by the bidder for tower/tower parts supply, is deemed to be inclusive of galvanizing charges including the cost of zinc.

5.8 The contractor is permitted to get inspected and supply up to 2.5% extra fasteners to take care of losses during erection. No payment shall be admissible for these extra supplies.

6.0 Galvanizing

6.1 Fully galvanized towers shall be supplied. Hot dip galvanization of the tower members shall conform to IS: 2629 and IS: 4759 and that of fasteners to IS: 5358. The stubs also shall be fully hot dip galvanized. The galvanization shall be done after all the fabrication work is completed except that the nuts may be tapped or re-run after galvanization. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned into finger throughout the length of the threads of bolts and shall be capable of developing full strength of the bolts. Excess zinc shall not remain in threads, in holes, at member ends in connection areas. Post treatment (chromating) recommended as per IS: 2629 shall be carried out after galvanizing. Zinc used shall be as specified in IS 209 or IS 13229.

6.2 All galvanized material shall withstand Tests as per IS: 2633.

7.0 Check Assembly of Towers

7.1 Based on the approved fabrication drawings, the Contractor shall fabricate and assemble in his works for inspection by the Owner or his authorized representative, one tower of each type as finally approved for checking the fabrication accuracy and workmanship. The proto assembly shall be in a horizontal position. Proto assembly made on ground in horizontal position shall be adequately supported to prevent distortion and overstressing of members to ensure proper fit and shall be accomplished without extraordinary efforts to align bolt holes or to force pieces into position. For the proto-assembly, bolts and nuts shall be not more than finger tight.

7.2 The Contractor shall provide facilities to the Owner or their representatives for inspection of materials during manufacturing stage of proto assembly

8.0 Standards

8.1 The design, manufacturing, fabrication, galvanization, testing, and materials used for manufacture shall conform to the following Bureau of Indian Standards (BIS), which shall mean latest revisions with amendment/Changes adopted and published, unless specifically stated otherwise in the Specification. In the event of supply of materials conforming to Standards other than specified, the Contractor shall confirm in his bid that these Standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

8.2 The material and services covered under these specifications shall be performed as per requirements of the relevant standard code referred hereinafter against each set of equipment and services. Other internationally accepted standards, which ensure equal or higher performance than those specified shall also be accepted.

Bureau of Indian Standards (BIS)	Title
IS: 209	Specification for Zinc
IS: 278	Specification for Galvanized Steel Barbed Wire for Fencing
IS: 800	Code of Practice for general construction in steel
IS: 802 (Part I)	Code of Practice for use of structural steel in overhead transmission line towers
Sec -1	Materials and Loads

Bureau of Indian Standards (BIS)	Title
Sec -2	Permissible stresses
IS: 802 (Part II)	Code of Practice for Use of Structural Steel in Overhead Transmission Line Towers - Part II : Fabrication, Galvanizing, Inspection and Packing
IS: 802 (Part III)	Code of practice for use of structural steel in overhead transmission line towers - Part III : Testing
IS: 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
IS: 875	Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures - Part 3 : Wind Loads
IS: 1200	Methods of measurement of building and civil engineering works: Part 1 to 28
IS: 1340	Code of practice for chromate conversion coating on zinc and cadmium coated articles and zinc base alloys
IS: 1363	Hexagon Head Bolts, Screws and Nuts of Product Grade `C' - Part 1 to 3
IS: 1367	Technical Supply Conditions for Threaded Steel Fasteners - Part 1 to 20
IS: 1477	Code of Practice for Painting of Ferrous Metals in Buildings - Part 1: Pre-treatment, Part 2: Painting
IS: 1573	Specification for Electroplated Coatings of Zinc on Iron and Steel
IS: 1852	Rolling and cutting tolerances for hot rolled steel products
IS: 1893	Criteria for earthquake resistant design of structures
IS: 2016	Specification for Plain Washers
IS: 2062	Steel for General Structural Purposes - Specification
IS: 2074	Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome, Priming – Specification
IS: 2551	Danger Notice Plates
IS: 2629	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS: 2633	Methods for testing uniformity of coating of zinc coated articles
IS: 3043	Code of Practice for Earthing
IS: 3063	Fasteners - Single coil rectangular section spring lock washers – Specification
IS: 3757	Specification for High Strength Structural Bolts

Bureau of Indian Standards (BIS)	Title
IS: 4000	Code of practice for high strength bolts in steel structures
IS: 4759	Hot-dip zinc coatings on structural steel and other allied products
IS: 5358	Hot dip galvanized coatings on fasteners
IS: 5369	General Requirements for Plain Washers and Lock Washers
IS: 5613	Code of Practice for Design, Installation and Maintenance for Overhead Power Lines - Part 3 : 400 kV Lines - Section 1 : Design, Section 2 : Installation and Maintenance
IS: 6610	Specification for Heavy Washers for Steel Structures
IS: 6623	High Strength Structural Nuts - Specification
IS: 6639	Specification for Hexagon Bolts for Steel Structures
IS: 6745	Method for determination of mass of zinc coating on zinc coated iron and steel articles
IS: 7215	Tolerances for fabrication of steel structures
IS: 8500	Structural Steel - Micro-alloyed (Medium and High Strength Qualities – Specification
IS: 10238	Fasteners - Threaded Steel Fastener - Step Bolts for Steel Structures
IS: 12427	Fasteners - Threaded Steel Fasteners - Hexagon Head Transmission Tower Bolts – Specification
	Indian Electricity Rules
	Railway Regulations for Electrical Crossings of Railway Tracks

9.0 Earthing

9.1 The Contractor shall measure the tower footing resistance (TFR) of each tower after it has been erected and before the stringing of the earth wire during dry weather. Each tower shall be earthed. The tower footing resistance shall not exceed 10 ohms. Pipe type earthing and counter poise type earthing wherein required should be done in accordance with IS: 3043 and IS: 5613.

9.2 The earthing will vary depending on soil resistivity. For soil resistivity less than 1500 Ohm-meter, earthing shall be established by providing 4 lengths of 30-metre counterpoise wire (total 120m length wire). For soil resistivity greater than 1500 Ohm-meter, earthing shall be established by providing 4 lengths of 70-metre counterpoise wire (total 280 m length wire).

9.3 Additional earthing shall be provided on every 7 to 8 km distance at tension tower (exact quantity & location to be decided by Site In-charge) for direct earthing of both shield wires (earth wire/ OPGW). The scope of work shall include supply & installation of PG clamp & down lead clamps and supply & installation of additional earthing (pipe type or counter poise type) depending upon soil resistivity.

9.4 For River Crossing towers/pile foundation, galvanized earthing strip of flat 50x6 mm is to be provided in two legs of tower for each location. The proper arrangement of connecting these strips by 16 mm bolts shall be provided in the stub. For pile foundation, the strip has to be taken up to scour level along the concrete of pile foundations. Only bolted connection is allowed for connecting this strip to achieve desired length. Contractor shall submit the detailed drawing for approval by the Owner before installation.

10.0 Packing (Tower Wise)

10.1 Angle section shall be wire bundled.

10.2 Cleat angles, gusset plates, brackets, fillet plates, hanger and similar loose pieces shall be bolted together in multiples or securely wired through holes.

10.3 Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.

10.4 The packing shall be properly done to avoid losses and damages during transit. Each bundle or package shall be appropriately and properly marked.

11.0 Inspection and Tests

11.1 General

All standard tests, including quality control tests, in accordance with appropriate Indian/ International Standard, shall be carried out unless otherwise specified herein.

11.2 Inspection

11.2.1 The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.

11.2.2 The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.

- 11.2.3 The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.
- 11.2.4 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.
- 11.2.5 Should any member of the structure be found not to comply with the supplied design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Purchaser or his authorized representative considers that the defects can be rectified.
- 11.2.6 Defects which may appear during fabrication shall be made good with the consent of the Employer according to the procedure proposed by the Contractor and its approval.
- 11.2.7 All gauges and templates necessary to satisfy the Employer shall be supplied by the Contractor.
- 11.2.8 The specified grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

12.0 Foundation

12.1 General

- 12.1.1 All materials, design, detailing and construction methods for foundations shall be as per the latest revision of relevant Indian Standards except as set out and specified below. In case of incompatibility between Indian Standards and the specifications herein, the more demanding parameters shall govern.
- 12.1.2 Foundation includes supply of all the materials such as cement, sand, coarse aggregates, reinforcement steel, and related all the construction material / equipment's, etc.

12.2 Classifications of Foundations

Depending upon the type of soil, water table and the presence of surface water, the foundations have been classified as follows (except for pile foundation).

12.2.1 Normal Dry Type

To be used for locations where water table is below the foundation depth and the soil met is cohesive and homogeneous upto the full depth, having clay content of 10- 15%.

12.2.2 Sandy Dry Type

To be used for locations where water table is below the foundation depth and the soil met is cohesion less (pure sand) or negligible cohesion (sand mixed with soil), having clay content of 0-10%.

12.2.3 Wet Type

To be used for locations:

- Where water table is above the foundation depth and upto 1.5 meters below the ground level.
- Where standing surface water is for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.

12.2.4 Partially Submerged Type

To be used at locations where water table is at a depth between 0.75 meters to 1.5 meters below the ground level and the soil met is normal and cohesive.

12.2.5 Fully Submerged Type

To be used at locations where water table is at a depth within 0.75 meters below the ground level and the soil met is normal and cohesive.

12.2.6 Black Cotton Soil Type

To be used at locations where soil is cohesive having inorganic clay exceeding 15% and characterized by high shrinkage and swelling property (need not necessarily be black in colour)

12.2.7 Soft Rock/Fissured Rock Type

To be used at locations where strata met is decomposed or fissured rock, hard gravel, kankar, limestone, laterite, or any other soil of similar nature. Under cut foundation is to be used at these locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

12.2.8 Hard Rock Type

To be used at locations where strata met requires chiseling, drilling and blasting is required for excavation. For these locations, rock anchoring is to be provided to resist uplift forces. For design purpose, rock level shall be considered at ground level and no overburden soil weight shall be considered for resisting the uplift.

