



ODISHA POWER TRANSMISSION CORPORATION LIMITED

TECHNICAL SPECIFICATION

FOR

CONSTRUCTION OF TRANSMISSION LINES

1)132 KV SC/DC,

2)220 KV SC/DC AND

3)400 KV DC

TRANSMISSION LINES

Nature of work

The work covered by this Specification is for 400 kV and/or 220 kV and/or 132 kV transmission lines as specified herein and in the attached Schedules. The overhead transmission lines will form part of the OPTCL Transmission System.

General particulars of the system

The following are the general particulars governing the design and working of the complete system of which the Works will form a part —

- a) Electrical energy is generated at interconnected power stations as three-phase current at a frequency of 50 Hz, and transmitted therefrom by means of overhead lines.
- b) The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons

1.0 SCOPE-

Construction of 400 KV, 220 KV and 132 KV

As indicated in the Bidding Proposal Sheet & scope of work.

Important: Contractor has to obtain project license from the competent authority in respect of the mentioned works prior to commencement of the works. The expenses towards the project license have to be borne by the contractor.

2.0 SURVEY (detail & check, estimating of quantities & spotting of towers)

2.1.1 General: Preliminary route alignment in respect of the proposed transmission lines has been fixed by the employer subject to alteration of places due to way leave or other unavoidable constraints. The Right of way shall be solved by the contractor and all expenses there of shall be borne by him. However, OPTCL shall render all helps in co-ordination with law and order department for solving the same. Forest clearance if any shall be arranged by OPTCL.

2.1.2 Provisional quantities/numbers of different types of towers have been estimated and indicated in the BOQ Schedule given. However final quantities for work shall be as determined by the successful bidder, on completion of the detail survey, preparation of route profile drawing and designing of the different types of towers as elaborated sin the specification and scope of work.

2.1.2.1 The contractor shall undertake detailed survey on the basis of the tentative alignment fixed by the employer. The said preliminary alignment may, however, change in the interest of economy to avoid forest and hazards in work. While surveying the alternative route the following points shall be taken care by the contractor.

- (a) The line is as near as possible to the available roads in the area.

- (b) The route is straight and short as far as possible.
- © Good farming areas, religious places, forest, civil and defence installations, aerodromes, public and private premises, ponds, tanks, lakes, gardens, and plantations are avoided as far as practicable.
- (d) The line is far away from telecommunication lines as reasonably possible. Parallelism with these lines shall be avoided as far as practicable.
- (e) Crossing with permanent objects are minimum but where unavoidable preferably at right angles.
- (f) Difficult and unsafe approaches are avoided.
- (g) The survey shall be conducted along the approved alignment only in accordance with IS: 5613 (Part-II/Section-2), 1985.
- (h) For river crossing/ Crossing of Nallas : Taking levels at 20 metre interval on bank of river and at 40 metre interval at bed of river so far as to show the true profile of the ground and river bed. The levels may be taken with respect to the nearest existing towers, pile foundation of towers, base or railway/road bridge, road culvert etc. The levels shall be taken at least 100 m. on either side of the crossing alignment. Both longitudinal and cross sectional shall be drawn preferably to a scale of 1:2000 at horizontal and 1:200 vertical.

After completing the detailed survey, the contractor shall submit the final profile and tower schedule for final approval of the employer. The final profile and tower schedule shall incorporate position of all type of towers. To facilitate checking of the alignment, suitable reference marks shall be provided. For this purpose, concrete pillars of suitable sizes shall be planted at all angle locations and suitable wooden/iron pegs shall be driven firmly at the intermediate points. The contractor shall quote his rate covering these involved jobs. The contractor shall

Only approved sag template shall be used for tower spotting and the final profiles. However preliminary survey has been done by OPTCL and any further survey required shall be done by the contractor.

2.1.2.2 PROFILE PLOTTING AND TOWER SPOTTING

The profile shall be plotted and prepared to the scale 1 in 2,000 for horizontal and 1 in 200 for vertical on squared (mm) paper. If somewhere the difference in levels be too high, the chart may be broken up according to the requirements. A 10 mm overlap shall be shown on each following sheet. The chart shall progress from left to right for convenience in handling. The sheet size may be conveniently chosen.

With the help of sag template, final tower location shall be marked on the profiles and while locating the tower on survey chart, the following shall be kept in mind:

The contractor shall also submit the land schedule on revenue (if required) maps indicating alignment therein duly authenticated by Revenue Inspector & Tahasildar, enumeration of trees with the help of Forest officer and other prominent features required for alignment of the proposed 132 KV line. Final route to be plotted on 1:50000 topo sheet for approval. Detail GIS (Geographical Information System) of towers to be included.

- (a) The number of consecutive span between the section points shall not exceed 10 in case of straight run on a more or less plain stretch.
- (b) Individual span shall be as near as to the normal design ruling span.

In different crossing the contractor shall take into consideration the prevailing regulations of the respective authorities before finalizing type and location of the towers. While carrying out survey work, the contractor has to collect all relevant data, prepare and submit drawings in requisite number for obtaining clearance from the PTCC, road, aviation, railways, river and forest authorities.

The contractor shall remain fully responsible for the exact alignment of the line. If after erection, any tower is found to be out of alignment, the same shall have to be dismantled and re-erected after correction by the contractor at his own cost, risk and responsibility, including installation of fresh foundation, if belt necessary by the employer.

After peg marking of the angle tower or tension towers, the contractor shall obtain approval from the employer and thereafter pegging of suspension type tower shall be done by the contractor and pegging of all the four legs of each type of towers at all the locations shall be done.

2.1.2.3 SCHEDULE OF MATERIALS

When the survey is approved, the contractor shall submit to the employer a complete detail schedule of all materials to be used in the line. Size and length of conductor etc. are also to be given in the list. This schedule is very essential for finalizing the quantities of all line material. The contractor shall furnish the same.

2.1.2.4 CHECK SURVEY

The contractor shall undertake the check survey during execution on the basis of the alignment profile drawing and tower schedule approved by the employer. If during check survey necessity arises for minor change in route to eliminate way leave or other unavoidable constraints, the contractor may change the said alignment after obtaining prior approval from the employer.

The contractor, while carrying out the check survey, shall peg mark the power position on ground conforming to the survey charts. In the process, it is necessary to have the pit centers marks according to the excavating marking charts to be prepared by the contractor and approved by the employer. The levels up or down of each pit center with respect to the center of the tower location shall be noted and recorded for determining the amount of earth work required to meet the design. At the charting point of the route

survey, an angle iron spite shall be driven firmly into the ground showing a little above the ground level.

2.1.2.5 WAY-LEAVE AND TREE CUTTING

Way-leave permission which may be required by the contractor shall be arranged at his cost. While submitting final-survey report for approval, proposals for way-leave right of way shall be submitted by the contractor. Employer may extend help to get the permission within a reasonable time as mutually agreed upon for which due notice shall be given by the contractor in such a way so that obtaining permission from appropriate authority do not hinder the continued and smooth progress of the work.

The employer shall not be held responsible for any claim on account of damage done by the contractor or his personnel to trees, crops and other properties.

The contractor shall take necessary precaution to avoid damage to any ripe and partially grown crops and in the case of unavoidable damage, the employer shall be informed and necessary compensation shall be paid by the contractor.

All the documents required for application to the statutory authorities must be prepared by the contractor & submission to the employer for Submission of the application towards approval of PTCC, Railway Crossing etc. However, the responsibilities lies with the contractor to get the clearance.

Trimming of tree branches or cutting of a few trees en-route during survey is within the scope of survey to be done by the contractor. Contractor shall arrange for necessary way-leave and compensation in this regard. During erection of the line, compensation for tree cutting, damage caused to crops, actual cutting and felling of the trees including way-leave permission for such route clearance shall be arranged by the contractor at his cost. The contractor will identify the number of trees and detail of obstructions to be removed for erection of the line and intimate the employer well in advance in case of any help. Other related works like construction of temporary approach roads, etc. as required, shall be done by the contractor and the same will lie within the scope of contractor's work and such cost shall be considered to be included in the rates quoted by him.

While quoting the rate for detailed and check survey as per bidding activity schedule, the contractor shall include all costs involved in different activities described herein earlier.

2.0 SUB-SOIL INVESTIGATION

To ascertain soil parameters in various stretch inter, the contractor shall carry out sub-soil investigation through reputed soil consultant as approved by the employer.

2.1 SCOPE OF WORK

The scope of sub-soil investigation covers execution of complete soil exploration for the transmission line under this contract including boring, drilling, collection of undisturbed soil sample where possible, otherwise disturbed samples, conducting laboratory test of soil samples to find out the various parameters as detailed in this specification and submission of detailed reports in 6 copies along with specific recommendation regarding

suitable type of foundation for each bore-hole along with recommendation for soil improvement where necessary.

2.1.1 QUALIFYING REQUIREMENTS OF SOIL CONSULTANTS

The soil consultants shall provide satisfactory evidence concerning the following as and when asked for.

That, he/they has/have adequate technical knowledge and previous practical experience in carrying out complete soil investigation jobs in any kind of soil.

That he/they has/have well equipped, modernized soil testing laboratory of his/their own. If asked for by the employer, the contractor shall arrange inspection of such laboratory of the soil consultant by the representative of the employer.

If in the opinion of the employer, the soil consultant (proposed by the contractor) is not well equipped or capable to undertake the sub-soil investigation job relating to this contract, then such soil consultant shall not be engaged to undertake the job. In that case, they shall have to engage other agency as will be approved by the employer.

2.1.3 TEST BORING

The boring shall be done at the major locations/crossing, special towers. However, it is desirable that there should be at least one sub-soil investigation bore-hole for the line. Such locations for sub-soil investigation shall be selected and finalized in consultation with the employer.

The test boring through different layers of all kinds of soil shall have to be carried out by the contractor through the approved soil consultant as briefed hereunder.

(a) Method of boring, selection of sampling tubes, sampling, recording of boring, protection, handling, leveling of samples shall be done as specified in IS: 1892/1977, if any, after obtaining approval from the employer. The contractor/consultant shall furnish in the soil report in details, the equipment and method of boring actually adopted.

(b) Depth of boring below ground level shall be 15 M. only unless continuous bedrock is encountered earlier. In case rock is encountered at any depth within 15 M. adequate study of rock and assessment of strength characteristics shall be done and recommendation shall be given.

(c) Undisturbed soil samples shall be obtained for the initial 4M depths at every 1.5M interval and at change of strata. After these initial 4M depths, samples shall be obtained preferably at every 3M or where there is a change of strata, or as advised by the employer.

(d) In case collection of undisturbed samples becomes difficult/impossible detailed soil testing on remoulded soil samples is to be considered and reported in the soil report.

(e) Standard penetration test as per IS: 2131 with latest amendment shall have to be conducted in different strata and recorded properly.

- (f) The ground water table shall be recorded during boring operation and incorporated in the bore log. If possible, the position of the water table just after monsoon period be ascertained from local people and indicated in the report.
- (g) Plate Load test shall have to be conducted at special tower location.

3.0 LABORATORY TESTS OF SOIL SAMPLES

The method and procedure of testing of soil sample to be followed shall be as per relevant IS codes. Adequate volume of test samples shall be collected from site. Sample shall be properly sealed immediately after recovery as specified in relevant IS code and transported carefully to laboratory for carrying out necessary laboratory tests to find out the following parameters of every samples. Data and time of taking of the sample shall be recorded in the test report.

- (a) Natural moisture content, Liquid limit, Plastic limit and Plasticity index.
- (b) Bulk, dry and buoyant density of soil.
- (c) Void ratio (e-long P curve shall be submitted)
- (d) Specific gravity.
- (e) Grain size distribution (Sieve analysis and hydrometer analysis)
- (f) Tri-axial and consolidation tests (consolidation undrained and consolidated drained as and when application in table, graph and drawing.
- (g) Permeability tests
- (h) Chemical tests for both water and soil samples at different layers.
- (i) Evaluation of safe bearing capacity at different strata for square footings shall be done for a maximum value of 25-mm. settlements.
- (j) At depths. From 3M to 10M be different strata.
- (k) Factor of safety shall be considered as 3 for evaluation of safe bearing capacity of soil.
- (l) Unconfined compression test for cohesive soil ($=0$) if encountered.

3.1 REPORT ON SUB-SOIL INVESTIGATION

The contractor shall make analysis of soil samples and rock cores as collected by him in the field and approved by the employer as collected by him in the field and approved by him in the field and approved by the employer as well as field tests and laboratory tests. A comprehensive report shall have to be prepared by him, finally incorporating all the data collected in proper tabular forms or otherwise along with the analysis.

The 3(three) copies of report in the draft form shall be submitted for employer's approval. 6(six) copies of final report incorporation employer's comments, if any shall be submitted within 3(three) weeks after completion of this work.

Recommendations shall include but not be limited to the following items (a) to (p)

- (a) Geological information of the region.
- (b) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.
- (c) Procedure of investigations employed and field and field as well as laboratory test results.

- (d) Net safe bearing capacity and settlement computation for different types of foundations for various widths and depths of tower and building.
- (e) Recommendations regarding stability of slopes, during excavations etc.
- (f) Selection of foundation types for towers, transformers and buildings etc.
- (g) Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
- (h) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how the soil/rock strata are varying vertically and horizontally.
- (i) Modulus of sub grade reaction from plate load test for pressure ranging up to 6 kg/cm. The recommended values shall include the effect of size, shape and depth of foundations.
- (j) Deformation modulus from plate load test in various test depth/stratification.
- (k) Coefficient of earth pressure at rest.
- (l) Depth of ground water table and its effect on foundation design parameters.
- (m) Recommendations regarding stability of slopes, during shallow excavation etc.
- (n) Whether piles are necessary or not. If piles are necessary, recommendation of depth, diameter and types of piles to be used.
- (o) Recommendations for the type of cement to be used and any treatment to the underground concrete structure based on the chemical composition of soil and sub-soil water.

3.1.2 MEASUREMENT OF SOIL RESISTIVITY

For the purpose of grounding design, soil resistance measurement shall be taken in the locations as stated under clause 1.0 above and based on which the value of soil resistance shall be derived.

Wenner's four (4) electrode method shall be used for earth resistance measurement in accordance with the procedure and the calculation detailed in IS:3043 1987. At least 8(eight) test direction shall be chosen from the center of the locations to cover the whole site.

The employer reserves the right to carry out separate soil investigation at his cost by engaging a separate agency for cross checking the result obtained by the contractor.

In case the results are at variance, the soil parameters to be adopted for final design will be at the sole discretion of the employer and such will be binding upon the contractor.

IMP:-The material and services covered under these specifications shall be performed as per requirements of the relevant standards and codes referred hereinafter against each set of equipment and services. In case of a conflict between such codes and/or standards and the Specifications, the latter shall govern. Other Internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

SL. No.	Indian Standards	Title	International & Internationally recognised Standards.
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1.	2.	3.	4.
1.	IS 209-1979	Specification for Zinc	ISO/R/752-1968 ASTM B6
2.	IS 226-1975	Structural steel (Standard quality)	ISO/R/630-1967 CAN/CSA G40.21 BSEN 10025
3.	IS 269-1976	Ordinary rapid hardening and low heat Portland cement.	ISO/R/597-1967
4.	IS 383-1970	Coarse and fine aggregates from natural sources for concrete.	CSA A23.1 /A23.2
5. a)	IS 398-1982 Part-I	Specification for aluminium conductors for overhead transmission purposes	IEC 1089-1991 BS 215-1970
b)	IS 398-1982 Part-II	Aluminium conductor galvanised steel reinforced	BS 215-1970 IEC 1089-1991
c)	IS 398-1994 Part-IV	Aluminium alloy stranded conductor	BS 3242-1970 IEC 1089-1991 ASTM 8393M86
d)	IS 398-1982 Part-V	Aluminium conductor galvanised steel reinforced for Extra High Voltage (400kV and above)	BS 215-1970 IEC 1089-1991
6.	IS 278-1978	Specification for barbed wire.	ASTM A 121
7.	IS 406-1964	Method of chemical analysis of Zinc slab	
8.	IS 432-1966 (Part 1 & 11)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement.	BS 4449 CSA G-30. BS 4482
9.	IS 456-1978	Code of practice for plain and reinforced concrete.	ISO 3893-977
10.	IS 731-1971	Porcelain insulators for overhead power lines with nominal voltage greater than 1000 Volts.	BS 137-1982 (Part-I & II) IEC 383-1993 (Part-I& II)
11.	IS 800-1962	Code of practice for use of structural steel in general building cons-	CSA S 16.1 BS 5950

		duction.	
12.	a) IS 802-1995 (Part-I/Sec.I) (Part-I/Sec.II) -1992	Code of practice for use of structural steel in overhead transmission Line: materials, loads and permissible stresses.	IEC 826 ANSI/ASCE 10-90 (1991) BS 8100
	b) IS 802-1978 (Part-II)	Code of practice for use of structural steel in overhead transmission line: Fabrication, galvanising, inspection and packing.	ANSI/ASCE 10-90 (1991)
	c) IS 802-1978 (Part-III)	Code of practice for use of structural steel in overhead transmission line towers: Testing.	ANSI/ASCE 10-90 (1991) IEC 652
13.	IS 1139-1966	Hot rolled mild steel, medium tensile steel and high yield strength deformed bars for concrete reinforcements.	CAN/CSA G30.18 ASTM A615 BS 4449
14.	IS 1367-1967	Technical supply conditions for threaded fasteners	
15.	IS 1489-1976	Portland pozzolena cement.	ISO/R 863-1968
16.	IS 1521-1972	Method of tensile testing of steel wires	ISO 6892-1984
17.	IS 1573-1976	Electroplated coating of zinc on iron and steel	
18.	IS 1786-1966	Cold twisted steel bars for concrete reinforcement.	
19.	IS 1778-1980	Reels and drums for bare conductors	BS 1559-194
20.	IS 1893-1965	Criteria of earthquake resistant design of structures.	IEEE 693
21.	IS 2016-1967	Plain washers	ISO/R 887-1968. ANSI B18.22.1
22.	IS 2071 Part-I-1974 Part-II-1974 Part-III-1976	Method of high voltage testings	IEC 60
23.	IS 2121 a) Part-I -1981	Specification for conductor and earthwire accessories for overhead power lines. Armour rods, binding wires	

	b) Part-II -1981	and tapes for conductors. Mid-span joints and repair sleeve for conductors.	
	c) Part-III-1992	Accessories for earthwire.	
	d) Part-IV-1991	Non-tension joints.	
24.	IS 2131-1967	Method of standard penetration test for soils.	ASTM D 1 883
25.	IS 2551-1982	Danger notice plates	
26.	IS 2486	Specification for insulator fittings for overhead power lines with a nominal voltage greater than 1000 Volts.	
	Part-I	General requirements and tests.	BS 3288 IEC 1284
	Part-II	Dimensional requirements	IEC 120-1984
	Part-III	Locking devices	IEC 372-1984
27.	IS 2629-1966	Recommended practice for hot dip galvanising of iron and steel.	ASTM A123 CAN/CSA G 164 BS 729
28.	IS 2633-1972	Method of testing uniformity of coating of zinc coated articles.	ASTM A123 CAN/CSA G164
29.	IS 3043-1972	Code of practice for earthing(with amendment No.1 and 2).	
30.	IS 3063-1972	Single coil rectangular section spring washers for bolts nuts, screws.	DIN 127-1970
31.	IS 3188-1965	Dimensions for disc insulators.	IEC 305-1978
32.	IS 4091-1967	Code of practice for design and construction of foundation for transmission line towers and poles.	ASCE/IEEE 691
33.	IS 4826-1979	Galvanised coating on round steel wires.	IEC 888-1987 BS 443-1982
34.	IS 5358-1969	Hot dip galvanised coatings on fasteners.	CAN/CSA G 164 ASTM A153
35.	IS 5613 (Part-II/Sec-1) -1985 (Part-III/Sec.1)	Code of practice for design, installation and maintenance of overhead power lines (Section-I:	ANSI/ASCE 10-90(1991)

	-1989	Designs)	
36.	IS 5613 (Part-II/Sec-2) -1985 (Part-III/Sec.2) -1989	Code of practice for design, installation and maintenance of overhead power lines (Section 2: Installation and maintenance)	
37.	IS 6610-1972	Specification for heavy washers for steel structures.	
38.	IS 6639-1972	Hexagonal bolts for steel structure.	ISO/R 272-1968 ASTM A394 CSA B33.4
39.	IS 6745-1972	Methods for determination of weight of zinc coating of zinc coated iron and steel articles.	ASTM A90 ISO 1460
40.	IS 8263-1976	Method of radio interference tests on high voltage insulator	IEC 437-1973 NEMA 107-1964
41.	IS 8269-1976	Method of switching impulse tests on HV insulators.	IEC 506-1975
42.	IS 8500-1977	Specification for weldable structural steel (medium and high strength qualities)	BSEN 10025
43.	IS 9708-1980	Specification for Stock Bridge vibration dampers for overhead power lines.	
44.	IS 9997-1988	Aluminium alloy redraw rods	IEC 104-1987
45.		Hard drawn aluminium wires for overhead line conductors.	IEC 889-1987
46.		Thermal mechanical performance tests and mechanical performance tests on string insulator units.	IEC 575-1977
47.		Salt fog pollution voltage withstand tests.	IEC 507-1991
48.		Residual strength of string insulator units of glass or ceramic material for overhead lines after mechanical damage of the dielectric.	IEC 797-1984
49.		Guide for the selection of insulators in respect of polluted conditions.	IEC 815-1986
50.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage	IEC 383-1993 (Part I and II)

		greater than 1000 Volts.	
51.		Ozone test on elastomer	ASTM D-1171
52.	IS 1363	Hexagonal head bolts, screws and nuts of product Grade - C	
	Part - 1	Hexagonal head bolts	ISO 4016
	Part - 3	Hexagonal nuts	ISO 4034
53.	IS 1367	Technical supply conditions for threaded steel fasteners	
	Part III	Mechanical properties and test methods for bolts, screws and studs with full loadability	ISO 898-1
	Part VI	Mechanical properties and test methods for nuts with full loadability	ISO/DIS 898/II
54.		Indian Electricity Rules - 1956	
55.		Indian Electricity Act - 1910	
56.	IS 1498-1970	Classification and identification of soil for general engineering purposes	
57.	IS 1888-1982	Method of load test on soils	
58.	IS 1892-1979	Code of practice for subsurface investigation for foundation	
59.	IS 2911-1979 (Part-I)	Code of practice for design and construction of pile foundations	
60.	IS 4453-1980	Code of practice for exploration by pits, trenches, drifts and shafts	
61.	IS 6935-1973	Method for determination of water level in a bore hole	
62.	IS 8009-1976 (Part-I)	Code of practice for calculation of settlement of foundation subjected to symmetrical vertical loads (Shallow Foundation)	
63.	IS 2386-1963 (Part-3)	Methods of test for aggregates for concrete : Specific gravity, density, voids, absorption and bulking	
64.	IS 14000-1994	Quality management and quality assurance standards	ISO 9000-1994
65.		GRIDCO Safety Manual (draft)-1997	
66.		Composite insulators for a.c. overhead lines with a nominal voltage greater than 1000 V : Definition, test methods and acceptance criteria	IEC 1109-1992 ANSI C29-11 IEEE 987

SUPPLY OF TOWER STRUCTURES FOR THE TRANSMISSION LINES

1.0 SCOPE

1.1 This specification provides for design, proto fabrication, galvanizing and delivery FOR (destination) of transmission line towers including super-structure stubs, tower extensions, stub-templates, tower accessories (Hangers, U-bolts, bird guards, anti-climbing devices), bolts and nuts, step bolts, flat and spring washers etc. as described hereinafter in this volume.

THE PRELIMINARY SURVEY WORK HAS ALREADY DONE AND THE FOLLOWING TOWERS HAVE BEEN DECIDED.

The contractor shall design the tower foundation and the concreting shall be done by M-20 grade concrete.

a) Wind effects:

Tower shall be designed for **reliability Level-I, Terrain category-I & Wind Zone-V** Design wind pressure on towers, conductors, earth wire and insulator string in the range of 30.45 mt. And above 45 mt. Height shall be computed as per IS-802(Part/Sec-I) 1995 Bidder shall furnish the maximum wind pressure adopted in their design against each component mentioned above.

b) Design Temperatures:

The following temperature range for the power conductor and ground wires shall be adopted for the line design:

- (i) Minimum temperature: 5 deg. C
- (ii) Everyday temperature of conductor: 32 deg. C

(iii) Maximum temperature of :

- a) Conductor:ACSR 75 deg. C for ACSR
Moose/Zebra/Panther 90 deg. C for AAAC.

(**Double Moose conductor in 400 KV system)

- b) Ground wire exposed to sun. 53 deg. C

The above values are subject to latest revision if any made in IS-802 (part-I/Sec-I) 1995

Maximum Tension:

Maximum tension shall be based on either:

- a) at 5 deg. C with $2/3^{\text{rd}}$ full wind pressure or Conform to IS 802-1995
- b) at 32 deg. C with full wind pressure whichever Part-I/Sec-I-Clause No.10.3 is more stringent.

Factors of Safety & Span details:

Factor of Safety: Should conform to IS-802 Part-I-1995

Normal span: The normal span of the line shall be 350 meters of 220KV and 320 meters for 132 KV.

Wind & Weight Span:The wind and weight span to be adopted in the design of the structures shall be as follows:

- (i) Wind span: The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on a perfectly horizontal terrain, this shall be the normal span. For design purpose the wind on conductor shall be calculated on a wind span of at least 1.1 times the normal span.

Weight Span: The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower. All C and D type towers shall be designed for uplift spans (minimum weight spans in the following table) also. These are applicable both for pointed and square cross arms.

For details of cross arms and towers , the span limits given below shall prevail.

Tower type.	400KV/220 KV				132 KV			
	Normal condition.		Broken wire condition.		Normal condition.		Broken wire condition.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A/DA & B/DA	525	100	315	100	500	100	300	100
C/DC & D/DD	600	100	360	100	500	100	300	100

1.1.1 The design of towers and their extensions shall be done conforming to the design parameters specified herein, the scope of design also includes supply of design calculation for towers and extensions including detailed structural/shop drawings of towers extensions and stub setting templates. The bidder, who has already type tested the various tower viz: 0-2°, +3, +6; 0-15°, +3, +6; 0-30°, +3, +6; 0-60°, +3, +6 (400/220/132 KV) in any nationally or internationally recognized laboratories, and conforming to our specification, may also offer the same.