12.2.9 Shallow Type

Based on geotechnical investigation, there may be necessity, especially in sandy soils with water table present; to have shallow depth spread footings, where the depth of footing needs to be restricted to 1.5 to 2.5 m below ground level.

The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation; and approval for the same shall be obtained from the Owner.

12.2.10 The properties of various types of soil shall be considered as per CBIP publication No. 323.

12.3 Construction of Tower Foundations

12.3.1 Excavation

Excavation work in a section must not be started until the tower schedule and profile of that section has been approved by the Owner.

12.3.2 Except as specifically otherwise provided, all excavation for footings shall be made as per approved design of the foundation. The excavation walls shall be vertical, and the pit dimensions shall be such as to allow a clearance of not more than 150mm on all sides from the foundation pad except for foundations in soft and hard rock. In soft rock and hard rock foundation, excavation will be of the exact size of the foundation. All excavation shall be protected so as to maintain a clean sub grade until the footing is placed, using timbering, shoring or casing, if necessary. Any sand, mud, silt or other undesirable materials that may have accumulated in the excavation shall be removed by the Contractor before placing concrete.

12.3.3 The soil to be excavated for tower foundations shall be classified as follows:

12.3.3.1 Dry Soil

Soil removable by means of a spade and shovel. Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

12.3.3.2 Wet Soil

Where the subsoil water table is encountered within the range of foundation depth or land, where pumping or bailing out of water is required due to presence of surface water, shall be treated as wet soil. The excavation done in wet soil in case of wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

12.3.3.3 Dry Fissured Rock

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition, which can be quarried or split with crow bars, wedges, or pickaxes.

However, if required, light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.

12.3.3.4 Wet Fissured Rock

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

12.3.3.5 Hard Rock

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required.

12.3.3.6 No extra charge shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

12.3.3.7 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimize fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner.

12.3.3.8 The Contractor shall supply requisite blasting material and be responsible for its storage and use.

12.3.3.9 Indian Standard IS: 3764 shall be followed regarding safety.

13.0 Stub Setting

13.1 For all towers the Contractor shall submit for approval the proposed method for setting of stubs.

13.2 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment, and levels with the help of stub setting templates and leveling instruments. Stubs shall be set in the presence of Owner's representative available at site where required and for which adequate advance intimation shall be given to Owner by Contractor.

13.3 Setting of stubs at each location shall be approved by Owner.

13.4 For river crossing towers, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Owner.

13.5 Stub Setting Templates

13.5.1 All the stub setting templates/props as required shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates/props as required shall be of adjustable type and painted. The Contractor shall deploy sufficient number of templates for timely completion of the line without any extra cost to Owner.

13.5.2 One set of each type of stub setting template shall be supplied to the Owner, on completion of the project, at no extra cost to Owner.

14.0 Concrete

14.1 All cement to be used shall be Ordinary Portland cement meeting the requirements of the relevant Indian Standards (mainly IS: 269), from an approved manufacturer. Cement shall be adequately protected from moisture or contamination during transportation and storage at site. Cement in bags shall be limited within a heap of 13 bags in store and 7 bags at site. No cement containing lumps or deleterious matter shall be used.

14.2 The concrete used for the foundation shall be of M20 grade (i.e. of 20N/mm² cube compression strength at the end of 28 days); with 20mm downgraded stone metal for chimney portion and slab portion and 40mm downgraded stone metal for slab/pyramid portions. Aggregates shall conform to specifications for coarse and fine aggregates from natural sources for concrete as per IS: 383. The methods used for the preparation of concrete, and all its properties regarding its strength under compression, tension, shears, punching and bending etc., as well as workmanship shall conform to IS 456.

14.3 **Fine Aggregates:** The sand used for the concrete shall be composed of hard siliceous materials. It shall be clean and of a sharp angular grit type and free from earthy or organic matter and deleterious salts. The sand shall conform to

Zone 1 Grade to IS: 383, which is the coarse variety with maximum size of 4.75 mm. Zone II Grade of fine aggregates may also be used.

14.4 Coarse Aggregates: The aggregates shall be of clean broken hard granite or other stone specified or approved by the Owner. It shall be of hard, closed-grained quality. It shall also be as far as possible cube like, preferably angular, but not flaky, perfectly clean and free from earth, organic or other deleterious matters. 40mm through 20mm square mesh measured in clear. All fine and coarse aggregates shall be obtained from sources approved by the Owner. Aggregate shall be of size as will pass through a mesh of 40mm measured in the clear and 20mm aggregate

14.5 The water used for mixing concrete shall be fresh clean and free from oil, acid and alkali organic materials or other deleterious substances. Salty or brackish water should not be used. Potable water is generally satisfactory.

14.6 Though not generally expected, sulphate-resisting cement may be necessary in certain areas of the line route, and the cost of this shall be deemed to have been included in the rates entered in the Schedule of Rates for concrete and foundation items. Sulphate resisting Ordinary Portland cement shall be in accordance with IS standards and shall be obtained from a source approved by the Owner. The Owner shall decide the locations where it shall be mandatory for the Contractor to use sulphate-resisting cement. The Contractor shall certify that the proposed cement is of the required quality regarding resistance to corrosion due to sulphates. Methods of testing this quality shall be deemed to have been included in the rates quoted. The use of aluminous cements will not be permitted.

14.7 Batching and Mixing of Concrete

14.7.1 It shall be Contractor's responsibility to carry out tests on samples for concrete mixture design that the Contractor proposes to employ in foundation concrete. The test result of the proposed mixture together with data for water cement ratio and slump shall be submitted to the Owner for approval at least four (4) weeks before the commencement of concreting operation. The trial mix proportions shall be approved if the average compressive strength of a set of 9 specimens tested at 28 days exceeds 21N/mm², with not more than 3 specimen being less than 20N/mm², and no single specimen being less than 17 N/mm².

14.7.2 The Contractor shall be responsible for maintaining the mixture, control and testing of concrete throughout the working period. Neither the mix proportions

nor the source of the supply of materials shall be altered without the prior approval of the Owner.

14.7.3 The minimum cement content, the water cement ratio, the slump and all other characteristics of concrete shall be demonstrated to conform to the relevant Indian Standards.

14.7.4 The concrete shall be mixed with an approved concrete mixer. In no case shall hand mixing be allowed. The Contractor shall provide the measuring equipment and shall maintain and operate the equipment as required to accurately determine and control the amount of each separate ingredient entering the concrete. The equipment shall be constantly maintained in first-class workable condition during the working period. The concrete mixing shall be cleaned and inspected at suitable intervals in the presence of the Owner.

14.7.5 Each time the work stops, the mixer shall be cleaned out, and while recommencing; the first batch shall have 10% additional cement to allow for sticking in the drum.

14.7.6 In difficult location, where it is not possible to transport the concrete mixer, the Owner may allow hand mixing of concrete. In such cases 10% additional cement shall be used over and above that being used for such foundation where mixer is being used. Additional cost in such cases shall be borne by the Contractor.

14.7.7 Mixing shall be continued until there is uniform distribution of material and the mix is uniform in color and consistency but in no case the mixing is done for less than 2 minutes. Normally mixing shall be done close to the foundation, but in case it is not possible the concrete may be mixed at the nearest convenient place, the concrete shall be transported from the place of mixing to place of final deposit as rapidly as practicable by methods (transit mixers), which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences. The concrete should be mixed as stiff as the requirement of placing the concrete in the forms or molds with ease and the degree to which the concrete resists segregation. Hence the quantity of water used should not be too much.

14.7.8 In the event that the Contractor proposes to use ready mixed concrete for foundation work approval must first be obtained from the Owner, who will inspect the batching plant and sand, cement and broken stone used in the making of concrete at the work. No ready mixed concrete shall be used in foundation work, if it has been mixed in the lorry during its journey to site for

more than 45 minutes prior to placing. At the discretion of the Owner, ready mixed concrete may be used in foundation if the journey to site is in excess of 45 minutes, if the cement is added to the drum at site and is thoroughly mixed prior to placing. Alternatively and at the discretion of the Owner, if the ready mixed lorry carries its own water drum, water may be added to the cement and aggregate in the mixing drum during the lorry's journey provided the concrete is not mixed for more than 45 minutes prior to placing. The Owner's decision to reject any of the above methods of supplying ready mixed concrete shall be final.

14.7.9 Concrete shall not be directly poured from a height more than 1.5m to avoid mix segregation.

14.7.10 Proper forms or molds adequately braced to retain proper shape while concreting should be used for chimney and pyramid or slab portions. The mould should be watertight so that cement cream should not come out leaving only sand and jelly consequently forming of honeycombing in the concrete. The form boxes shall be cleaned and oiled before these are used for concreting.

14.7.11 The stub angle shall be free of rust and cleaned thoroughly and painted with cement paste, made of 1 part of cement and $\frac{3}{4}$ part of water (cement slurry) to a thickness of 1.6mm before the concrete is laid against the stub angle. The painting with cement slurry shall be done each time to such a height before the cement wash becomes dry.

14.7.12 Concrete shall, in all cases, be placed in the presence of the Owner. No concrete shall be placed until the Owner has approved the excavated surface, stub setting, and inspection of formwork and completion of all preparation work. Adequate chutes or other approved method shall be employed to place concrete. All concrete shall be consolidated to the maximum practicable density with a concrete vibrator and make surface smooth and free from pockets and honeycomb.