1.1.2 STANDARDS

Except as modified in this specification, the material and work covered under this specification, shall conform to the latest revision with amendments thereof of the following of Indian Standards and equivalent International Standards whenever indicated below.

Sl. No	Bureau of Indian standards (BIS)	Title	International & Internationally recognized standard
1.	IS:209	Specification for Zinc	ISO/R/752
2.	IS: 2062	Structural steel (Standard quality)	ISO/R/660
3.	IS: 432	Mild steel and medium tensile bars and for concrete reinforcement	BS-785CSA-G-30
4.	IS: 802	Code of practice for use of structural steel in overhead transmission line Part-I/Section-I & Section2: Load and permissible stresses Part-II: Fabrication Galvanizing Inspection and Packing PART-III: TESTING	
5.	IS: 1367	Technical supply conditions for threaded fasteners	
6.	IS: 1893	Criteria of Earthquake resistant design structures	
7.	IS: 2016	Plain washers	ISO/R/987
8.	IS: 2551	Danger Notice Plates	
9.	IS: 2629	Recommended practice for hot dip galvanizing of iron and steel	
10.	IS: 2633	Method of testing uniformity of casting of zinc coated articles	
11.	IS: 3063	Single coil rectangular section spring washers for bolts, bolts, screws	DIN-127
12.	IS: 5358	Hot dip galvanized coatings on fasteners	
13.	IS:5613 Part-1 & 2 Of Section-I	Code of Practices for design, installation & maintenance of overhead power line	

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| 14. | IS: 6610 | Specification for heavy washers for steel structures. |
| 15. | IS: 6745 | Methods of determination of weight of zinc coating of zinc coated iron and steel articles. |
| 16. | IS: 12427 | Hexagonal bolts for steel structures |
| 17. | INDIAN ELECTRICITY RULES 1956 | |
| 18. | Publication for Regulation for electrical crossing or railway tracks | |

1.1.3 The standards mentioned above are available from

Reference/ Abbreviation	Name and Address from which the Standards are available
IS	BUREAU OF INDIAN STANDARDS Manak Bhavan, 9, Bahadur Shah Zafar Marg, NEW DELHI(India)
ISO	INTERNATIONAL ORGANISATION FOR STANDARDISATION, Danish Board Standardisation, Danish Standardising Street, Aurehoegbvej-12, DK-2900, Hellestrup, DENMARK
CSA	CANADIAN STANDARD ASSOCIATION 178, Rexdale Boulevard, Rexdale, Ontario, CANADA M9W 1R
BS	BRITISH STANDARDS British Standard Institution, 101, Pentonville Road, N-19-ND-UK
DIN	DEUTSCHES INSTITUT FÜR NORMEN Gurggrafenstrasse 5-10 Post Fach 1107 D-1000, Berlin – 30
INDIAN ELECTRICITY RULES 1956, REGULATION FOR	KITAB MAHAL Baba Khari Singh Marg,

CROSSING OF

RAILWAY TRACKS (INDIA)

a)	System voltage (kV rms)	400/220/132
b)	Max. voltage (kV rms)	420/245/145
c)	Lightning impulse withstand voltage (dry & wet) (kVp)	1550/1050/650
d)	Power frequency withstand voltage (wet) (KV rms)	630/395/275
e)	Short circuit level (KA for 1 sec.	40/40/31.5

1.6 Line data

1.7 Conductor

a)	Name	ACSR Zebra	ACSR Moose	ACSR Panther
b)	Strength & wire dia			
i)	Aluminium	54/3.18	54/3.53	30/3.00
ii)	Steel	7/3.18	7/3.53	7/3.0
c)	Conductors per phase 1) 400 KV 2)220 KV 3)132 KV	Single	Double	Single
d)	Spacing between the conductors of same phase (sub-conductor spacing) (mm)	----	As per standard	----
e)	Inter-phase spacing (mm)	8,400	8,400	6800
f)	Configuration			

i)	Single circuit	Delta	Delta	Delta
ii)	Double circuit	Vertical	Vertical	Vertical
g)	Nominal Aluminium area (mm ²)	420	528.5	212.1
h)	Section area of Aluminium (mm ²)	428.90	597	261.5
i)	Total sectional area (mm ²)	484.50	597	262
j)	Calculated resistance at 20 °C (Max.) ohm/km per conductor	0.06915	0.05552	0.140
k)	Approx. calculated breaking load (KN)(Minimum)	130.32	161.2	89.67
l)	Modulus of elasticity (GN/M ²)	69	69	82
m)	Co-efficient of linear exp. Per degree cent.	19.3X10 ⁻⁶	19.3X10 ⁻⁶	17.8X10 ⁻⁶
n)	Mass of zinc in gms/sqm	275.....
o)	Overall diameter (mm)	28.62	31.77	21.00
p)	Weight (kg/km)	1621	2004	974
q)	Minimum ultimate tensile strength (KN)	130.32	161.2	89.67
r)	Conductor tension at 32° C without external load			
i)	Initial unloaded tension	35%.....
ii)	Final unloaded tension	25%.....

1.1.8 Galvanized Steel Ground Wire

- | | | |
|----|----------------------------------|--|
| a) | Size (no. of strands/strand dia) | 7/3.15 for 132 and 220 KV, and 7/3.66 for 400 KV |
| b) | Overall diameter (mm) | 9.45(7/3.15) and 10.98(7/3.66) |

- c) Standard weight (Kg/km) 432(7/3.15) and 583(7/3.66)
- d) Location of ground wire One continuous ground wire
Wire to run horizontally on the top of the towers for 132 and 220 KV and two ground wire for 400 KV lines.
- e) Tensile load in each ground wire (to be furnished by the Bidder)
- i) At min. temp. of 5° C and in still air (kgs)
- ii) At every day temp. of 32° C and still air (kgs)
- iii) At 5° C and 2/3rd of full wind (kgs)

1.1.8.1 Towers

a)	Span lengths in metres	ACSR Zebra	ACSR Moose	ACSR Panther
i)	Ruling design span	300	300	250
b)	Wind load (kg/sqm) on conductor	52	52	52
c)	Shielding angle with vertical	20°	20°	20°
d)	Towers to be designed for heavy wind zone	V-zone	V-zone	v-zone

1.1.8.2 Insulator Strings(Disc)(Antifog type)

Sl. No.	Particulars	Single Suspensi on string	Double suspension string	Single Tension string	Double Tension string
1.	No. of standard Discs (nos)				
1)	400 KV	1X25	2X25	1X25	2X25
2)	220 kV	1X15	2X15	1X15	2X15
3)	132 Kv	1X10	2X10	1X10	2X10
2.	Size of Disc (400kv/220kV/132 kv)	280x145/255X145/255X145	280x145/255X145/255X145	305x170/305x170/280x145	305x170/305x170/280x145
3.	Electromechanical strength (KN) (400 KV/220 kV/132	120/90/90	120/90/90	160/160/120	160/160/120

KV)

4.0 GENERAL TECHNICAL REQUIREMENTS

4.1 Tower Design – General

The employer is looking for a structurally safe design of transmission line towers to be installed on EHV lines keeping the loadings and line parameters detailed in this specification and in compliance with IS: 802 (Part-1/Sec-1)-1995, IS: 802(Part-1/Sec-2)-1992.

The Bidder may offer economical designs with rational sections or offer towers of recent design, proven in service and accepted by other reputed Central and State Sector Utilities and by OPTCL (Previously OSEB) confirming to this technical specification.

The technical particulars for vibration analysis and damping design of the system are as follows:

FOR 400kV LINES.

SL. No.	Description	Technical Particulars
1.	Configuration	Double Circuit Twin ACSR Moose 54/7//3.53 mm, conductor bundle per phase in horizontal formation and all three phases of each circuit in vertical configuration on each side of tower.
2.	Span length in meters	
	(i) Ruling design span	400 meters
	(ii) Maximum span	1100 meters
	(iii) Minimum span	100 meters
3.	Tensile load in each sub-conductor for ruling span	Wind Zone : 5 (50 m/s).
	a) At temperature of 5 deg-C and still air	3267 Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4646 Kgf.
	c) At temperature of 32 deg.C and full wind	7805 Kgf.
4.	Armour rods used	Standard preformed armour rods/AGS
5.	Maximum permissible	+/- 150 micro strains

dynamic strain

FOR 220 kV and 132 kV LINES

SL.NO.	Description	Technical Particulars	
		220kV ACSR ZEBRA 54/7/ 3.18mm Double Circuit Single ACSR conductor per phase in verti- cal formation	132kV ACSR PANTHER 30/7/3.0mm Double Circuit Single ACSR conductor per phase in verti- cal formation
1.	Configuration		
2.	Span length in metres		
	(i) Ruling design span	350 metres	300 metres
	(ii) Maximum span	1100 metres	1000 metres
	(iii) Minimum span	100 metres	100 metres
3.	Tensile load in each conductor for ruling span	Wind Zone:5 (50 m/s.)	Wind Zone:5 (50 m/s.)
	a) At temperature of 5 deg.C and still air	2919 Kgf.	1791Kgf.
	b) At temperature of 5 deg.C and 36% full wind	4090 Kgf.	2735Kgf.
	c) At temperature of 32 deg-C and full wind	6551 Kgf.	4469 Kgf.
4.	Armour rods used	Standard performed performed armour rods/AGS	Standard armour rods/AGS
5.	Maximum permissible dynamic strain	± 150 micro- strains	± 150 micro- strains

4.0 DETAILS OF SOLID CORE LONG ROD INSULATORS:

5.1 The insulator shall consist of standard-discs for a three-phase 50 Hz effectively earthed 220 KV transmission system heavily polluted atmosphere. The insulator shall be ball and socket type.

5.1 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanically strength and mechanical strength of insulator string alongwith hardware shall be as follows:

Sl. No.	Type of string.	Size of long rod insulator (mm)/(Unit) 132/220 KV	Minimum creepage distance (mm) 132/220 KV	No.of unit 132/220 KV)	Electromechanical strength of insulator (KN) 132/220 KV)
1.	Single suspension	200X 1305 /210X2030	4000 / 6125	'1/2	90 KN
2.	Double suspension	-do-	-do-	'2/4	90 KN
3.	Single tension.	205 X 1450 / 215X2550	4300/7130	'1/2	120 KN/160 KN
4.	Double Tension.	-do-	-do-	'2/4	120 KN/160 KN

5.0 **SPECIFICATION DRAWINGS:**

6.1 A list of specification drawings in respect of the long rod insulators indicated above is given at Annexure-II. These specification drawings are attached herewith for information and guidance of the bidder only. The drawings to be furnished by the supplier shall be as per his own design and manufacture and shall be distinct and separate from these specification drawings.

6.0 **GENERAL TECHNICAL REQUIREMENT:**

7.1 **PORCELAIN:**

The porcelain used in the manufacture of the shell shall be ivory white, nonporous of high dielectric, mechanical and thermal strength free from internal stress blisters and thermal strength from internal stresses blisters, laminations, voids, foreign matter. Imperfections or other defects, which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid alkalis, and zinc of dust. The manufacturing shall be by the wet process and impervious character obtained by through vetrification.

7.2 **PORCELAIN GLAZE:**

Surfaces to come in contact with cement shall be made rough by stand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of the glaze shall be uniform throughout and the colour of the glaze shall be brown. The glaze shall have a visible luster and smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain under compression on the porcelain body throughout the working temperature range.

7.3 **METAL PARTS:**

7.3.1 **Cap and Ball pins:**

Twin Ball pins shall be made with drop forged steel and caps with malleable cast iron. They shall be in one single piece and duly hot dip g galvanized. They shall not contain parts or pieces joined together, welded, shrink fitted or by any other process from more than one piece of material. The pins shall be of high tensile

steel, drop forged and heat malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity with minimum of 6 dips. The bidder shall specify the grade, composition and mechanical properties of steel used for caps and pins.

7.3.2 SECURITY CLIPS:

The security clips shall be made of phosphor bronze or of stainless steel.

7.4 FILLER MATERIAL:

Cement to be used as a filler material shall be quick setting, for curing Portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not react chemically with metal parts in contact with it and its thickness shall be as small and as uniform as possible.

7.0 MATERIAL DESIGN AND WORKMANSHIP:

8.1 GENERAL:

i) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw materials quality control and to stage testing quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Bidders shall therefore offer insulators as are guaranteed by them for satisfactory performance on Transmission lines.

ii) The design, manufacturing process and material control at various stages be such as to give maximum working load, highest mobility, best resistance to corrosion good finish, elimination of sharp edges and corners to limit corona and radio interference voltage

8.2 INSULATOR SHELL:

The design of the insulator shell shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

8.3 METAL PARTS:

a) The twin ball pin and cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the insulator or is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

b) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any macroscopically visible cracks, insulations and voids.

8.4 GALVANIZING:

All ferrous parts shall be hot dip galvanized six times in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.5 as per IS: 209. The zinc coating shall be uniform, smoothly adherent, reasonably light, continuous and free from impurities such as flux ash, rust stains, bulky white deposits and blisters. Before ball fittings are galvanized, all die flashing on the shank and on the bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

8.4.1 CEMENTING:

The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surfaces of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials.

8.5 SECURITY CLIPS (LOCKING DEVICES)

The security clips to be used as locking device for ball and socket coupling shall be 'R' shaped hump type to provide for positive locking of the coupling as per IS: 2486 (Part-IV). The legs of the security clips shall allow for sore adding after installation to prevent complete withdrawal from the socket. The locking device shall be resilient corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units and fitting 'W' type security clips are also acceptable. The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions. The force required for pulling the clip into its unlocked position shall not be less than 50 N (5 Kgs.) or more than 500N (50 Kgs.)