14.7.13 The concrete shall be laid in 150mm layers and consolidated well so that the cement cream works up to the top and no honeycombing are left in the concrete. Concreting is to be done continuously so that the subsequent layers are laid before the final setting of the bottom layer begins.

14.7.14 If fresh concrete is to be laid on old concrete less than a week old, the surface of the old set concrete should be chipped and cleaned thoroughly with wire brush and washed with a layer of thick cement slurry before the new concrete

is laid. If, however, the concrete is more than 10 days old, the top layer of the set concrete should be chipped and cleaned thoroughly with wire brush and water and layer of cement mortar (1:2) 12 mm thick shall be laid evenly after giving a coat of cement slurry, as specified above to ensure proper bonding between old and new concrete. If a foundation is damaged after stringing, it shall be brought to the notice of the Owner and rectified as directed by him.

14.7.15 After concreting the chimney portion to the required height, the top surface should be finished smooth, with slight slope towards the outer edge to drain off the rainwater falling on the coping.

14.7.16 In wet locations, the site must be kept completely de-watered both during the placing of the concrete and for 24 hours after completion. There should be no disturbance of concrete by water during this period.

14.7.17 The forms or mold shall not be removed before a lapse of about 24 hours after the completion of concreting. After removal of the forms, the concrete surface, where required shall be repaired with a rich cement and sand mortar in the shortest possible time.

14.7.18 For concreting during hot weather and cold weather, adequate provision shall be made to maintain the suitable concrete temperature.

In hot weather, the concrete temperature shall not increase beyond 40°C at the time of placement of fresh concrete.

In cold weather, the temperature of the concrete shall not be less than 4.5°C in moderate weather or 10°C when the mean daily temperature drops below 4.5°C.

14.8 Reinforcement

14.8.1 All materials, activities and methods regarding reinforcing steel shall conform to the relevant I.S. Codes, particularly to IS: 432 for mild steel bars and wires, IS: 1786 for High Strength bars and wires, and IS: 1566 for steel wire fabric. The Contractor shall provide certificates stating origin and process of manufacture of reinforcing steel, and submit test certificates from supplier to the Owner. At the discretion of the Owner, samples of reinforcing steel selected by the Owner shall be tested by the Contractor at a local laboratory of the Owner's choice, to demonstrate the tensile strength of the steel. The cost of such testing shall be deemed to be included in the Scheduled Rates of Items.

14.8.2 The wire shall be 1.25mm in diameter or heavier black annealed iron wire. Preformed clips or attachments shall be of proper design and strength so that

reinforcing bars are rigidly supported / held in position, and are not capable of movement during concrete pouring.

14.8.3 Reinforcing steel shall be protected from damage during transportation and during storage. It shall be stacked horizontally with adequate supports to prevent distortion. Bars of different lengths and diameters shall be stacked separately and marked for easy identification.

14.8.4 Reinforcing steel shall be cold bent without any application of heat, by a slow and regular movement. Bending shall be done accurately to dimensions given in the bar bending schedule or foundation drawings in accordance with IS: 2502.

14.8.5 Bars having cracks or splits on the bends shall be rejected.

14.8.6 Immediately before placing concrete, it shall be ensured that reinforcing steel is free from dirt, detrimental scale, paint, mortar, oil, or other foreign substances.

14.8.7 Reinforcing steel embedded or partially embedded in the concrete shall remain completely undisturbed for a minimum period of 24 hours, or longer if the Owner so directs, after a unit of concrete placement has been completed.

14.8.8 Steel shall be placed accurately in accordance with the Drawings. It shall be tied securely at each intersection. Metal or concrete chairs and metal spreaders of approved types shall be used where necessary for support or spacing of steel bars.

14.8.9 Wood supports or spreaders shall not be used.

14.8.10 Splicing of bars except where shown on the Drawings shall not be permitted without the prior written consent of the Owner. Bar splicing shall be by overlapping, as indicated on the drawings, and the lap lengths shall not be less than 52 times the diameter of the smaller bar.

14.9 Backfilling, Compacting, and Removal of Stub Templates

14.9.1 Following opening of form work and removal of shoring and strutting, if any, backfilling shall be started after repairs, if any, to the foundation concrete. The space around the foundation shall be cleared of all debris, and filled with earth in layers not exceeding 200 mm, each layer being leveled, wetted and tamped properly before the succeeding layer is laid. Each layer of earth shall be consolidated by ramming with approved mechanical compaction machines. Special care shall be taken to prevent any wedging action against the footing. The backfill shall be compacted to 95% of the maximum dry density obtainable

in the standard Procter density test as specified in relevant standards. The excavation and placing operations shall be such that material when compacted will be blended sufficiently to secure best practicable degree of compaction, impermeability and stability.

14.9.2 The backfilling and grading shall be carried up to an elevation of about 75mm above the finishing ground level to drain out water. After backfilling, 50mm high earthen embankment will be made along the sides of excavation pits and sufficient water will be poured in the back-filled earth for at least 24 hours.

14.9.3 The fill materials will be subject to the Owner's approval. To the extent available, the selected surplus soils from excavated materials shall be used as backfill. Fill material shall be free from clods of earth, salts, sulphates, organic or other foreign materials. All earth clods shall be broken or removed. A clay type soil with a grain size distribution of 50% or more passing the # 200 sieve as well as a black cotton soil are unacceptable for backfilling. Where excavated material is mostly rocks, the boulders shall be broken to maximum size of 80 mm, mixed with properly graded fine material consisting of earth to fill up the voids and the mixture used for filling. If any selected fill material is required to be borrowed, Contractor shall make arrangements for bringing such material from outside borrow pits at his cost irrespective of lead & lift. The material as well as source shall be subject to prior approval of the Owner. The approved borrow area shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Topsoil containing salts/sulphates and other foreign material shall be removed. The material so removed shall be burnt or disposed off as directed by the Owner. Contractor shall make necessary access road to borrow area, and maintain the same, if such access road does not exist, at his cost.

14.9.4 The stub-setting template shall be opened only after the completion of backfilling in the pits to full depth.

14.10 Curing

14.10.1 The concrete, after it is 24 hours old, shall be cured by keeping concrete wet continuously for a period of 10 days after laying. The pit may be backfilled with selected earth sprinkled with necessary amount of water and well consolidated in layers not exceeding 200 mm of consolidated thickness after a minimum period of 24 hours and thereafter both the back-filled earth and chimney top shall be kept wet for the remainder of the prescribed period of 10 days. The uncovered concrete chimney above the back-filled earth shall be kept wet by providing empty cloth or hessian bags dipped in water fully wrapped around the

concrete chimney for curing and ensuring that the bags are kept wet by frequent pouring of water on them.

14.11 Benching

When the line passed through hilly/undulated terrain, leveling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Owner. Benching shall be resorted to only after approval from Owner.

14.12 Protection of Tower Footing

14.12.1 Tower spotting shall Endeavour to minimize the quantity of revetment required.

14.12.2 The work shall include providing all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nallahs, river bed undulated terrain, etc., including suitable revetment or galvanized wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required.

14.12.3 Tower footings shall generally be backfilled using soil excavated at site unless deemed unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of lead. The backfilling shall also include the required lead and consolidation and leveling of earth after backfilling. The activity of random rubble masonry revetment shall include excavation, construction of random masonry in 1:5 mortars, creating weep holes, providing filter material behind weep holes, and providing top sealing band with M15 concrete, etc all complete. The volume of random rubble masonry revetment shall be measured from bottom to top sealing band.

14.13 De-watering

14.13.1 Contractor shall furnish all materials and equipment and perform all work required for de-watering during line construction activities. The de-watering shall be inclusive of de-watering equipment, its transport and installation at site, and of all operational costs like skilled and unskilled man - power, fuel, maintenance charges, etc. all complete.

14.13.2 There shall not be any separate item for de-watering in the Schedule of Rates. It shall be assumed that the quoted rate for any item that could require de-

watering (e.g. excavation, concreting for footings, special works like revetment or excavation for any other purpose, etc.) is inclusive of de-watering.

15.0 TOWER ERECTION, STRINGING, AND INSTALLATION OF LINE MATERIAL

15.1 General

The details of the scope of erection work shall include the cost of labour, all tools and plant such as tension stringing equipment and all other incidental expenses in connection with erection and stringing work.

The Contractor shall indicate in his bid, the sets of stringing equipment he would deploy exclusively for each transmission line. The stringing equipment shall be of adequate capacity to string simultaneously a bundle of TWIN AAAC MOOSE conductor.

- 15.1.1 The Contractor shall be responsible for transportation of all the materials to be provided by the Contractor as per the scope of work to site, proper storage and preservation at his own cost till such time the erected line is taken over by the Owner. Similarly, the Contractor shall be responsible for proper storage, safe custody, loss or damage of all the Owner supplied items, if any, for incorporation in the works and shall maintain and render proper account for all such materials at all times.
- 15.1.2 Contractor shall setup required number of stores along the line and exact location of such stores shall be discussed and agreed to between the Contractor and the Owner.
- 15.1.3 The contractor shall furnish a brief write-up on the 'Execution methodology' he proposes to deploy for each of the above-mentioned transmission lines. The brief shall include the following activities:
 - Obtaining of ROW, Railway, PTCC & other statutory approvals/Clearances
 - Material management
 - Store management
 - Stringing/sagging
 - Final checking
 - Deployment of Tools & Plants for each activity
 - Manpower deployment

15.2 Treatment of Joints and Minor Galvanization Damage

Before starting assembly, minor defects in hot-dip galvanized members shall be repaired first by cleaning. After ensuring that the surface is dry, two coats of zinc rich paint having at least 90% zinc content conforming to relevant Indian Standard shall be applied to the satisfaction of the Owner. Also, for the line portion in highly polluted areas, the surfaces at joints shall be cleaned and applied with a coat of zinc rich paint specified above.

15.3 Assembly of Towers

Towers shall be erected on the foundations, not earlier than 10 days after concreting. The Contractor shall give complete details of erection procedures he proposes to adopt. For erection of towers using crane (wherever feasible) Cranes of suitable capacity along with other necessary T&P, power operated hydraulic/ motorized winches, Gin pole/ Derrick etc. shall be deployed by the Contractor accordingly.

The method of erection of towers shall ensure the following:

- 15.3.1 Straining of the members shall not be permitted for bringing them into position. It may, however, be necessary to match the hole positions at joints and to facilitate this, tommy bars not more than 450mm in length may be used.
- 15.3.2 Prior to commencement of erection of an upper section, the lower section shall be completely braced, and all bolts fitted in accordance with approved drawings to prevent any mishap during tower erection.
- 15.3.3 All plan diagonals relevant to a section of tower shall be in place prior to taking up the assembly of an upper Section.
- 15.3.4 All bolts shall have their nuts facing outside of tower for horizontal or nearly horizontal bolt connections and downwards for vertical bolt connections.
- 15.3.5 Tower shall be fitted with number, danger, phase and circuit plates as well as anti-climbing device and bird guards (on suspension towers), as described.
- 15.3.6 After complete erection of the tower, all blank holes, if any, are to be filled by bolts and nuts of correct size.
- 15.3.7 The towers shall not be out of vertical by more than 1 in 360 before stringing is carried out.

15.4 Tightening of Bolts and Nuts

- 15.4.1 All nuts shall be tightened properly using correct size spanner and torque wrench. Before tightening, it will be verified that filler washers and plates are placed in relevant gap between members, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washer shall be placed under the outer nut. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. It may be better to employ four persons, each covering one leg and the face to his left.
- 15.4.2 The threads of bolts projecting outside the nuts shall be punched at three positions on the diameter to ensure that the nuts are not loosened in course of time. If during tightening, a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced forthwith.
- 15.4.3 The threads of all the bolts, projected outside the nuts shall be welded at two diametrically opposite places. The circular length of each welding shall be at least 10mm. The welding shall be provided from ground level to bottom cross arm for double circuit towers. However, for river crossing towers, the welding shall be provided from ground level to 30m height from stub level. After welding zinc-rich paint with at least 90% zinc content shall be applied to the welded portion. At least two coats of the paint shall be applied. The cost of welding and paint including application of paint shall be deemed to be included in the erection price.

15.5 Insulator Hoisting

Suspension insulator strings shall be used for suspension towers and tension Insulator strings on tension towers. The strings shall be fixed on the tower just prior to the stringing of conductors. Damaged insulators and strings, if any, shall not be employed in the assemblies. Prior to hoisting, all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for that purpose. For checking the soundness of insulators, IR measurement using 10 kV (DC) Megger shall be carried out on insulators. Corona control rings/arcing horns shall be fitted in an approved manner. Torque wrench shall be used for tightening various line materials and components, such as suspension clamp for conductor and earth-wire/OPGW, etc., whenever recommended by the manufacturer of the same.

15.6 Handling of Conductor and Earth-wire

15.6.1 Running Out of the Conductors

- 15.6.1.1 While running out the conductors, care shall be taken such that the conductors do not touch and rub against the ground or objects which could cause scratches or damage to the strands. The conductors shall be run out of the drums from the top, in order to avoid damage due to chafing. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing. A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors.
- 15.6.1.2 The sequence of running out shall be from the top downwards i.e. the earth-wires/OPGW shall be run out first, followed by the conductors in succession. Unbalanced loads on towers shall be avoided as far as possible. The Contractor shall take adequate steps to prevent clashing of sub-conductors until installation of the spacers/spacer dampers. Care shall be taken that sub-conductors of a bundle are from the same Contractor and preferably from the same batch so that creep behavior of sub-conductors remains identical. During sagging, care shall be taken to eliminate differential sag in sub-conductors as far as possible. However, in no case shall sag mismatch be more than 25mm.
- 15.6.1.3 Towers not designed for one sided stringing shall be well guyed and steps taken by the Contractor to avoid damage. Guying proposal along with necessary calculations shall be submitted by the Contractor to Owner for approval. All expenditure related to this work is deemed to be included in the bid price and no extra payment shall be made for the same.
- 15.6.1.4 When the transmission line runs parallel to existing energized power lines, the Contractor shall take adequate safety precautions to protect personnel from the potentially dangerous voltage built up due to electromagnetic and electrostatic coupling in the pulling wire, conductors and earth-wires during stringing operations. The Contractor shall also take adequate safety precautions to protect personnel from this potential danger by the way of providing travelling ground.

15.6.2 Running Blocks

- 15.6.2.1 Immediately after running out, the conductor shall be raised at the supports to the levels of the clamp and placed into running blocks. The groove of the running blocks shall be of such a design that the seat is semi-circular and larger than the diameter of the conductor/earth-wire, and it does not slip over or rub against

the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

15.6.2.2 The running blocks shall be suspended in a manner to suit the design of the cross- arm. All running blocks, especially at the tensioning end, will be fitted on the cross- arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work.

15.6.3 Repairs to Conductors

The conductor shall be continuously observed for loose or broken strands or any other damage during the running out operations.

15.6.3.1 Repairs to conductor if necessary, shall be carried out during the running out operations, with repair sleeve. Repairing of conductor surface shall be carried out only in case of minor damage, scuff marks, etc., keeping in view both electrical and mechanical safety requirements. Number of damaged strands shall not exceed one- sixth ($1/6$) of the total strands in outer layer. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.

15.6.3.2 The Contractor shall be entirely responsible for any damage to the towers during stringing.

15.6.4 Enroute Crossings

15.6.4.1 Derricks or other equivalent methods shall be used during stringing operations where roads, channels, telecommunication lines, power lines and railway lines, etc have to be crossed, to ensure non-interruption in their normal services and also damage caused to property. However, shut down shall be obtained by the Contractor, while working at crossings with existing overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earth-wire/OPGW and accessories in the field and to ensure safe operation.

15.6.4.2 Joint measurement of electrical clearances shall be done by the Engineers of Employer and contractor after completion of final sagging in major crossing spans i.e. Railway crossing, River crossing, National/ State Highway crossing, expressway crossing, transmission line crossing (132kV and above voltage level) by using hand held clearance measurement device/ total station. Deviation, if any, is to be attended immediately. Value of measured electrical clearances is to be recorded for future reference.

15.7 Stringing of Conductor and Earth-wire/OPGW

- 15.7.1 The stringing shall be done by the control tension method, with the help of tension stringing equipment. The equipment shall be capable of maintaining a continuous tension.
- 15.7.2 The bidder shall give complete details of the stringing methods he proposes to follow. Prior to stringing, the Contractor shall submit the stringing charts for the conductor and earth-wire/OPGW showing the initial and final sags and tension for various temperatures and spans along with equivalent spans in the line for the approval by the Owner.
- 15.7.3 A controlled stringing method suitable for simultaneous stringing of the sub-conductors shall be used. The four conductors making up one phase bundle shall be pulled in and paid out simultaneously. These conductors shall be of matched length. Conductors or earth-wires/OPGW shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.
- 15.7.4 Stringing of OPGW shall be carried out carefully under the supervision of the professional agency.
- 15.7.5 While handing over the Employer supplied OPGW drums, the testing (fibre loss and length measurement using OTDR) of OPGW in each drum shall be carried out by Contractor in presence of OPGW supplier and/or Employer representatives.
- 15.7.6 After installation of OPGW, the testing of each section shall be carried out by Contractor in presence of Employer representatives. In case of any damage / high loss in the fiber, the total length of that particular section/ portion of OPGW shall be replaced by the contractor and in such case, the de-stringing & re-stringing shall be carried out by the contractor without any extra cost to Employer and cost of additional OPGW cable, hardware fittings and joint box, if any, for replacement of damaged OPGW etc. shall be recovered from the contractor.

15.8 Joints

- 15.8.1 When approaching the end of a drum length, at least three coils shall be left in place when the stringing operations are stopped. These coils shall be removed carefully, and if another length is required to be run out, a joint shall be made as per the recommendations of the accessory manufacturer.

- 15.8.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment / methods during conductor stringing, which ensures complete compliance in this regard.
- 15.8.3 All the joints on the conductor and earth-wire shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies, etc. shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc., and be properly greased with anti-corrosive compound, if required and as recommended by the manufacturer, before the final compression is carried out with the compressors.
- 15.8.4 Dimensions of compression type joints (Dead end clamps, MS compression joints, jumper cones, repair sleeves etc.) shall be measured before and after compression to check compliance as per approved drawings. Record of dimension measurement shall be maintained by the Contractor.
- 15.8.5 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads, railways and small rivers in tension spans. Not more than one joint per sub-conductor shall be allowed in one span. The compression type fittings shall be of the self-centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminum sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.
- 15.8.6 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints in case they are to be passed over pulley blocks/aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

15.9 Tensioning and Sagging in Operations

- 15.9.1 The tensioning the sagging shall be done in accordance with the approved stringing charts. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductor shall be clamped within 56 hours of sagging in.

- 15.9.2 The sag shall be checked in the first and the last span of the section in case of sections upto eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.
- 15.9.3 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.
- 15.9.4 At sharp vertical angles, conductor and earth-wire/OPGW sags and tensions shall be checked for equality on both sides of the angle on running blocks. The suspension insulator assemblies will normally assume verticality when the conductor is clamped.
- 15.9.5 Tensioning and sagging operations shall be carried out in calm weather, when rapid changes in temperature are not likely to occur.