8.6 BALL AND SOCKET DESIGNATION:

The dimensions of the balls and sockets for 80 KN long rod insulators shall be of 16mm and for 120 KN shall be of 20mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-III).

8.7 DIMENSIONAL TOLERANCE OF INSULATORS DISCS

It shall be ensured that the dimensions of the long rod insulators are within the limits as per relevant IEC/ISS.

Bundle spacer (only for 400kV lines)

Armour grip bundle spacers shall be used to maintain the spacing of 450 mm between the two sub-conductors of each bundle under all normal working conditions.

Spacers offering equivalent or better performance shall also be accepted provided offer meets the qualifying requirements stipulated in the Specification.

The offer shall include placement charts recommending the number of spacers per phase per span and the sub span lengths to be maintained between the spacers while installing on the twin bundle conductors.

The placement of spacers shall be in such a way that adjacent sub spans are sufficiently detuned and the critical wind velocity of each sub span shall be kept more than 30 km/hr and to avoid clashing of sub conductors. The placement shall ensure bundle stability under all operating conditions.

The placement chart shall be provided for spans ranging from 100m to 1100m. The number of spacers recommended for a nominal ruling span of 400m shall however be not-less than six.

The Bidder shall also furnish all the relevant technical documents in support of their placement charts along with the Bid.

Jumpers at tension points shall also be fitted with spacers so as to limit the length of free conductor to 3.65 m and to maintain the sub conductor spacing of 450 mm. Bidder shall quote for rigid spacer for jumper. It shall meet all the requirements of spacer used in line except for its vibration performance. Spacers requiring retaining rods shall not be quoted for jumpers. For slack span also rigid spacers shall be used with maximum spacing of 30 metres.

The spacer offered by the Bidder shall satisfy the following requirements:

Spacers shall restore normal spacing of the subconductors after displacement by wind, electromagnetic and electrostatic forces under all operating conditions, including the specified short circuit level, without permanent deformation or damage either to conductor or to the assembly itself. They shall have uniform grip on the conductors.

For spacers requiring preformed retaining rods, the retaining rods shall be designed for the specified conductor size. The rods shall be made of high strength special aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The ends of retaining rods shall be ball ended. The rods shall be heat-treated to achieve specified mechanical properties and give proper resilience and retain the same during service.

Four rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall 7.87 +/- 0.1 mm. and the length of the rods shall not be less than 1100 mm.

Where elastomer surfaced clamp grooves are used, the elastomer shall be firmly fixed to the clamp. The insert shall be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be duly heat treated and aged to retain its consistent characteristics during service.

Any nut used shall be locked in an approved manner to prevent vibration loosening. The ends of bolts and nuts shall be properly rounded for specified corona performance or suitably shielded.

Clamp with cap shall be designed to prevent its cap from slipping out of position when being tightened. The clamp grooves shall be in uniform contact with the conductor over the entire clamping surface, except for rounded edges. The groove of the clamp body and clamp cap shall be smooth and free of projections, grit or other material, which may cause damage to the conductor when the clamp is installed. For the spacers involving bolted clamps, the manufacturer must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5kN. The clamp when installed on the conductor shall not cause excessive stress concentration on the conductor leading to permanent deformation of

the conductor strands and premature fatigue failure in operation. Universal type bolted clamps, covering a range of conductor sizes will not be permitted. No rubbing, other than that of the conductor clamp hinges or clamp swing bolts shall take place between any parts of the spacer. Joints incorporating a flexible medium shall be such that there is no relative slip between them. The spacer shall be suitably designed to avoid distortion or damage to the conductor or to themselves during service. Rigid spacers shall be acceptable only for jumpers. The spacer shall not damage or chafe the conductor in any way which might affect its mechanical and fatigue strength or corona performance. The clamping system shall be designed to compensate for any reduction in diameter of conductor due to creep. The spacer assembly shall not have any projections, cuts, abrasions or chattering parts which might cause corona or RIV. The spacer tube shall be made of aluminium alloy of type 6061 or equivalent aluminium alloy. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacers involving ferrous fasteners shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per subconductor. Elastomer, if used, shall be resistant to the effects of temperature up to 85 deg.C, ultraviolet radiation and other atmospheric contaminants likely to be encountered in service. It shall have good fatigue characteristics. The physical properties of the elastomer shall be of approved standard. The electrical resistance between the sub-conductor across the assembly in case of spacer having elastomer clamp grooves shall be suitably selected by the manufacturers to ensure satisfactory electrical performance and to avoid deterioration of elastomer under all service conditions. The spacer assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage. The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

Spacer damper (only for 400kV lines)

As an alternative to vibration dampers and bundle spacers combination, suitable spacer dampers for twin bundle AAAC 61/3.45 conductor may be offered. The spacer damper covered by this Specification shall be designed to maintain the bundle spacing of 450mm under all normal operating conditions and to effectively control aeolian vibrations as well as subspan oscillations to nominal conductor spacing after release of any external extra-ordinary load.

The spacer damper shall restore the normal subconductor spacing due to displacement by wind, electromagnetic and electrostatic forces including the specified short circuit level without permanent deformation or damage either to bundle conductors or to spacer damper itself.

The design offered shall be presented as a system consisting of a recommended number of spacer dampers together with their spacing schedule for spans ranging from 100m to 1100 m.

Under the operating conditions specified, the spacer damper system shall adequately control Aeolian vibrations throughout the life of the transmission line in order to prevent damage to conductor at suspension clamps, dead end clamps and at the spacer clamps.

The spacer damper system shall also control the sub span oscillations in order to prevent conductor damage due to chafing and due to severe bending stresses at the spacer damper clamps as well as suspension and dead end clamps and to avoid wear to spacer damper components.

The spacer damper shall consist of a rigid central body called the frame, linked to the conductors by two articulated arms terminated by suitable clamping system. The dynamic characteristics of the articulations shall be maintained for the whole life of the transmission line.

The clamping system shall be designed to provide firm but gentle and permanent grip while protecting the conductor against local static or dynamic stresses expected during normal operating conditions. The clamping system shall be designed to compensate for any reduction of conductor diameter due to creep.

The clamp of the spacer damper, when installed, shall not cause excessive stress concentration on the conductor leading to permanent deformation of the conductor strands and premature fatigue failure in operation. The slip strength of the clamp shall be maintained between 2.5kN to 5kN. The tightening torque for the bolts, if applicable, shall be specified by the manufacturer to achieve the above slip strength.

Bolted type clamps shall allow installation without removal of the bolts or the clamps from clamp body. Locking mechanism shall be suitable to prevent bolt loosening. Clamp locking devices using small loose components shall not be accepted.

Bolts and nuts shall be of mild steel, stainless steel, or high strength aluminium alloy in accordance with the design of the spacer damper.

Where elastomer surfaced clamps are used, the elastomer elements shall be firmly fixed to the clamp. The insert should be forged from aluminium alloy of type 6061 or equivalent aluminium alloy having minimum tensile strength of 35 kg/sqmm. The insert shall be moulded on the insert surface. The insert shall be duly heat treated and aged to retain its consistent characteristics during service. The grain flow of the forged insert shall be in the direction of the maximum tension and compression loads experienced.

If clamps involving preformed rods are used, these rods shall be designed for specific conductor size. They shall be made of high strength aluminium alloy of type 6061 or equivalent aluminium alloy having a minimum tensile strength of 35 kg/sqmm. The rods shall be ball ended. The rods shall be heat treated and aged to achieve specified mechanical properties and to retain the same during service.

The spacer damper body shall be cast/forged from suitable high strength corrosion resistant aluminium alloy. The aluminium alloy shall be chosen in relation with the process used. However a combination of aluminium alloy and steel shall also be accepted.

The rubber components like damping elements involved in the design shall be made with rubber compound selected specifically for that particular application. The Bidder shall submit a complete list of physical and mechanical properties of the elastomer used. This list shall make reference to all applicable ASTM or other Internationally recognised standards.

The rubber compounds used shall have good resistance to the effects of temperature up to 85 deg.C and to ultra violet radiation, ozone and other atmospheric contaminants. The rubber shall have good wear and fatigue resistance and shall be electrically semi-conductive.

The spacer damper involving ferrous material shall not have magnetic power loss more than one watt at 600 amps., 50 Hz alternating current per sub conductor.

The spacer damper assembly shall have electrical continuity. The electrical resistance between the subconductors across the assembly in case of spacer damper involving elastomer surfaced clamps shall be suitably selected by the manufacturer to ensure satisfactory electrical performance and avoid deterioration of elastomer under service conditions.

The spacer damper assembly shall have complete ease of installation and shall be capable of removal and reinstallation without any damage.

The spacer damper assembly shall be capable of being installed and removed from the energised line by means of hot line techniques.

The Bidder shall recommend the spacing between spacer dampers on the line which shall ensure the most satisfactory fatigue performance of the line as specified. The scheme shall indicate the number of spacer dampers per phase per span and the sub-span lengths to be maintained between spacer dampers when installed on the twin bundle conductors.

The number of spacer dampers and their spacing shall be provided for spans ranging from 100 to 1100m. The number of spacer dampers for a nominal ruling span of 400 m shall be not less than six.

No sub-span shall be greater than 70m and no end sub-span shall be longer than 40 metres.

The proposed scheme shall be such that the spacer dampers be unequally distributed along the span to achieve sufficient detuning of adjacent sub-spans for oscillations of sub-span mode and to ensure bundle stability for wind speeds up to 30 kms/hr (8.33 m./sec.).

The Bidder shall furnish all the relevant technical documents in support of the staggering scheme recommended for the spacer damper.

The Bidder in the latter case shall forward documentation of proto type tests conducted and acceptance given by the user authorities as also performance report for such towers in service.

Vibration dampers

All the requirements for vibration damper suitable for line conductors, shall also be applicable for galvanised steel earthwires (7/3.66mm. for 400kV and 7/3.15mm. for 220kV/132kV lines). Minimum one damper on each side per earth wire at suspension point and two dampers on each side at tension point shall be used for ruling design span. Bidders may offer damping systems involving a greater number of dampers for ruling design span; however, suitable price compensation shall be considered for evaluation.

The vibration analysis of the system, with and without dampers, dynamic characteristic of the damper as detailed shall be submitted by the Bidder along with his bid. The technical particulars for vibration analysis and damping design of the system are as follows :

For 400kV Lines

Sl. No.	Description	Technical Particulars
1.	Configuration	Two galvanised steel earthwires in horizontal configuration
2.	Span length in meters	
	Ruling design span	400 meters
	Maximum span	1100 meters
	Minimum span	1 00 meters
3.	Tensile load in each	Wind Zone : 5 earthwire for ruling span
	(50m/s)	
	a) At temperature of 5° C and still air	1368 Kgf
	b) At temperature of 5° C and 36% full wind	2056 Kgf
	c) At temperature of 32° C and full wind	3593 Kgf
4.	Maximum permissible dynamic strain	+/- 150 micro strains

For 132kV and 220kV Lines

Sl. No.	Description	Technical Particulars
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1 .	Configuration configuration .	One galvanised steel earthwire in horizontal configuration .	
2.	Span length in meters	220 kV Line	132 kV Line
	Ruling design span	350 meters	300 meters
	Maximum span	1100 meters	1000 meters
	Minimum span	100 meters	100 meters
3.	Tensile load in each earthwire for ruling span	Wind Zone:5 (50m/s)	Wind Zone:5 (50m/s)
	a) At temperature of 5 deg.C and still air	1120 Kgf.	1120 Kgf.
	b) At temperature of 5 deg.C and 36% full wind	1667 Kgf.	1606 Kgf.
	c) At temperature of 32 deg.C and full wind	2815 Kgf.	2625 Kgf.
4 .	Maximum permissible dynamic strain	+/- 150 micro strains	+/- 150 micro strains

Flexible copper bond

At suspension and tension towers the earth wire suspension and tension clamps shall be securely bonded to the tower steelwork by means of a multi-strand flexible copper bond wire. The copper bond shall be sufficiently flexible to allow movement of the suspension clamp under all operating conditions and terminated with compression lugs. The flexible copper bond shall be of nominal 34 sq.mm equivalent copper area and not less than 500 mm in length. It shall consist of 259 wires of 0.417 mm dia. tinned copper conductor. It shall be laid up as seven stranded ropes, each of 37 bunched wires. The tinning shall be as per IS 9567. Two tinned copper connecting lugs shall be press jointed to either ends of the flexible copper cable. One lug shall be suitable for 12 mm, dia. bolt and the other for 16 mm dia. bolt. The complete assembly shall also include one 16 mm dia., 40 mm long mild steel bolt hot dip galvanised with nut and lock washers

Arcing horn

The arcing horn shall be either ball ended rod type or tubular type and shall be formed from galvanised mild steel and of approved types. The arcing horns shall be attached in an approved manner to all suspension and tension insulator sets. The horns shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the arcing horns shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and arcing horns themselves under all flashover conditions. The

general shape and method of attachment of the live end arcing horn shall also not restrict the replacement of insulators under live line conditions.

The total effective arcing distance shall be 1530mm., 2130mm. and 3050 mm. for 132kV, 220kV and 400kV respectively under nominal dimensions of insulator.