15.10 Clipping In

- 15.10.1 Clipping of the conductors in position shall be done in accordance with the manufacturer's recommendations. Conductor shall be fitted with armor rods where it is made to pass through suspension clamps.
- 15.10.2 The Jumpers at section and at angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, if found necessary, to restrict jumper swing to design values.
- 15.10.3 The Jumper drop shall be maintained as per design requirement. Jumper length calculations for different line deviation angles shall be submitted by the Contractor to Employer/ Site-In-Charge. The jumpers shall be prepared to the required length & compressed with jumper pads at site stores. These shall be assembled with due care taking into consideration conductor bundle configuration and installed correctly.
- 15.10.4 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

15.11 Fixing of Conductors and Earth-wire/OPGW Accessories

- 15.11.1 Conductor and earth-wire/OPGW accessories including spacers, spacer dampers (for bundle conductor) and vibration dampers shall be installed by the Contractor as per the design requirements and manufacturer's instruction within

24 hours of the conductor/earth-wire/OPGW clamping. While installing the conductor and earth- wire/OPGW accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage occurs to any part of the accessories. Torque wrench shall be used for fixing the Dampers/Spacer Dampers, Suspension Clamps, etc. and torque recommended by the manufacturer of the same shall be applied.

15.12 Replacement

15.12.1 In case of any material replacement after stringing and tensioning or during maintenance, leg members and bracings shall not be removed without reducing the tension on the tower without proper guying techniques or releasing of the conductor. If the replacement of cross-arms becomes necessary after stringing, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

16.0 FINAL CHECKING, TESTING AND COMMISSIONING

16.1 After completion of the works, final checking of the line shall be carried out by the Contractor to ensure that all foundation works, tower erection and stringing have been done strictly according to the specifications and as approved by the Owner. All the works shall be thoroughly inspected in order to ensure that:

16.1.1 Sufficient backfilled earth covers each foundation pit and is adequately compacted.

16.1.2 Concrete chimneys and their copings are in good condition and finely shaped.

16.1.3 All tower members are used strictly according to final approved drawing and are free of any defect or damage whatsoever.

16.1.4 All bolts are properly tightened, punched, tack welded and painted with zinc rich paint.

16.1.5 The stringing of the conductors, earth-wire and OPGW has been done as per the approved sag and tension charts and desired clearances are clearly available.

16.1.6 All conductor, earth-wire and OPGW accessories are properly installed.

16.1.7 All other requirements for completion of works such as fixing of danger plate, circuit plate, phase plate, number plate, anti-climbing device, bird guard, aviation signal have been fulfilled.

16.1.8 Wherever required, that proper revetment (erosion protection) is provided.

16.1.9 All the design and drawing documents, bill of materials, plan and profile drawings, and survey documents are submitted to the Owner for reference and record.

16.1.10 All towers are properly grounded.

16.1.11 The line is tested satisfactorily for commissioning purpose.

16.2 The contractor shall submit minimum 4 nos. of high resolution (min. 20MP) geo tagged photographs of each tower after completion of stringing. Stringing shall not be considered completed without submission of soft copy of following photographs of each tower.

- Complete tower Close up on Cross arms covering insulators, Hardware etc.
- Forward span focusing on Conductor & corridor
- Foundation

16.3 After commissioning of the line, thermos-vision scanning of jumper connections, dead end joints and mid span compression joints of the complete line shall be completed by the Contractor by deploying third party agency within three months of commissioning of the line using minimum 640x480 pixel resolution day time thermos-vision Camera along with suitable lenses. Details of the proposed third-party agency (including past experience) shall be submitted by the Contractor to Employer site-in-charge/ RHQ. The thermos-vision scanning shall be carried out under supervision of Contractor & Employer's site engineers. Location and span wise report of thermos-vision scanning shall be submitted by the Contractor to Employer's site-in-charge. Identified defects, if any, shall be rectified by the Contractor within contractual defect liability period.

17.0 Field Quality & Manufacturing quality Plan

All field activity shall be carried out in accordance with Standard Field Quality Plan as approved by Quality department of Employer.

SITE REQUIREMENTS

1.0 Site Requirements:

- 1.1 Keeping in view of the project time lines and to meet the milestones, the contractor shall follow the below aspects diligently during the execution of works at site.
- 1.2 Separation of ROW resolution team and work execution team is required to be put in place for making the work front available continuously for smooth execution of the works. The contractor shall be dealing & liaising with the relevant govt. authorities as and when required for ROW resolution. The construction manager shall be enabled suitably with sufficient team and resources. Detailed plan of forming the teams for execution of the things shall be submitted by the contractor to the project in charge before commencement of works for acceptance Or As per Agreed scope of Work.
- 1.3 Necessary evaluation mechanism of deciding the compensations shall be devised right in the beginning of the project. Contractor shall ensure timely disbursement of compensations tree or crop or any other well in time to avoid any public agitation/ unrest for the execution of works. The contractor's Construction Manager at site shall be adequately enabled for doing all the needful in this matter. The Employer shall be provided the record of the compensations released for maintaining as a licensee for reference as may be sought by various authorities. Separate team for disbursing the compensation payments shall be engaged without mixing the responsibilities with execution team members.
- 1.4 Safety and security of the workplace and work men will have to be ensured by the contractor for smooth execution of the works. Necessary preventive and proactive measures shall be put in place by the EPC contractor as per the directions of the project/ site in charge from time to time based on the site conditions.
- 1.5 Separate teams shall be engaged for enumeration, preparation of documentation & submission of tree cutting applications to the concerned officers for approval shall be arranged much in advance as directed by the site in charge. A suitable program in this respect shall be submitted by the contractor for acceptance by the site in charge. Clearance of the corridor be done well in advance before initiating the stringing works so as to maintain no damages happen to the conductors during stringing.

- 1.6 Detailed planning of executing the EHV power line crossings shall be done much in advance considering the inputs of seasonal load flows and staggering days. The plan shall be submitted to the site in charge for acceptance. All EHV crossings outage be arranged by Contractor as per requirement. In the unlikely event, if the outage is not available, stringing by live line crossing technique shall be arranged by the contractor. All other power line crossings LT/11KV/33KV outages should be timely arranged by the contractor so that it does not hamper planned stringing schedule even if it amounts to providing temporary arrangements like cable bypass etc. for uninterrupted works.
- 1.7 Any issues from time to time during the course of execution as directed by the Project/ Site In-charge in the interest of the project for faster execution shall be implemented by the contractor diligently.

BRIEF DESCRIPTION OF

HEALTH SAFETY ENVIRONMENT & QUALITY

1.0 Quality Assurance, Inspection & Testing

1.1 Quality Assurance

To ensure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his Sub- Contractor's premises or at site or at any other place of work are in accordance with the specifications. The Contractor shall adopt suitable quality assurance program to control such activities at all points necessary. Such program shall be broadly outlined by the Contractor and shall be finalized after discussions before the award of Contract. The detailed program shall be submitted by the contractor after the award of contract and finally accepted by the Employer after discussion. A quality assurance program of the Contractor shall generally cover but not limited to the following:

- (i) His organization structure for the management and implementation of the proposed quality assurance program.
- (ii) Documentation control System.
- (iii) Qualification data for Contractor's key personnel.
- (iv) The procedure for purchase of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
- (v) System for shop manufacturing including process controls and fabrication and assembly controls.
- (vi) Control of non-conforming items and system for corrective action.
- (vii) Control of calibration and testing of measuring and testing equipment's.
- (viii) Inspection and test procedure for manufacture.
- (ix) System for indication and appraisal of inspection status.
- (x) System for quality audits.
- (xi) System for authorizing release of manufactured product to the Employer.
- (xii) System for maintenance of records.
- (xiii) System for handling storage and delivery and
- (xiv) A quality plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to critical and important items of supply.

The Quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

(xv) Quality Assurance Documents

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employer's inspection of equipment/material.

(xvi) The Employer or his duly authorized representatives reserves the right to carry out Quality Audit and quality surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

1.2 QUALITY ASSURANCE & INSPECTION PROGRAMME

1.2.1 The Contractor shall supply all the materials, equipment and services conforming to high standard of Quality and Workmanship commensurate with Indian standards and practices. The Contractor shall implement a Comprehensive Quality Management Program in line with the Employers Technical Specifications, for the items manufactured at his own works as well as the items procured from other manufacturers. The salient features of association of the Employer in this Quality Management Program are as follows:

- a) Vendor Approvals: In respect of the items identified for vendor approval by the Employer, the Contractor shall procure the materials and items only from the vendors duly approved by the Employer. For vendor assessment and approval, the Contractor shall provide necessary vendor details to the Employer and shall coordinate assessment visit, wherever so required by the Employer.
- b) Manufacturing Quality Plan Approvals: In respect of the items identified for Quality Plan approval by the Employer, the Contractor shall submit the Quality Plans and related reference documents to the Employer for his review and approval. While approving the Quality Plan, the Owner shall also identify the specific tests/ checks envisaged to be conducted in presence of the Employer.
- c) Inspection by Employer: In respect of the inspection/ testing stages envisaged as Witness/ Hold point by the Employer, the Contractor

shall raise inspection call to the Employer with advance notice period as per the contract.

- d) The Contractor shall provide to the representatives of Employer, at all reasonable time, a free access to the manufacturing works and related premises of the Contractor and vendors.
- e) Non-conformity Dispositioning: The Contractor shall dispose any non-conformity observed in the products or services only with due approval from the Employer.
- f) The Contractor shall facilitate the quality audits by the Employer at the works and establishments related to manufacture of the supplies under the Contract.
- g) Material Dispatch Clearance Certificate: The Contractor shall dispatch the material and items to project site only after obtaining Material Dispatch Clearance Certificate (MDCC) issued by the representative of the Employer after satisfactory compliance of inspection and testing requirements. The MDCC shall be one of the necessary documents for claiming payment against dispatch of the material/ equipment.