Arcing horns shall be provided on tower and/or line side as indicated on the enclosed string sketches, however, same has been tabulated below for ready reference :

SL.No.	Voltage Level	Types of Strings	Arcing horns to be provided on	Min. Arcing dist. to be maintained(mm)
1.	2.	3.	4.	5.
1.	132kV and 220kV	Single 'I' suspension strings	Line side only	1530(for132kV)& 2130(for 220kV)
2.	-do-	Double suspension strings	Both on line side and tower side	1530(for132kV)& 2130(for 220kV)
3.	-do-	Single tension strings	Line side only	-do-
4.	-do-	Double tension strings	Both on line side and tower side	-do-
5.	400kV	Single 'I' suspension and pilot strings	Tower side (corona/grading rings on line side)	3050
6.	-do-	Double suspension strings	-do-	-do-
7.	-do-	Single tension strings	-do-	-do-
8.	-do-	Double tension strings	-do-	-do-

4.1.1 Transmission Towers

4.1.2 General Description

The towers shall be of the following types:

- (b) Double Circuit (A, B, C & D)
- (c) Special Towers (River Crossing, Railway Track Crossing, Power Line Crossing etc.)

Types Of Towers

The towers shall normally be of the following standard types, and as stated in Schedule C.

Type of Tower	Deviation Limit	Typical Use
---------------	-----------------	-------------

(1)	(2)	(3)
DA/OA/PA	0deg- 2deg	a) To be used as tangent tower with suspension strings. b) Also to be designed for specified broken wire conditions.
DB /OB/PB	0 deg- 15deg	a) Angle towers with tension insulator string b) Also to be designed for tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m 200m (for 132kV)on each side
and 400kV), of 350m and 250m and of the tower.	unbalanced	c) Also to be designed for uplift forces resulting from an up-lift span of 200m under broken wire conditions. d) Also to be designed for specified broken wire conditions.
DB/OB/PB	0 deg.	e) Also to be designed for anti-cascading condition. f) To be used as section tower.
DC/OC/PC	15 deg-30 deg.	a) Angle tower with tension insulator strings. b) Also to be designed for from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m 132kV)on each side of the
unbalanced tension resulting and 200m (for tower.		c) Also to be designed for uplift forces resulting from an up-lift span of 200m under broken wire conditions. d) Also to be designed for specified broken wire conditions.

		e) Also to be designed for anti-cascading condition.
DC/OC/PC	0 deg.	f) To be used as transposition tower with modifications (only where specified)
DD	30 deg-60 deg	a) Angle tower with tension insulator string
		b) Also to be designed for the unbalanced tension resulting from unequal ruling span of 400m and 200m (for 400kV), of 350m and 250m (for 220kV) and of 300m and 200m (for 132kV) on each side of the tower.
		c) Also to be designed for uplift forces resulting from an uplift span of 300m(for 400kV) and 200m (for 132kV and 20kV) under broken wire conditions.
		d) Also to be designed for specified broken wire conditions.
		e) Dead end with 0 deg to 15 deg deviation on line and 0 deg to 30 deg for sub-station side (slack span side).
DD	0 deg	f) Complete dead end.
		g) For river crossing anchoring with longer wind span with 0 deg deviation on crossing span side and 0 deg to 30 deg deviation on other sides .

Note: The above towers can also be used for longer span with smaller angle of deviations. (To be decided as per the tower spotting data to be submitted by the Contractor and approved by Project Manager.)

4.1.3 The towers shall be of the self-supporting type, built up of lattice steel sections or members and designed to carry the power conductors with necessary insulators. Ground wires and all fittings under all loading conditions. Outline diagrams of the towers required are to be furnished by the Bidder.

4.1.4 The towers shall be fully galvanized structures built up of structural mild steel sections. All members shall be connected with bolts, nuts and spring washers.

For design of structure weight span limits given in Table 5.1 shall prevail.

TABLE 5.1 (a)
For 132 kV Line

Tower Type	Normal Condition		Broken Wire Cond	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	450	150	270	100
DB, DC & DD	450	0	270	-200

TABLE 5.1 (b)

For 220 kV Line

Tower Type	Normal Condition		Broken Wire Cond	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	525	200	315	100
DB, DC & DD	525	0	315	-200

TABLE 5.1 (c)

For 400 kV Line

Tower Type	Normal Condition		Broken Wire Con	
	Max. (m)	Min. (m)	Max. (m)	Min. (m)
DA	600	200	360	100
DB, DC	600	0	360	-200
DD	600	0	360	-300

However, for calculating the tower height, an allowance of 150mm shall be provided, over and above the specified ground clearances, at still air and maximum conductor temperature, to account for any stringing error.

TABLE

Situation		Minimum clearance (metres)		
System voltage (kV):		132	220	400
*	Normal ground (open country)	6.10	7.015	8.84
	Road crossings, road level	7.00	7.90	9.7
	Rail crossings, rail level:	17.9	17.9	19.3
	River crossings, bank level			
	River crossings, navigable rivers, above highest as specified by the Authority			
flood level;(data to be obtained from Navigation Authority)				
	Above trees	4.0	4.6	5.5
	Buildings, poles, structures and walls, etc. upon which a man may stand : horizontal clearance	4.6	5.5	7.3
	Same above : vertical clearance	2.9	3.8	5.6
	Power lines	3.1	4.6	6.1

*Any road which is normally maintained by Government and/or other recognised public authority.

4.1.5 Stubs and Superstructures:

- (i) The stub shall mean a set of four stub angles fully galvanized from the and shall include cleats, gussets, bolts and nuts, etc. the black portion of the stub being cast in foundation footings. Stub length shall correspond to foundation depth of 3-0 metres from ground level.
- (ii) Superstructure shall mean the galvanized tower assembly above the stubs which includes structural members like angle sections, cross arms, ground wire peaks, accessories and fittings such as gusset plates, pack washers, spring, washers, ladders, step bolts, anti climbing devices and such other items which are required for completing the towers in all respect. Steel and zinc required for manufacturing these items will be arranged by the supplier.
- (iii) Supply of bolts and nuts and spring washers, hangers/D-shackles for attaching suspension strings and 'U' bolts for attaching ground wire suspension assemblies are included in the supply of tower.
- (iv) The following provisions shall apply in connection with the procurement of steel and zinc by the supplier.
 - (a) The steel used for fabrication of tower parts extensions, templates etc. shall be of mild steel of tested quality as per IS:2062 GRA.
 - (b) The Bidder shall take into account the fabrication wastage while quoting the rates. The employer will not accept any liability in connection with the wastage of steel during fabrication or otherwise.
 - (c) The Bidder shall indicate in his offer the sizes of steel sections which are proposed to be used by him in the design of towers.
 - (d) Substitutions, if any, of steel sections of the tower parts by higher sizes, due to non-availability or otherwise shall be to the supplier's account. The employer will not accept any liability on this account.
 - (e) The steel shall be procured exclusively from the main steel producers. However, sections not rolled by main producers, can be procured from re-rollers provided.

Re-rolling of structural steel sections is done from billets/ingots of tested quality.

Re-rolled sections are duly tested as per relevant standard.

- (f) The zinc used for galvanizing fabricated material shall be of High Grade Electrolytic zinc.

4.1.6 Extensions:

- a) The towers shall be designed so as to be suitable for adding 3 metres, 6 metres, 9 metres extensions for maintaining adequate ground clearances without reducing the specified factor of safety in any manner.
- b) The Bidder shall have to design leg extensions for all types of towers ranging from minus 3 metres to plus 9 metres at intervals of 1.5 metres and such leg extensions shall be suitable for being fitted to a normal tower as well as a tower with extensions. This is to enable tower spotting in hilly terrain.

4.1.7 Stub setting Templates:

Stub templates shall be designed and supplied by the supplier as per requirement for all types of towers with or without extensions. Stub templates for standard towers and towers with extension shall be fixed type. The stub templates shall be painted with anti-corrosive paints.

4.1.8 Fasteners: Bolts, Nuts & Washers

4.1.9 All bolts shall be of property class 5.6 and nuts of property class 5.0 IS: 1367 (Part – 3) 1991 and IS: 6639-1972 shall conform to IS: 12427, they shall be galvanized and shall have hexagonal heads and nuts, the heads being forged out of solid steel rods and shall be truly concentric and square with the shank. The shank shall be perfectly straight.

4.1.10 Fully threaded bolts shall not be used, the length of bolts should be such that the threaded portion shall not extend into the place of contact of the members.

4.1.11 All bolts shall be threaded to take the full depth of the nut and threaded far enough to permit firm gripping of the members, but not any further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit hand tight to the point where the shank of the bolt connects to the head.

4.1.12 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of electro-galvanized steel and of the positive lock type. Their thickness shall be 2.5 mm for 12 mm dia bolts, 3.5 mm for 16 mm dia bolts and 4.5 mm for 20 mm dia bolts.

4.1.13 The Bidder shall furnish bolt schedules giving thickness of members connected, size of bolts and nuts, the length of the shank, the length of the threaded portion of bolts, sizes of bolt holes, thickness of washers and any other special details of this nature.

4.1.14 To obviate bending stress in bolts or to reduce it to a minimum, no bolt shall connect aggregate thickness of more than three (3) times its dia.

4.1.15 The bolt positions in assembled towers shall be as per IS: 5613 (Part-I/Section-I) (Part-II/Section-2)-1985.

4.1.16 Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

5.0 Tower Accessories

5.1 Step Bolt Ladders: These bolts shall be of property class 4.6 conform to IS: 6639-1972.

5.1.1 Each tower shall be provided with step bolts on one of the main legs, of not less than 16 mm diameter and 175 mm long, spaced not more than 400 mm apart and extending from about 2.5 metres above the ground level to the top of the tower. Each step bolt shall be provided with two nuts on one end to fasten the bolt security to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN and shall be used as a ladder for climbing.

5.1.2 Anti-climbing devices: This shall conform to IS: 5613 (Part-I/Sec –I), 19085.

Fully galvanized barbed wire type anti-climbing device shall be provided at a height of approximately 3 metres as an anti-climbing measure. Four layers of barbed wires will be provided each inside and outside the tower in horizontal plane, spacing between the layers being 140 to 150 mm. The towers to be designed by the supplier shall have provision to fixed the barbed wire as indicated above. Thus the angle pieces with notches for accommodating barbed wire shall be designed and supplied with the towers along with provision for suitable bolt holes on leg members for fitting bolt holes on leg member for fitting the angles. The scheme of the anti-climbing device shall be submitted along with the tower drawing. Barbed wire shall be included in the scope of bidder.

5.1.3 Insulator strings and ground wire clamp attachments

(a) For the attachment of suspension insulator strings a suitable swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditions and free swinging of the string.

The hanger shall be designed to withstand an ultimate tensile strength of 11.500 kg.

5.1.4 (a) For ground wires at suspension towers suitable 'U' Bolts strong enough to withstand the full designed loads shall be provided to accommodate the hook of the ground wire suspension clamps.

(b) At tension towers, horizontal strain plates of suitable dimensions on the underside of each power cross-arm tip and at the top ground wire peak shall be provided for taking the 'D' Shackles of the tension insulator strings or ground wire tension clamps, as the case may be. Full details of the attachments shall be submitted by the supplier for the employer's approval before commencing with mass fabrication.

5.1.5 Phase Plate

Phase plate shall be of mild steel of 16 gauge vitreous enameled at back and front, circular in shape and diameter 75 mm. One set of phase plate shall be consisting of 3 plates red, yellow and blue coloured accordingly to indicate the phase of the

conductor. There shall be one fixing bolt on the plate. This shall conform to IS: 5613 (Part-II/Section01) of latest edition.

5.1.6 Number Plate

The number plate shall be mild steel vitreous enameled at back and front, 200 mmx 150 mm, rectangular shape and inscribed thereon shall be the number of the tower location preceded by letter corresponding to the short name of the line and the type of towers. There shall be two fixing bolts on both end of the plates. The dimension and details of the number plate shall be as per IS: 5613 (Part-II/Section1 & Section-2), 1985.

5.1.7 Danger Plate

These shall be of mild steel vitreous enameled at back and front 250 x 200 mm rectangular shape and inscribed thereon shall be in signal red the work 'DANGER' with its Oriya and Hindi translation and also with the inscription of Bone and Skull and voltage of the line. There shall be two holes on the plates for fixing. This shall conform to IS: 2551 (latest edition).

5.1.8 Details to Tower Fabrication Workmanship

5.1.9 Except where hereinafter modified details of fabrications shall confirm to IS: 802 (Part-II)-1978.

5.1.10 But splices shall generally be used such that the inside cleat angle and outside plates are designed to transmit load. The inside cleat angle shall not be less than half the thickness of the connected heaviest member plus 2 mm. Lap splices may also be used for connecting members of unequal size in such a manner that the inside angle of the lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts. But as well as lap splices shall be made as above and as close to and above the main panel point as far as possible.

5.1.11 Points shall be so designed so as to avoid eccentricity. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where connections are such that the elimination of the gusset plates would result in eccentric joints then gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plate, required to transmit stress, shall not be less than that of the thinnest of connected member but not less than 5 mm in any case.

The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary so as to avoid the use of filler and it shall be connected at the point of inter-section by one or more bolts.

5.1.12 The tower structures shall be accurately fabricated to bolt together easily at site without any strain on the bolts.

5.1.13 No angle member shall have the two leg flanges brought together by closing the angle.

5.1.14 The diameter of the hole shall be equal to the diameter of bolt plus 1.5 mm.

5.1.15 The structure shall be designed such that all parts are accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depressions are likely to hold water.

5.1.16 All similar parts shall be made strictly interchangeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which shall not injure the materials so that when assembled, the different matching surfaces are in close contact throughout. No rough edges shall be permitted anywhere in the structure.

5.1.17 Drilling and Punching

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

(b) Holes for bolts shall be drilled or punched with a jig but drilled holes are preferred. The following maximum tolerance of accuracy of punched holes is permissible.

(i) Holes must be perfectly circular and no tolerance in this respect is permissible.

(ii) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8 mm i.e. the allowable taper in punched holes should not exceed 0.8 mm on diameter.

(iii) Holes must be square with the plates or angles and have their walls parallel.

© All burrs left by drills or punches shall be removed completely. When the tower members be truly opposite to each other. Drilling or reaming to enlarge defective holes is not permitted.

5.1.18 Erection Mark:

Each individual member shall have an erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be done with marking dies of 16 mm size before galvanizing and shall be legible after galvanizing.

The erection mark shall be A-BB-CC-DDD where

A Employer code assigned to the supplier (Alphabet).

BB Supplier's Mark (Numerical)

CC Tower type (Alphabet)

DDD Number mark to be assigned by Supplier (numerical).

5.1.19.1 Galvanizing

The super structure of all towers and stubs upto 150 mm below plinth level (Top of concrete pedestal) shall be galvanized. Galvanizing of tower members and stub shall be in conformity with IS: 4759-1984 and shall be done after all fabrication work has been completed except that the nuts may be tapped or return after galvanizing. Threads of bolts and nuts after galvanizing shall have a neat fit and shall be such that they can be turned with fingers throughout the length of the threads of bolts and they shall be capable of developing the full strength of the bolts. Spring washers shall be electro-galvanized as per Grade – 4 of IS: 1573 – 1986. Galvanizing for fasteners shall conform to IS: 1367 (Part-XIII) – 1978.

5.1.19.2 Quantities and Weights

5.1.20 The quantities stated in Annexure – I are only provisional. Final quantities will be informed by the employer to the supplier on completion of detailed survey. However, bids will be evaluated based on quantities indicated in the Annexure – I.

5.1.21 The employer reserves the right to order for the final quantities at the rates quoted in the bid, which shall be valid throughout the pendency of the contract.

5.1.21.1 The unit weight of each type of tower stubs, super structure and extension be furnished by the Bidder. The weight of tower shall mean the weight of tower calculated by using the black section(ungalvanized) weight of steel members including stubs, of the sizes indicated in the approved fabrication drawings and bills of materials, without taking into consideration the reduction in weights due to holes, notches, cuts, etc. but taking into consideration the weight of special fittings.

5.1.21.2 Tower designs Superstructure

5.1.21.3 Wind Pressure

The wind pressure on towers, power conductors and earth wire shall be as per IS: 802 (Part-I/Sec-I) – 1995.

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5.1.21.4 Design Temperatures

The following temperature range for the power conductor and ground wires shall be adopted for the line design confirming to IS: 802 (Part –I/Sec – I) – 1995.

i) Minimum temperature 50°C.

ii) Every day temperature 32°C

iii) Maximum temperature of:

- | | |
|-----------------------------------|---|
| a) Conductor | 75°C for ACSR Moose/Zebra/Panther
90°C for AAAC (Moose equivalent) |
| b) Ground wire
exposed to Sun. | 53°C |

5.1.21.5 Factors of Safety & Span details

a) Factor of safety.

The factor of safety based on crippling strength of struts and elastic limit of tension members shall not be less than 2(two) under normal condition and 1.5 (one and a half) under broken wire conditions for all the members of the towers and their cross arms.

b) Normal Span

The normal span of the line shall be 300 metres for 400 KV and 220 kV and 250 meters for 132 kV.

c) Wind and weight spans

The wind and weight spans to be adopted in the design of the structures shall be as follows:

i) Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. In case of towers located on an perfectly horizontal terrain, this shall be the normal span. For design purposes the wind on conductor shall be calculated on at least 1.1 times the normal.

ii) Weight Span

The weight span is the horizontal distance between the lowest point of the conductors on the two spans adjacent to the tower.

All C and D type towers shall be designed for uplift spans (minimum) weight spans in the following table also. These are applicable both for pointed and square cross arms.

For details of cross arms and towers, the span limits given below shall prevail.

WEIGHT SPANS

Tower Type	400/220 KV				132KV			
	Normal Condition		Broken wire condition		Normal Condition		Broken wire condition	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
A & B	525	100	300	100	320	100	250	100
C & D	600	100	300	100	320	100	250	100

5.1.21.6 Conductor and Ground wire Configuration

For single circuit towers the three phases shall be Delta formation. One number of ACSR conductor shall be used for each phase. One galvanized steel wire shall be used as ground wire. The ground wire shall be continuous and shall be provided above the conductors at suitable elevation to offer effective shielding and safe clearances. For double circuit towers the phases shall be in vertical formation with phase to phase horizontal spacing of not less than 8.4 meters and vertical 4.9 meters for 220 kV.

5.1.21.7 Loads on Towers

i) Transverse Loads:

Transverse load due to wind on towers conductors and under broken wire earthwire shall be calculated in accordance with IS: 802(Part-I/Sec-I)-1995.

ii) Longitudinal Loads due to wind on towers conductors and shield shall be calculated as per IS: 802 (Part-I/Sec-I)-1995.

iii) Vertical Loads:

The vertical load due to conductors and ground wire shall also include 150 kg. As weight of a Lineman with tools. These loads are in addition to the vertical loads due to insulator fittings and the dead weight of the structure. The weight of a Lineman with tool should not be considered in minimum vertical load calculation. An additional erection load of 3.5 KN shall also be considered for the design of the tower. The stringing procedure shall ensure that the above vertical loads are not exceeded. For calculating vertical loads the following insulator weights may be considered.

400/220/132 KV

Each single suspension insulator string	160 kg
Each double suspension insulator string	320 kg
Each double tension insulator string	420 kg
Pilot string for 60° tower	160 kg

iv) Broken Wire condition

a) Suspension Tower Type A/DA

Breaking of any one power conductor in one phase only, resulting in instantaneous unbalance tension of 50% of conductor tension at 32°C without wind or breaking of one earthwire resulting in an unbalance tension equal to the maximum tension of the ground wire whichever is more stringent is to be considered for design along with appropriate impact factor.

b) Tower Type B & C

Breakage of two phases on the same side and on the same span or breakage of any one phase and any one ground wire on the same span whichever combination is more stringent along with appropriate impact factor for a particular member.

c) Tower Type D/DD

Breakage of all the three phases on the same side and on the same span or breakage of two phases and any one ground wire on the same span, whichever combination is more stringent along with appropriate impact factor for a particular member. Cross arms for angle tower shall be of equal length for both sides.

v) Design Load

Employer's requirement for design longitudinal and transverse loads shall confirm to IS: 802(Part-I/Sec-I)-1995.

The Bidder shall furnish the details of design loads proposed to be adopted in the tower design in accordance with this specification.

The design criteria and other special requirements as stipulated for special towers shall be applicable for river crossing/special towers.

5.1.21.8 Tower Steel Sections:

i) Steel sections of tested quality in conformity with IS: 2062 GRA are to be used in towers, extensions and stub setting templates. No individual members shall be longer than 6000 mm.

For designing of towers only rationalized steel sections shall be used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section at no extra cost. However, design approval for such substitution shall be obtained from the employer.

ii) Thickness of Members

The minimum thickness of angle sections used in the design of towers, shall be kept not less than the following values:

- a) Main corner leg members excluding the ground wire peak and main cross arm 6 mm.
- b) For all other main members 5 mm.
- c) Redundant members 4 mm.

iii) Bolt Arrangement

The minimum bolt spacing and rolled edge distance and sheared edge distances of sections from the centers of the bolt holes shall be provided as furnished in Table-1.

Dia of Bolts (mm)	Hole Dia (mm)	Min. bolt Spacing (mm)	Min. rolled Distance (mm)	Min. Sheared Edge distance (mm)
12	13.5	30	16	19
16	17.5	40	20	23
20	21.5	50	25	27

Bolts sizes mentioned above shall only be used. The minimum width of flanges without bolt holes shall be 30 mm.

For the purpose of calculating stress and bearing stress for bolts refer clause 14.4 and 14.5 of IS: 802 (Part-I/Sec-2)-1992.

iv) Allowable Stress:

Structural steel angle section manufactured according to the latest ISL: 808(Part-V & VI) and tested according to the latest edition of IS:2062 and having its yield strength not less than 255 N/mm. sq. shall be used in the fabrication of tower members.

v) Axial Stress in tension:

The estimated tensile stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vi) Axial Stress in Compression

The estimated compressive stress in various members multiplied by the appropriate factors of safety shall not exceed the value given by the formula specified in Clause 9.2.1 of IS:802(Part-I/Sec-2)-1992.

vii) Slenderness ratio:

Slenderness ratio for members shall be computed in accordance with IS:802(Part-I/Sec-2)-1992. Slenderness ratio for compression and tension members shall not exceed the values specified therein. The following maximum limits of the slenderness ratio shall be adopted i.e. the ratio of unsupported length of the section in any place to the appropriate radius of gyration.

- | | | |
|----|--|-----|
| a) | For main corner leg member including the corner members of earth wire peak and the lower corner members of the arms... | 150 |
| b) | For other members having calculated stresses.... | 200 |
| c) | For redundant members.... | 250 |
| d) | For members having tensile stress only.... | 375 |

viii) Erection Stress

Where erection stresses combined with other permissible co-existent stresses could produce a working stress in any member appreciably above the specified working stress, then additional materials shall be added to the member or such other provision made so as to bring the working stress within the specified limit. For the purpose of this clause the specified working stress shall be the ultimate stress divided by the factor of safety of 2.0.

ix) Design calculation and Drawings

The following design calculations and drawings are required to be furnished to the employer.

- a) Along with the Bid:

Detailed design calculations and drawing for each type of tower.

- b) On award of Contract

The supplier shall submit design of tower extension, stub templates and loading/rigging arrangement of tower testing to enable the employer to make preliminary check regarding structural stability of tower tests.

Upon successful testing of tower and subsequent approval of designs, drawings and bill of materials, the supplier shall furnish Photostat copies of the following in 6(six) copies to the employer for necessary distribution along with one copy of reproducible print.

- a) Detailed design calculations along with drawings of towers and foundations.
- b) Detailed structural drawings indicating section size, length of member. Sizes of plate along with hole to hole distances, joint details etc.
- c) Bill of materials indicating cutting and bending details against each member.
- d) Shop drawings showing all details relevant to fabrication.

- e) All drawings for the tower accessories.

The supplier is required to submit four copies of the drawings with Photostat copies mentioned above for approval by the employer while submitting the designs, structural drawings. Bill of materials and any other drawings pertaining to the subject transmission line. The supplier shall clearly indicate in each drawing the project code number, if any, specification no., name of transmission line, letter reference no. and date on which the submissions are made. The said procedure is to be followed while submitting the distribution copies.

5.1.21.9 Statutory Electrical Clearances:

- i) Ground Clearances:

The minimum ground clearance from the bottom conductor shall not be less than 7.00 metres for 220 kV at the maximum sag conditions i.e. at maximum temperature and in still air. However, to achieve the above clearance the height of the tower shall be increased in the following manner:

- a) An allowance of 4% of the maximum sag shall be provided to account for errors in stringing.
- b) Conductor creep shall be compensated by over tensioning the conductor for a temperature of 26°C lower than the stringing temperature.

In case of rail track crossings the minimum height above rail level of the lowest portion of any conductor under conditions of maximum sag, in accordance with the regulations for Electrical Crossing of Railway Tracks are given in Table – 5.

TABLE – 5

	Type of work	Inside stn. Limits(mm)	Outside stn. Limits(mm)
a)	For unelectrified track and tracks electrified on 1500 V.DC		
	i) For metre/narrow gauge	10,000	17,600
	ii) For broad gauge	11,200	8,800
b)	Tracks electrified on 25 kV AC for metre, narrow and broad gauge	15,300	13,300

Minimum clearance between the subject power line and any other power line crossing shall not be less than 7000 mm.

- ii) Live Metal Clearance:

The minimum live metal clearance to be provided between the live parts and steel work of superstructure shall be as given in IS:5613 (Part-2/Sec-I).

The Bidder may adopt separate cross arm design and length for 'D' type towers under dead end conditions provided adequate live metal clearance is available with at least 15° angle and also provided that all the other specified conditions of this specifications are fulfilled. In case pilot insulator strings are proposed to be used, the angle of swing to be considered shall be minimum of 15°.

In computing live metal clearances, the dimensions of suspension and tension string shall be taken as given in drawings attached herewith. The design of the towers shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the insulator strings.

iii) Angle Shielding

The angle shielding, defined as the angle formed by the line joining the center lines of the ground wire and outer conductor in still air, at tower supports, to the vertical line through the center line of the ground wire shall not be more than 30°. The drop of the ground wire clamp which is employer supplied item should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of ground wire suspension clamp along with U-bolt may be taken as 150 mm.

iv) Mid Span Clearance

The minimum vertical span clearance between any of the earthwire and the nearest power conductor under all temperatures and in still air condition in the normal ruling span shall be 8.10 metres for 220 kV. Further the tensions of the earthwires and power conductors, shall be so co-ordinated that the sag of earthwires shall be at least 10% less than that of the power conductors under all temperatures and loading conditions.