1.2.2 QA Documentation Package: The Contractor shall submit to the Employer, QA Documentation package for major equipment consisting of the technical documents and inspection / test records. The Contractor shall provide relevant technical inputs and documents to the Employer for activities related to Field Quality at project site in line with the recommendations, standards and practices of the original equipment manufacturers.

1.2.3 The Employer reserves the right of approval of Quality Plans, Vendor approvals and inspection of equipment and services, which is recognized and accepted by the Contractor and the Employer.

1.2.4 The language of the documents, correspondence/communication and equipment displays/ software- interface, shall be English.

1.2.5 The status of progress and effectiveness of implementation of QA Management System shall be periodically reviewed jointly by the Contractor and the Employer.

1.3 Employer's Supervision

- 1.3.1 To eliminate delays and avoid disputes and litigation to the Contract, all matters and questions shall be resolved in accordance with the provisions of this document.
- 1.3.2 The manufacturing of the product shall be carried out in accordance with the specifications. The scope of the duties of the Employer, pursuant to the contract, will include but not be limited to the following.
- 1.3.3 Interpretation of all the terms and conditions of these Documents and Specifications.
- 1.3.4 Review and interpretation of all the Contractor's drawings, engineering data etc.
- 1.3.5 Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the contract.
- 1.3.6 Inspect, accept or reject any equipment, material and work under the Contract, in accordance with the Specifications.
- 1.3.7 Issue certificate of acceptance and/or progressive payment and final payment certificate.
- 1.3.8 Review and suggest modification and improvement in completion schedules from time to time, and
- 1.3.9 Supervise the Quality Assurance Program implementation at all stages of the works.

2.0 Inspection and Tests

2.1 Inspection

- 2.1.1 The Employer, his duly authorized representative and/or outside inspection agency acting on behalf of the Employer shall have, at all reasonable times, access to the premises and /or works of the contractor and/or their sub-contractor(s)/sub-vendors and shall have the right, at all reasonable times, to inspect and examine the materials and workmanship of the product during its manufacture.
- 2.1.2 The Contractor shall give the Employer's Inspector fifteen (15) days (in case of domestic testing and thirty (30) days (in case of foreign testing), as the case may be, written notice of any material being ready for testing. The contractor shall give the notice for inspection and shall associate in the inspection with Employee's inspector. All such inspections shall be to the

Contractor's account except for the expenses of the Employer's inspector. The Employer's inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days (in case of domestic testing) and thirty (30) days in (in case of foreign testing) of the date of which the equipment is notified as being ready for test/inspection or on a mutually agreed date, failing which the Contractor may proceed with the test in accordance with the technical specification after informing the Employer in writing and he shall forthwith forward to the inspector duly certified copies of test reports / certificates in triplicate.

- 2.1.3 The Employer's Inspector shall, within fifteen (15) days from the date of inspection, give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet the said objections.
- 2.1.4 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Employer's inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Owner's inspector, the certificate shall be issued within fifteen
- 2.1.5 (15) days of receipt of the Contractor's Test Certificate by the Employer's Inspector. The completion of these tests or the issue of the certificate shall not bind the Employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.
- 2.1.6 In all cases where the Contract provides for test whether at the premises or works of, the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such item as labor, materials, electricity, fuel, water, stores, apparatus and instruments as may be reasonably demanded by the Employer's inspector or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall give facilities to the Employer's Inspector or to his authorized representative to accomplish testing.
- 2.1.7 The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

- 2.1.8 The Contractor shall keep the Employer informed in advance about the time of starting and of the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.
- 2.1.9 The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification. The Employer or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Employer's material for satisfying himself that the fabrication is being done in accordance with the provisions of the Specification.
- 2.1.10 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be concluded so as not to interfere unnecessarily with the operation of the work.
- 2.1.11 Should any member of the structure be found not to comply with the supplied design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Employer or his authorized representative considers that the defects can be rectified.
- 2.1.12 Defect which may appear during fabrication shall be made good with the consent of, and according to the procedure proposed by the Contractor and approved by the Employer.
- 2.1.13 The Employer reserves the right for getting any additional field tests conducted on the completely assembled equipment at site to satisfy that material complies with specifications.
- 2.1.14 All gauges and templates necessary to satisfy the Employer shall be supplied by the contractor.
- 2.1.15 The specified grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used, the inspector may at his discretion get the material tested at an approved laboratory.

2.2 Tests

- 2.2.1 The type, acceptance and routine tests and tests during manufacture shall be carried-out on the material and shall mean as follows:
 - 2.2.1.1 Type Tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to this

Specification. These tests shall be carried out on samples prior to commencement of commercial production against the order. The Contractor shall indicate his schedule for carrying out these tests.

- 2.2.1.2 Acceptance Tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.
- 2.2.1.3 Routine Tests shall mean those tests, which are to be carried out on the material to check requirements which are likely to vary during production.
- 2.2.1.4 Tests During Manufacturing shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the product supplied.
- 2.2.1.5 The norms and procedure of sampling for these tests will be as per the Quality Assurance Program to be mutually agreed to by the Contractor and the Employer.
- 2.2.1.6 Where a particular test is a specific requirement of this Specification, the norms and procedure of the test shall be as specified in as mutually agreed to between the Contractor and the Employer in the Quality Assurance Program.
- 2.2.1.7 For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Contractor, as applicable.

2.3 Standard Technical Particulars

The Standard Technical Particulars of various items are given in the relevant part of the specification. The bidder is required to comply with the same.

2.3.1 Packing

- 2.3.1.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. The Contractor shall be responsible for any loss or damage during transportation, handling, and storage due to improper packing.
- 2.3.1.2 The Contractor shall include and provide for securely protecting and packing the materials to avoid loss or damage during transport by air, sea, rail and road.

- 2.3.1.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing 'up' and 'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.
- 2.3.1.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e. fragile, handle with care, use no hook etc. wherever applicable.
- 2.3.1.5 Each package shall be legibly marked by the Contractor at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the Contractor etc.
- 2.3.1.6 Angle section shall be wire bundled.
- 2.3.1.7 Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.
- 2.3.1.8 Bolts, nuts washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.
- 2.3.1.9 The packing shall be properly done to avoid losses & damages during transit. Each bundle or package shall be appropriately marked.
- 2.3.2 Storage of Material under Transmission Line Package.**

Brief guidelines including typical drawing for storage of different type of construction material used in the transmission line projects are as under:

2.3.2.1 Cement Storage

Cement received at site should be stored in a building or shed which is dry, leak proof and moisture proof. The building should have minimum numbers of windows. Cement bags stored and stacked off the floor on wooden planks in such a way to keep about 150 mm to 200 mm clearance from the ground. The floor may be of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A minimum space of 600 mm shall be kept around and between the exterior walls and the stacks. In stacks, bags shall be kept close together to reduce air circulation. The height of the stack shall not be

more than 12 bags and the width of the stack shall not be more than four bags or 3 meters. For extra safety during monsoon, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a waterproofing membrane such as polyethylene etc. Different type and make of cement shall be stacked and stored separately.

2.3.2.2 Aggregates

Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of planks or old corrugated iron sheets, or floor bricks or a thin layer of lean concrete shall be made to prevent contamination with clay, dust, vegetable, and other foreign matter.

The stacks of fine and coarse aggregates shall be kept in separate stockpiles sufficiently removed from each other to prevent the material at the edges of the piles from getting intermixed. Fine aggregate shall be stacked in a place where loss because of wind is minimum.

2.3.2.3 Reinforcement Steel

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bars shall be stacked above ground level by at least 150 mm either on brick/cement/stone platform or concrete/bricks planks.

2.3.2.4 Structural Steel for Tower Parts

The structural steel of different classification, sizes and lengths shall be stored separately. These shall be stored above ground level at least 150 mm upon platforms, skids, or any other suitable supports to avoid any distortion of sections. Also, to prevent white rust formation sufficient care should be exercised while storing, handling and transporting galvanized products. The structural steel/ tower parts shall be stored in an adequately ventilated area. The article shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the structural steel/ tower parts.

2.3.2.5 Conductor & Earth wire Drums

It is essential to save the conductor drums from damage during storage and transportation and the wooden battens and main wheel should be intact so that same can be successfully mounted on the conductor jacks to release the conductor during stringing. All the conductor and earth wire drums should be stored on a proper hard platform above ground to avoid deterioration of the drum and further avoiding the damage of conductor. The conductor & earth wire drums should be stored in such a manner that each drum can be accessed at any time for inspection purposes.

2.3.2.6 Hardware fitting, Accessories & Insulators

All the hardware fittings, accessories and insulators should be stored on raised platform above ground so as not to damage the packaging and to avoid further damage or denting on the fittings and chipping of insulators. All the aluminum parts should be stored on a plain/raised platform under a cover shed in such a way that the aluminum fittings cannot be distorted during storage.

3.0 Environment, Social and Wildlife conservation Policy, and its Implementation

Development and growth of mankind through Industrialization and unwarranted use of natural resources has inflicted considerable impact on Environment and Society. As a result, Environmental and Social issues have emerged as the focal point of global debate.