5.1.21.10 Packing

Angle sections shall be wire bundled, cleat angles, gusset plates, blackets, filler plates, hanger and similar other loose items shall be netted and bolted together in multiples or securely wired together through holes.

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

The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.

5.1.21.11 Special Towers:

i) Special towers are to be used for major river crossing requiring very long spans. These towers shall form part of the Bidder's scope.

Unit rates for design, fabrication, galvanizing, testing and supply for such towers shall be quoted in the appropriate schedule of Volume IB.

Anchoring of major river crossing towers, shall be with 'D' or DD type towers.

All the requirements as meant for standard towers shall apply for such special towers except those noted in the following clauses.

ii) Shielding Angle:

The shielding angle shall not be greater than 30°.

iii) Clearances:

The minimum clearance of lowest point of power conductor from the highest flood level in navigable rivers for crossing towers shall be obtained from the navigation authority.

The minimum electrical clearances between live parts and tower body and cross arm member shall be the same as for normal towers.

iv) Stub Location:

The approximate height of foundation on which stub for river cross towers are to be set, over the highest flood level of the river shall be fixed only after employer's approval.

v) Angle of Deviation

The minimum angle of deviation to be considered for special towers is 2° and all live material clearances are to be computed considering double suspension insulator strings as per drawing enclosed.

vi) Factors of Safety:

Towers:

The minimum factors of safety for towers shall be:

- a) Under normal conditions 2.0
- b) Under broken wire conditions 1.5

vii) Conductor and Earth wire:

The minimum factor of safety for conductors and ground wire shall be 2.5 maximum tension corresponding to 2/3rd full wind pressure at minimum temperature or full wind pressure at the mean annual temperature such that the initial unloaded tension at the mean annual temperature do not exceed 30% of the ultimate strength of conductor and ground wire respectively.

viii) Wind Loads:

- a) The procedure for wind load calculation on conductor and ground wire shall be the same as for normal structures.
- b) The wind pressure values on tower shall be based on IS:802(Part-I/Sec-I)-1995.
- ix) Longitudinal Loads:
 - a) The longitudinal loads due to power conductors and earth wires for suspension towers shall be nil under normal conditions and 100% of the maximum tension of bundled conductors or earth wire under broken wire conditions.
 - b) Under normal conditions, unbalanced longitudinal pull due to difference in tension in ruling span for river crossing towers on one side and span of the line on the other side shall also be considered for the design of anchor towers.

5.1.22 TESTS

5.1.23 General

- a) All standard tests including quality control tests in accordance with IS:802(Part-III)-1978 shall be carried out.
- b) A galvanized tower of each type complete with 6 metres extension shall be subjected to design and destruction test. The tower shall be tested with nuts and bolts of the same make and type which are proposed to be used on the line. The supplier shall submit to the employer for approval, a detailed programme and proposal for testing the towers showing the method of carrying out the tests and the manner of applying the loads. The supplier on receipt of such approval shall intimate the employer about carrying out of the tests at least 30 days in advance of the scheduled date of tests during which time the employer will arrange to depute his representatives to witness the tests. Six copies of the test reports thereof shall be submitted to the employer for approval.
- c) In case of premature failure, the tower shall be retested and steel already used in the earlier test shall not be used again. The supplier shall provide facilities to the employer for inspection of materials during manufacturing stage and also during testing of the same.
- d) No part of any tower subject to test shall be allowed to be used in the work. The prices to be quoted for such type tests shall be after allowing rebate for the scrap value of the tested tower which is to be retained by the supplier
- e) The supplier shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully undergone the tests. In case any deviation is detected the supplier shall replace such defective towers free of cost of the employer. All expenditure incurred in erection, to and fro transportation, any other expenditure or losses incurred on this account shall be fully borne by the supplier.; No extension in delivery time shall be allowed on this account. The employer, however, reserves the right to waive off the testing of the towers, provided the supplier had earlier successfully tested, erected and commissioned similar towers and certificates for such tests carried out earlier are furnished duly certified by the employer and are found acceptable.

- f) Each type of tower to be tested shall be a full scale prototype galvanized tower and shall be erected vertically on rigid foundation with the stub protruding above ground level as provided in the design/drawing between ground level and concrete level.
- g) The suspension tower to be tested shall be with hanger and 'U' Bolt as per approved design/drawings. The tension tower to be tested shall similarly be with the strain plate as per approved design/drawings.
- h) In case of any premature failure even during waiting period, the tower shall be retested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected then in such cases all the tests which have been carried out earlier are to be reconducted to the entire satisfaction of the employer.
- i) The sequence of testing shall be at the discretion of the employer.

5.1.23.1 Test for Galvanization

Galvanization of the members of the tower shall withstand tests as per IS:2633.

5.1.24 INSPECTION

5.1.24.9 The supplier shall keep the employer informed well in advance of the commencement of manufacture, progress of manufacture thereof and fabrication of various tower parts at various stages. So that arrangements could be made for inspection by the employer.

5.1.24.10 The acceptance of any batch of items shall in no way relieve the supplier of any his responsibilities for meeting all the requirements and intent of this specification and shall not prevent subsequent rejection if any item of that batch is later found defective.

5.1.24.11 The employer or his authorized representatives shall have free access at all reasonable time to all parts of the supplier's works connected with the fabrication of the material covered under the contract for satisfying themselves that the fabrication is being done in accordance with the provisions of this specification.

5.1.24.12 Unless specified otherwise, inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.

5.1.24.13 Should any member of the structure be found not to comply with the approved design, it shall be liable for 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.

5.1.24.14 Defects which occur during fabrication shall be made good with the consent of and according to the procedure to be laid down by the employer.

5.1.24.15 All gauges and templates necessary to satisfy the employer for conducting tests shall be made available at the test site by the supplier.

5.1.24.16 The correct grade and quality of steel shall be used by the supplier. To ascertain the quality of steel the employer may at his discretion get the material tested at an approved laboratory.

5.1.25 SCHEDULE OF REQUIREMENTS

5.1.25.1 The schedule of requirements of different types of towers is indicated in Volume-III. The quantities indicated therein are tentative and based on preliminary survey conducted by the employer. The exact quantity will be informed to the supplier on completion of detailed survey.

5.1.25.2 The time frame for executing the work is also indicated in this schedule. The supplier has to match the supply and delivery of stubs, tower-parts etc. to complete the work within the time schedule desired by the employer.

5.1.25.3 The supplier shall, as far as possible, dispatch the tower material as completed towers in order to enable erection of complete tower structures at site. Payment for the initial dispatches, to the extent of 30% of the total ordered quantity will be released on the basis of weight (i.e. Metric tones of steel supplied). Beyond this limit, however, payment will be released only for material supplied to complete towers.

5.1.26 SCUEDUALE OF PRICES

5.1.26.1 The prices for supply of materials shall be furnished in the relevant schedule in the manner specified in Volume-III.

5.1.27 GENERAL TECHNICAL REQUIREMENTS

	Design details	-	foundation
Line voltage	-		400/220132 kV
No. of circuits	-		Double/Double/Double
Particulars			

a) Properties of soil for bidding purpose only

Sl. No.	Details	Soft Loose	Mud	Hard Soil	Soft Rock	Hard Rock
1.	Angle of repose of soil(in degree)	30	15	0	0	0
2.	Ultimate bearing strength of earth (T/M ²)	10	5	20.0	50.0	125.0

b) Properties of concrete

All concrete shall be RCC with ratio(1:1.5:3).

- c) Factor of safety for foundation against over turning due to up-lift and thrust.
 - i) Normal condition 2.2
 - ii) Broken wire condition 1.65
- d) Concrete Mixture
 - i) pad 1:3:6
 - ii) Pyramid or stepped part of foundation 1:1:5:3
 - iii) Chimney 1:1:5:3
- e) Minimum thickness of chimney 300 mm
- f) Minimum thickness of concrete over stub
 - Dry soil 100 mm
 - Wet & WBC 150 mm
- g) Minimum length of stub 2000 mm
in concrete.
- h) Distance above ground level of 450 mm
Tower stub and super structure

5.1.28 .Foundation General Description

5.1.29 Design, construction and other relevant drawings shall be furnished by the tower designer for all types of towers (including special towers) for different kinds of soil as detailed below. According to the locations foundations for towers shall be normally of the following types:

- a) Soft/Loose Soil
- b) Mud
- c) Hard/Dense soil
- d) Hard/Disintegrated rock

5.1.30 For rock foundations the holes in rocks shall be made in an approved manner so as to eliminate the possibility of serious cracking of the rock. The concrete block shall be properly secured to rock base by adequate no. of anchor bolts and further secured by concrete lodge section by the sides.

TECHNICAL SPECIFICATION

ERECTION OF

400/220/132 KV D.C. TRANSMISSION LINES

CONSTRUCTION OF TOWER FOUNDATION AND ERECTION OF TOWER

1.0 ERECTION OF TOWER AND TOWER FOUNDATION

1.1 SCHEDULE OF ERECTION PROGRAMME

After due approval of the detailed and check survey, the contractor shall submit to the employer a complete detailed schedule of erection programme with a Bar-Chart for construction of the lines indicating therein the target date of completion.

1.1.1 DRAWINGS FOR TOWER AND FOUNDATIONS

The same shall be supplied by the contractor.

1.1.2 TAKING OVER

Tower and tower accessories received at site stores are to be stored item-wise and mark-wise to facilitate joint inspection of the materials (with reference to packing list and detailed order).

If the materials/equipment or any part thereof is damaged or lost during the transit, the replacement of such materials shall be effected by the contractor timely so as to maintain programme of work. However, the line under erection shall be taken over by the purchaser only when the entire line is completed in all respect and made ready for commissioning at rated voltage. Partly erected line will not be taken over.

Taking over of the line shall be in no way relieve the contractor from his responsibility for satisfactory operation of the erected line in terms of the guarantee clause of the specification.

1.1.3 MATERIALS HANDLING AND INSURANCE

The contractor shall deliver all equipment/materials against this contract to his site stores under cover of Transit Insurance to be taken in his name. Cost of such insurance is to be borne by the contractor.

Cost of transportation of materials from contractor's store to the site of work shall be borne by the contractor irrespective of mode of transportation and site condition.

The contractor has to bear the cost of premiums for all materials, tower accessories, total erection cost of the line including cement, torsteel for foundation.

It will be the responsibility of the contractor to report to the concerned Police Station about all incidents of thefts and lodge, pursue and settle all claims with Insurance Company in case of damage/loss due to theft, pilferage, flood and fire etc. and the employer of the work shall be kept informed promptly in writing about all such incidents. The loss, if any, on this account shall be recoverable from the contractor if the claims are not lodged and properly pursued in time or if the claims are not settled by the insurance company due to lapses on the part of the contractor. The contractor shall have to replenish promptly damaged, stolen tower members and accessories conductors, earth wire, hardwares etc. and repair/re-erect the damaged lines, free of cost to the employer so

as to maintain the programme of work. The employer will not be responsible in any way for such loss of materials.

1.1.4 EXCAVATION FOR FOUNDATION PITS, DE-WATERING AND SHORING SETS

The contractor shall execute the open excavation job in the foundation pits in all type of soil including latterite and or boulder mixed soil as detailed below including removing, spreading and/or stacking the excess spils (as directed by the employer). The item includes the necessary trimming of the sides, leveling, dressing and ramming (as necessary) the bottom of the pits including bailing out water, dewatering by manual and/or mechanical means by employing water pumps including removing of slushes from foundation pits and nominal open plank shoring with vertical poling boards placed at suitable intervals as directed with required runners, struts, battens for framing as required complete. While quoting the unit rate for foundation as per the activity schedule, the contractor shall include cost of design, all cost of labour, materials, tools, plants, incidentals for earth excavation, dewatering, cement, water, sand, coarse and fine aggregates, steel reinforcement, steel angles, forms, mixing, finishing, protection and curing of concrete, back-filling with carried earth, if necessary, disposal of surplus, spoils, stub setting and template. The contractor shall also include in the quoted unit rate for foundation, all charges/costs for preparing the pit marking and foundation layout drawing, grounding of towers including supply of pipe/concrete pipe, earthing, measurement of ground resistance before often growing etc.

1.1.5 CEMENT CONCRETE :

A) Materials

All materials whether to be consumed in the work or used temporarily shall conform to relevant IS specification, unless stated otherwise, and shall be of the best approved quality.

B) Cement

Cement to be used in the work under the contract shall generally conform to IS:269/455-1989. Cement bags shall be stored by the contractor in a water tight well ventilated store sheds on raised wooden platform/dunnage (raised at least 150 mm above ground level) in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter. Sub-standard or partly set cement shall not be used and shall be removed from the site by the contractor at his cost on receipt of approval from the Engineer.

C) Coarse Aggregates Stone chips or stone ballast

D) Reinforcement : Different size of reinforcement(MS ROD-FE-500) as per latest IS.