3.1 Employer's activities by their inherent nature and flexibility have negligible impacts on environmental and social attributes. In order to address these issues and to match the rising expectations of a cleaner, safer and healthier environment, the key principles of Employer's Environmental and Social Policy are:

3.1.1 Avoidance of environmentally and socially sensitive areas while planning project activities.

3.1.2 Minimization of impacts when project activities occur in environmentally and socially sensitive areas.

3.1.3 Mitigation of any unavoidable adverse impacts arising out of its projects.

3.2 Basic issues to be kept in mind while carrying out construction activities are to

3.2.1 Avoid socially sensitive areas with regard to human habitations and areas of cultural significance.

- 3.2.2 Secure the interest of people affected by Employer's projects.
- 3.2.3 Involve local people affected by transmission line projects as per requirement and suitability.
- 3.2.4 Consult affected people in decisions having implication to them if considered necessary.
- 3.2.5 Apply, efficient and safe technology/practices.
- 3.2.6 Keep abreast of all potential dangers to people's health, occupational safety and safety of environment and the respective mitigatory measures.
- 3.2.7 Establish preventive mechanisms to guarantee safety.
- 3.2.8 Mitigation measures in case of accidents.
- 3.2.9 Avoid unwarranted cutting of trees in forest and non-forest area.
- 3.2.10 While constructing the lines through forest stretches (if any) the contractor will provide alternate fuel to its employee e.g. working labors/supervisors etc. to avoid cutting of forest woods. Contractor will ensure safety to the wildlife, during working/camping near to the National park.
- 3.2.11 Contractor during construction of lines in agricultural fields will ensure minimum damages to the crops, trees, bunds, irrigation etc. If the same is unavoidable, the decision of Employer shall be final.
- 3.2.12 The waste/excess material/debris should be removed from the construction site including agricultural field, forest stretches, river etc. immediately after construction work.
- 3.2.13 The contractor will ensure least disturbance to the hill slope and natural drainage to avoid soil erosion. Natural drainage in plane area if disturbed is to be trained to the satisfaction of Employer
- 3.2.14 As far as possible existing path/kutcha road/approach shall be used for the construction.
- 3.2.15 The Contractor will ensure supply of stone chips/sand from authorized/approved quarry areas.
- 3.2.16 The contractor will submit safety procedures to be adopted by them/QAP/MQP/FQP etc., before execution of the job to the Employer and must obtain their approval

4.0 Methodology of Erection of Tower at Site

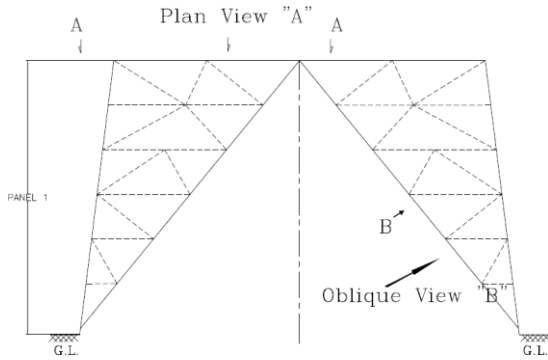
- 4.1 The towers shall be erected on the foundations not less than 10 days after concreting or till such time that the concrete has acquired sufficient strength.

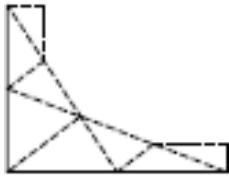
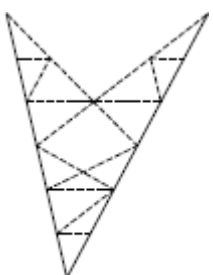
The tower structure consists mainly of:

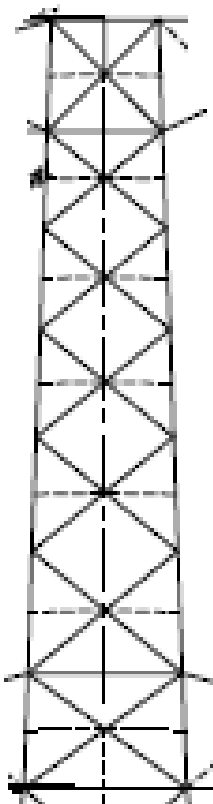
- Transverse & Longitudinal face
- Oblique View
- Plan View
- Cage
- Cross-Arms
- Plates
- Nuts/bolts

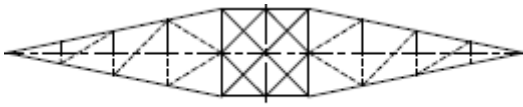
4.2 Steps of Erection Methodology

The towers shall be erected panel by panel as per below mentioned steps as per approved structural drawings:

Step No.	Procedure & Checks	Diagram
1.	Erection of tower will start from first panel from Ground level i.e. erection progresses from the bottom/Stub upwards. Erection of tower shall be done member by member of the first panel. Four main corner leg members of the first panel of the tower are firstly erected followed by erection of bracings & redundant of transverse face & longitudinal face. Erection of 2 nd panel be continued in the above manner and immediately after that the Oblique view &	

Step No.	Procedure & Checks	Diagram
	Plan view of the First Panel with all plates be installed & nuts / bolts properly fitted / tightened. Checks before proceeding for erection of next panel: Each & every member of transverse & longitudinal face of first two panels to be erected. Each & every member of oblique & plan view of the first panel to be erected. Every plate to be fitted in the first & second panel. Every leg joint shall have one inside cleat & two cover plate fitted with all nuts/bolts tightened as per approved drawings. All Nuts/bolts of proper size & length to be fully fitted & completely tightened. No hole should be vacant without nuts/ bolts. Before tightening it shall be ensured that spring washers & pack plates are placed in relevant gaps between the members as shown in the GA drgs. Erection of third panel should not be started before completion of all the above in the bottom panels in all aspects and visual verification / Confirmation	PANEL-1  <u>VIEW A-A</u> PLAN VIEW  <u>VIEW B</u> OBLIQUE VIEW
2.	Similarly, all panels up to waist levels to be erected as per the above steps/process	

Step No.	Procedure & Checks	Diagram
3.	After erection of tower up to waist level, All nuts/ bolts to be fully tightened completely. Erection of cage to be done as mentioned below: - Four main corner leg members of the cage of the tower are firstly erected followed by erection of bracings & redundant of transverse face & longitudinal face of the cage, Oblique view & Plan view (if any) with all plates to be installed & nut/bolts properly fitted. Checks before proceeding for erection of X-arms & Peak: Each & every member of transverse & longitudinal face of the cage to be erected. Each & every member of oblique & plan view (if any) to be erected. Every plate to be fitted in all the panels. Every leg joint shall have one inside cleat & two cover plate fitted with all nuts/bolts tightened as per approved drawings. All Nuts/bolts of proper size & length to be completely tightened. No hole should be left vacant without nuts/ bolts. Before tightening it shall be ensured that spring washers & pack plates are placed in relevant gaps between the members. Erection of X-arms should not be started before completion of Cage in all aspects and visual verification and certify for next panel erection.	 CAGE

Step No.	Procedure & Checks	Diagram
4.	All X-arms & peak to be completely assembled at Ground with all nuts & Bolts tightened completely. Assembled X-arms & Peak shall be uplifted to the respective cage level (Starting from Top to bottom) and fitted with all plates & nuts / bolts tightened completely.	 BOTTOM X-ARM BOTTOM PLAN

4.3 STRINGING

4.3.1 WORK FORCE:

- 4.3.1.1 Screening of the skilled persons by site engineer and safety co-coordinator is a must.
- 4.3.1.2 Ensure adequate nos. of workers in the gang.
- 4.3.1.3 Concerned engineer should brief the scheme for stringing to the stringing gang and ensure that they follow the same.
- 4.3.1.4 Stringing gang should be screened thoroughly and briefed about the Safety requirement.
- 4.3.1.5 Ensure competent and experienced supervisors all the time.

4.3.2 **TOOLS & TACKLES:** Inspect all the tools tackles and availability of test certificates.

4.3.3 HANDLING CONDUCTOR WIRE DRUMS:

- 4.3.3.1 To the possible extent cable drums should be transported by trucks / long bed trailer, except for short distances. All Loading & un-Loading should be done either by having ramp (Excavated slope) such that body of the truck will be at ground level or by using Hydra / cranes. Whenever Hydra / cranes are used, slings should be of adequate capacity. While deciding the capacity of the crane, Safe working loads for the boom angle to be checked up. This is very important to avoid accidents. After loading the drums into vehicle, proper wedges are to be provided and to be tied properly to avoid rolling of drums. Drums should never be dropped off from the truck/trailer.

- 4.3.3.2 While rolling the drums care should be taken to roll in proper direction as shown in the drum. Otherwise cable will get loosened and cause problems during conductor laying. Before rolling the drums, soil condition is to be checked up. Otherwise there is a possibility of sinking on one side of the drum and toppling. While rolling the drums in slopes, wedges should be provided at regular intervals to avoid drum picking up uncontrollable speed. Persons handling the drums should be always behind and on the sides of the drums and never in the front. This precaution is very essential and non-observance while handling the drums at slopes can be dangerous.
- 4.3.3.3 Never use cast iron pipes as drum jack shaft. Jacks should have proper and wide base to avoid tilting of jacks. Whenever the height of drum is more and packing is required, proper sleepers should be used.
- 4.3.3.4 Proper cordoning / barricading to be done while stringing activity is on.
- 4.3.3.5 Most important, thing to ensure is that the gang leader should have basic knowledge of rigging work.

4.3.4 Stringing Machinery:

- 4.3.4.1 Along with Stringing machinery supplied by different manufacturers, working manual must always be available with the TSE.
- 4.3.4.2 Proper arrangements Hydra / crane etc. should be made available at site for safe loading / unloading of conductor drums.
- 4.3.4.3 Place the drum loading jacks on the plain & firm ground level.
- 4.3.4.4 Hydra only to be used to place the conductor drums over the loading jacks.
- 4.3.4.5 Before the operation of the stringing, The TSE machines (Tensioner & Puller m/c) to be thoroughly checked for all the mechanical and braking system by the P&M supervisor and by the respective operators. Everyday maintenance is a must, especially greasing of the rotating parts.
- 4.3.4.6 Tensioner & Puller m/c should be placed a min. of 50 - 60 Mtrs. away and in co- linear to the towers. Much deviation from the line should be avoided.
- 4.3.4.7 Both the tensioner and the puller should be anchored on all the four sides rigidly and temporarily earthed.

4.3.5 Guying of Tower

- 4.3.5.1 All the anchor towers should be provided with adequate nos. of guys. It is preferable to have one guy each for every cross arm & also two guys for earth-wire point.
- 4.3.5.2 The guys should be more than 45 degrees to the ground. Back staying should be of steel wire rope - min. size 20mm. Anchoring for back -stays should be strong enough to withstand the intended load. Dead-men anchoring should be made by using wooden planks of 100mm dia, 2 Mtrs. Size, deeply buried to a excavated pit of size 2.0 x 1.5 x 2.5 Mtrs, duly attached by wire rope slings of 18mm and above. The pit should be properly compacted. In case the guying and back-staying arrangement has to be maintained for a long duration, then the anchoring area should be fenced and watchman should be posted round the clock.
- 4.3.5.3 Guy ropes are to be checked every day. When the gang moves from one anchor point to the next section, keep a watchman round the clock near the anchored guy ropes for the avoidance of misuse by miscreants. There is a possibility of cascading resulting in fatality.
- 4.3.5.4 Guying and back-staying is to be provided for one side stringing of D-type towers also.
- 4.3.5.5 Guying and back-staying arrangement should have to be connected through 10 MT. turn buckle & 10 MT. Tirfor / Wire rope winch etc. for adjustment of tension of the guy wires.
- 4.3.5.6 Electrical discharge rods should be of best quality and should be purchased from reputed manufacturer with test certificate
- 4.3.5.7 All the skilled workers at height and the operators should wear hand gloves.
- 4.3.5.8 If the transmission line is running parallel or crossing to any other HT/LT line, the workers will get induction effect on the conductors. Running earth must be provided during conductor paying out. Local earthing of the Tensioner & Puller must be ensured.

4.3.6 Paying out & Rough Sagging:

- 4.3.6.1 As far as possible, the conductor tension should be controlled in such a way that the conductors do not come close to the ground.
- 4.3.6.2 Sequence of paying out should be from top to bottom.

4.3.6.3 While doing tensioning work, fitters should stand inside tower body parts and not to be allowed to stand on the cross arms.

4.3.6.4 Walkie-talkie to be used compulsorily by the tensioner and puller operators and also in between supervisors. Battery level should be checked every day for walkie-talkie. It is preferable to have one or two spares. Flag man should be posted on each tower top during paying out.

4.3.7 Work on the Conductor:

4.3.7.1 When the workmen have to move on insulators, they must wrap the safety belt around the insulator and then move. While moving he should slide the loop of safety belt lanyard along with his movement.

4.3.7.2 Only after releasing the four-sheave / Six Sheave pulley, skilled and experienced fitter shall be allowed to move on conductor for releasing the come- along clamps provided on conductors. After the job, the workmen should return back through the towers only. No workmen should descent from the conductor by using rope directly.

4.3.7.3 Person responsible for verifying the sag of conductor / earth wire should be knowledgeable & well experienced in respective area.

4.3.7.4 In case of any entanglement in lead wire of Six / four sheave pulley at height, no workmen will be allowed to go on the insulator to release. The lead wire should be first released & made tension free then only the workmen should be allowed for releasing the entanglement at height.

4.3.7.5 Final sagging must be done by using Regulated / Hand / Engine Operated Sag winch only. Tractor pulling is not permitted. Six / Four sheave pulley arrangement with 12mm FMC wire rope to be used for final sagging & tensioning of conductors.

4.3.7.6 Dynamometer method / Sag board with sag scope on the appropriate span should be used to measure the sag / tension as per the approved sag-tension chart. Conductor thermometer is a must for finding the correct temperature during final sagging.

4.3.7.7 During Clipping, Double sheave pulley block arrangement or turn buckle arrangement with rubber / cotton packing be used for lifting the conductors from the running blocks and to avoid damages to the conductors.

- 4.3.7.8 Spacer cycle must be used for fixing of spacer dampers. No monkey climbing is allowed.
- 4.3.7.9 In Hilly terrain, Arm stays be provided to all those towers under compression.
- 4.3.7.10 The D-shackles used for Final sag should be of Grade-63 or Grade-80 and the SWL capacity should be as per the specification. Test certificates is a must. Step bolts or any other bolts should not be used as the D-shackle pin.
- 4.3.7.11 The wire rope pulley block should be snatched hook or closed type and the SWL should be as per specification only.

4.3.8 OTHERS:

- 4.3.8.1 Before taking up stringing work, it is a must to ensure that the towers are fully tightened, and all members are properly fixed. Through Final checking of towers must be done by competent person to ensure that no bolts are missing, and all members are secured & tightened properly and Back filing/compaction of soil around the foundations is done properly. Confirmation to be given by the Employers Supervisor for commencement of stringing work.
- 4.3.8.2 Children and animals playing around the area should be removed from the region. Barricading the stringing area is a must. Nearby Villagers must be conveyed about the job operation and related hazards in details.
- 4.3.8.3 Work should not be executed in inclement weather conditions.
- 4.3.8.4 Always wear helmets with chin straps and double lanyard safety belt. With proper anchorage of the lanyard to two separate fixed anchor points.
- 4.3.8.5 Ensure proper housekeeping. Do not throw the empty insulator crates/boxes, wire straps, conductor bits/strands, Conductor drum PP sheet and paper corrugation sheets in open. The same should BE collected and returned to stores.
- 4.3.8.6 Work methodology should be clearly understood by all the persons at site including supervisors & workers.
- 4.3.8.7 First aid box with sufficient qty. of medicines & two trained first aid persons should be available in the gang. List of nearby doctors and medicals available be available with the gangs. One dedicated vehicle must always be available during stringing work.
- 4.3.8.8 All wooden dead-men (temporary anchoring) to be buried at a depth of not less than 2.5 meters.

- 4.3.8.9 While doing tensioning work, fitters should stand inside tower body parts and not to be allowed to stand on the cross arms.
- 4.3.8.10 Prior necessary permits/approvals to be taken from respective authorities like Electricity Authority, Highway, Railway and Forest department etc. before taking up work.
- 4.3.8.11 All the towers of the stringing section should be permanently earthed.
- 4.3.8.12 Jumpers are to be left disconnected in sections until all the work of the entire line is completed.
- 4.3.8.13 Local public & Animals should not be allowed to the stringing area.
- 4.3.8.14 For crossing of any existing charged line, shut down and permit to work for the existing line must be taken. Induction tester also shall be used to check the induction.
- 4.3.8.15 All the insulator strings should be thoroughly checked for any crack, damage, missing split- pins etc., before lifting them on to the cross arm of the tower.
- 4.3.9 ADDITIONAL PRECAUTIONS - FOR STRINGING IN THE VICINITY OF CHARGED OVERHEAD LINES AND IN AREAS WHERE INDUCED VOLTAGE IS ANTICIPATED:
 - 4.3.9.1 All winches, pulleys and tensioner / puller must be properly earthed. Tensioner & puller operator should be provided with a HT insulated rubber mats.
 - 4.3.9.2 Conductor running blocks are to be earthed.
 - 4.3.9.3 All the conductors of the section are to be earthed through running earths.
 - 4.3.9.4 Before breaking the continuity of the conductor at any point it must be ensured that the conductors at both ends of either side are properly earthed. Earth shall also be provided at both sides of the working point and shall remain in position until the conductor is reconnected.

4.3.10 SPECIFICATIONS OF MAJOR STRINGING TOOLS & PLANTS:

D-shackle – 63 Grade 5.0MT/10.0MT/12.5/25.0MT
Single Sheave Pulley – 4.5MT.
Double Sheave Pulley block – 8.5MT.
FMC Wire rope - 12mm, 18mm, 20mm, 22mm
Wire rope Slings 18mm, 20mm, 22mm
Tirfor – 10.0MT.
Turn Buckle (Hook & Eye) – 10.0MT.
Regulated sag Winch – 15.0 MT
Articulate / Swivel Joint – 10.0MT. / 25.0MT
Pilot Wire – 16mm
3 /4/5/7 Sheave Aerial Roller – 800 mm
Hydraulic Drum Lifting Jack – 8MT
Bolted type come along clamp – 8 MT

Note;

* Contractor shall take prior approval from Employer for stringing tools as per site requirements.

CHECKLIST - GENERAL

No	Description of Activity	Feedback (Y/N)	Remarks
General points common for all activities during Excavation, Casting of foundation, Erection of tower and stringing of conductor.			
1	Check whether the contractor has procured required quantity of PPE considering maximum numbers of erection gangs deployed at site.		
2	Supervisors / Workmen have been provided with required healthy PPEs like (Safety helmet/Safety belts/ Safety shoes/ Gum boots as applicable)		
3	Availability of First Aid box with required medicines at site.		
4	Instruction register is available at site.		
5	Ensure Supervisor / Gang leader always issues instruction to the workmen before start of work.		
6	All driver and plant operators are holding valid driving license.		
7	Check the vehicle for rescue is available at site.		
8	Ensure engaged labor are aware of the job.		
9	Check that the unskilled laborers are not engaged in skilled job.		
10	Ensure supervisor / workmen engaged in the field are aware of First Aid Techniques (such as in case of Electric shock, fall from the height, Snake bite and the person rescued form buried under the debris etc.)		
11	Check for nearby Hospital / Doctor in case of emergencies arises.		
12	While transporting heavy consignment of conductor or earth wire drums from Central stores to site using Cranes, Truck, and Tractor. the safety aspect for construction and failure of brake system of moving machinery is to be checked,		

13	At least one dry powder type of portable fire extinguisher shall be provided especially where explosive or blasting agents are used for excavation.		
14	Check the competence (Qualification / experience) of supervisor / gang leader of contractor.		