Remarks: All foundation of tower shall be of RCC: M20 Grade(1:1.5:3) nominal mix

General Technical Particulars
C. 1 - Span Lengths

		132kV	220kV	400kV
Normal span	m	300	350	400
Tower design spans:				
Wind spans:				
Suspension towers	m	300	350	400
Tension towers	m	300	350	400
Maximum weight spans:				
Suspension towers	m	450	525	600
Tension towers	m	450	525	600
Minimum weight spans:				
Suspension towers	m	100	100	100
Tension towers (uplift net)	m	-200	-200	-200 (for DB&DC) -300 (forDD)

C . 2 - Line Conductor (132 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm ²	288.3
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR PANTHER
IEC STANDARD No		IEC 1089
INDIAN STANDARD No		IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium	No./mm	30/3.0
Total area of conductor	mm ²	261.5
Overall diameter of stranded conductor	mm	21
Mass of conductor per kilometre	kg	974
Ultimate strength of conductor	Newton	89670
Assumed equivalent modulus of elasticity of conductor	N/mm ²	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	17.8x 10 ⁻⁶
Maximum length of conductor supplied on one drum	km	2.4+/-5%

C . 3 - Line Conductor (220 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm ²	484.5
Number of conductors per phase		ONE
Horizontal distance between conductor centres of one phase	mm	-
Each single conductor:		
Equivalent to ACSR conductor of code name		ACSR ZEBRA
IEC STANDARD No		IEC 1089
INDIAN STANDARD No		IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium	No./m m	54/3.18
Total area of conductor	mm ²	428.9
Overall diameter of stranded conductor	mm	28.62
Mass of conductor per kilometre	kg	1621
Ultimate strength of conductor	Newto n	130320
Assumed equivalent modulus of elasticity of conductor	N/mm ²	81580
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3 x 10 ⁻⁶
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

C . 4 - Line Conductor (400 kV Construction)

Complete line conductor:		
Actual area (total) per single conductor	mm ²	597.00
Number of conductors per phase		TWO

Horizontal distance between conductor centres of one phase	mm	450
Each single conductor: Equivalent to ACSR conductor of code name		ACSR MOOSE
IEC STANDARD No		IEC 1089
INDIAN STANDARD No		IS 398 (Pt 4) 1994
Material of conductor		Aluminium
Number and diameter of wires: Aluminium alloy	No./mm	54/3.53
Total area of conductor	mm ²	597
Overall diameter of stranded conductor	mm	31.77
Mass of conductor per kilometre	kg	2004
Ultimate strength of conductor	Newton	161200
Assumed equivalent modulus of elasticity of conductor	N/mm ²	68600
Assumed equivalent coefficient of linear expansion of conductor	per °C	19.3 x 10 ⁻⁶
Maximum length of conductor supplied on one drum	km	1.8 +/- 5%

****ALL THE CONDUCTORS ARE ACSR CONDUCTORS HAVING 7 STRANDS OF GI STEEL WIRE.**

C . 5 - Earth Wire (132 kV And 220 kV Constructions)

		GSW
Complete earth conductor:		
Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./m m	7/3.15
Overall diameter of conductor	mm	9.45
Mass of conductor per kilometre	kg	428
Ultimate strength of conductor	Newto n	56000
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance at 20 °C	ohms/k m	3.375

C . 6 - Earth Wire (400 kV Construction)

	GSW
Complete earth conductor:	

Appropriate Indian Standard No		398(Part-2)
Appropriate British Standard No		183
Material of conductor		galvanised steel
Number and diameter of wires	No./mm	7/3.66
Overall diameter of conductor	mm	10.98
Mass of conductor per kilometre	kg	583
Ultimate strength of conductor	Newton	68400
Lay length	mm	160 +/- 15
Direction of the lay of the outer layer		Right hand
Chemical composition of the steel wire	%	
Carbon		not more than 0.55
Manganese		0.4 to 0.9
Phosphorous		not more than 0.04
Sulphur		not more than 0.04
Silicon		0.15 to 0.35
Purity of Zinc for galvanising	%	99.95
Galvanising after stranding		
a) Minimum weight of Zinc coating per sq. m. of the uncoated wire surface	gms	240
b) Minimum no. of one minute dips that the galvanised wire can withstand in Standard Preece Test		3 and 1/2
Maximum length of conductor on drum #	km	4 +/- 5%
D.C. resistance of the complete earthwire at 20°C	ohms/km	2.5

C.14 * - Disc Insulator Units (Anti-Fog Type)

		70kN	90kN	120kN	160kN
Size and designation of the ball pin shank	mm	16	16	20	20
Diameter of the disc	mm	280/305	280/305	280/305	280/305
Tolerance on the diameter	+/-mm	13/15	13/15	13/15	13/15

Ball to ball spacing between disc	mm	145	145	145	170
Tolerance on ball to ball spacing	+/-mm	4	4	4	5
Minimum creepage distance of a single disc **	mm	430	430	430	475
Steepness of the impulse voltage which the disc unit can withstand in Steep Wave Front Test	kV per micro sec.	2500	2500	2500	2500
Purity of Zinc used for galvanising	%	99.95	99.95	99.95	99.95
Purity of Zinc used for sleeve	%	99.7	99.7	99.7	99.7
No. of dips in Standard Preece Test		6	6	6	6
1) Cap socket		6	6	6	6
2) Ball pin					

***The parameters specified are for disc insulator unit only. For the Bids offering composite insulator units, the parameters may be suitably selected by the Bidder so as to meet the overall requirements of the respective strings and same shall be guaranteed at Schedules 13A and 14A of the Technical Data Requirement Schedules, Section X.**

**** The minimum creepage distance of single composite insulator unit shall be such that it matches with the total creepage distance of the respective strings with disc insulator units.**

C . 15 - Insulator Strings (Suspension Sets For 132 kV Lines)

		Single “I” Suspension Strings	Double “I” Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	275	275	275
Impulse withstand voltage (peak) under dry conditions				

1) Positive	Kv	650	650	650
2) Negative	kV	650	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	20	20	20
Number of insulator units in each string **		9	2x9	9
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 16 - Insulator Strings (Tension Sets For 132 kV Lines)

	Single Tension Strings	Double Tension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	275	275
Impulse withstand voltage (peak) under dry conditions		

1) Positive	kV	650	650
2) Negative	kV	650	650
Minimum corona extinction voltage under dry conditions	kV(rms)	105	105
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	90	2x90
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	22	22
Number of insulator units in each string **		10	2x10
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 17 - Insulator Strings (Suspension Sets For 220 kV Lines)

	Single "I" Suspension Strings	Double "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	460	460	460
Impulse withstand voltage (peak) under dry conditions			

1) Positive	kV	1050	1050	1050
2) Negative	kV	1050	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154	154
Radio interference voltage under dry conditions at 1MHz, at 154kV	Micro Volts	not more than 1000	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	70	2x70	70
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	13	13	13
Number of insulator units in each string**		14	2x14	14
Purity of Zinc used for galvanising	%	99.95	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 18 - Insulator Strings (Tension Sets For 220 kV Lines)

		Single Tension Strings	Double Tension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	460	460
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1050	1050

2) Negative	kV	1050	1050
Minimum corona extinction voltage under dry conditions	kV(rms)	154	154
Radio interference voltage under dry conditions at 1MHz, at 105kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	14	14
Number of insulator units in each string **		15	2x15
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 19 - Insulator Strings (Suspension Sets For 400 kV Lines)

		Single "I" Suspension Strings	Pilot Suspension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	680	680
Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			

1) Positive	kV	1550	1550
2) Negative	kV	1550	1550
Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	120
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	9	9
Number of insulator units in each string **		23	23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string.

In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 20 - Insulator Strings (Tension Sets For 400 kV Lines)

		SingleTensi on Strings (Low Duty)	Double Tension Strings
Power frequency withstand voltage of the string with arcing horns and corona control rings / grading rings under wet conditions	kV(rms)	680	680
Switching surge withstand voltage (peak) under wet conditions			
1) Positive	kV	1050	1050
2) Negative	kV	1050	1050
Impulse withstand voltage (peak) under dry conditions			
1) Positive	kV	1550	1550
2) Negative	kV	1550	1550

Minimum corona extinction voltage under dry conditions	kV(rms)	320	320
Radio interference voltage under dry conditions at 1MHz, at 305kV	Micro Volts	not more than 1000	not more than 1000
Mechanical strength of the complete insulator string along with all hardware fittings	kN	120	2x160
Maximum voltage (in percentage) across any disc in the complete insulator string under phase to earth voltage *	%	10	10
Number of insulator units in each string **		24	2x23
Purity of Zinc used for galvanising	%	99.95	99.95
Minimum No. of one minute dips the ferrous parts can withstand in Standard Preece Test	No.	6	6

* Voltage distribution criteria is not applicable for strings with composite insulator units.

** It is preferable to have single piece composite insulator unit for each limb of the string. In case, more than one units are used per limb, same shall be indicated by the Contractor.

C . 21 - Tower Design Particulars (132 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i.with suspension insulator set swing 0°	mm	1530
with suspension insulator set swing 15°	mm	1530
with suspension insulator set swing 30°	mm	1370
with suspension insulator set swing 45°	mm	1220
with suspension insulator set swing 60°	mm	1070
ii.with jumper loop swing 0°	mm	1530
with jumper loop swing 10°	mm	1530
with jumper loop swing 20°	mm	1070

with jumper loop swing 30°	mm	1070
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 60
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 22 - Tower Design Particulars (220 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	2130
with suspension insulator set swing 15°	mm	1980
with suspension insulator set swing 30°	mm	1830
with suspension insulator set swing 45°	mm	1675
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	2130
with jumper loop swing 10°	mm	1675
with jumper loop swing 20°	mm	1675

with jumper loop swing 30°	mm	-
with jumper loop swing 40°	mm	-
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 45
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	30

C . 23 - Tower Design Particulars (400 kV Construction)

Minimum clearance between live metal and tower steelwork:		
i. with suspension insulator set swing 0°	mm	3050
with suspension insulator set swing 15°	mm	3050
with suspension insulator set swing 30°	mm	1860
with suspension insulator set swing 45°	mm	-
with suspension insulator set swing 60°	mm	-
ii. with jumper loop swing 0°	mm	3050
with jumper loop swing 10°	mm	3050
with jumper loop swing 20°	mm	3050
with jumper loop swing 30°	mm	1860
with jumper loop swing 40°	mm	1860
Insulator suspension set, unobstructed transverse swing angle from vertical	degrees	0 - 30
Earth conductor suspension clamps, unobstructed transverse swing angle from vertical	degrees	0 - 50
Earth conductor maximum shielding angle from vertical at tower attachment point over outer line conductors	degrees	20

C . 25 - Particulars Of Double Circuit Towers (132 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	300	300	300	300
Minimum ground clearance of line conductor at 85°C, normal ground	m	6.42	6.42	6.42	6.42
Minimum height of earth conductors above upper line conductor at mid-span	m	6.1	6.1	6.1	6.1
Vertical spacing between line conductors at tower (minimum)	m	3.9	3.9	3.9	3.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	4.5	4.5	4.5	4.5

C . 26 - Particulars Of Double Circuit Towers (220 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	350	350	350	350
Minimum ground clearance of line conductor at 85 °C, normal ground	m	7.23	7.23	7.23	7.23
Minimum height of earth conductors above upper line conductor at mid-span	m	8.5	8.5	8.5	8.5
Vertical spacing between line conductors at tower (minimum)	m	4.9	4.9	4.9	4.9
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	5.5	5.5	5.5	5.5

C . 27 - Particulars Of Double Circuit Towers (400 kV Construction)

Type Of Tower		DA	DB	DC	DD
Type of insulator sets		Suspension	Tension	Tension	Tension
Maximum angle of deviation	degree	0 - 2	0 - 15	15 - 30	30 - 60
Normal span length	m	400	400	400	400
Minimum ground clearance of line conductor at 85 °C, normal ground	m	8.84	8.84	8.84	8.84
Minimum height of earth conductors above upper line conductor at mid-span	m	9.0	9.0	9.0	9.0
Vertical spacing between line conductors at tower (minimum) .	m	8.0	8.0	8.0	8.0
Minimum Clearance between conductors of one circuit and tower climbing leg of the other circuit.	m	6.5	6.5	6.5	6.5

C . 28 - Foundation Design Particulars

Assumed density of Plain Cement Concrete (PCC) for foundation in dry soil	kg/m ³	2240
Assumed density of Plain Cement Concrete (PCC) for foundation in presence of sub-soil water	kg/m ³	1240
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in dry soil	kg/m ³	2400
Assumed density of Re-inforced Cement Concrete (RCC) for foundation in presence of sub-soil water	kg/m ³	1400
28 day concrete cube strength (characteristic strength for M-20 concrete)	N/mm ²	20
28 day concrete cube strength (characteristic strength for M-15 concrete)	N/mm ²	15
Minimum proportion of stub load to be allowed for in the design of stub cleats	%	100
Density of all type of soils :		
1) under dry conditions	kg/m ³	1440
2) in presence of surface water	kg/m ³	1440
3) in presence of sub-soil water	kg/m ³	840
Ultimate bearing capacity of the soil :		
1) normal soil under dry condition	kN/m ²	214
2) normal soil in presence of surface as well as sub-soil water	kN/m ²	107
3) wet black cotton soil	kN/m ²	107
4) fissured rock (both for dry and wet)	kN/m ²	400
5) hard rock	kN/m ²	750
Angle of repose for :		
1) dry soil	Degree	30
2) wet soil due to presence of surface/ sub-soil water	Degree	15
3) wet black cotton soil	Degree	0
4) dry fissured rock	Degree	20
5) wet fissured rock	Degree	10
Ultimate bond between steel and concrete	kN/m ²	0.147

Note : All the soil parameters furnished above are subject to verification by actual soil investigations. The Contractor shall be required to carry-out field test for each type of foundation, as per the quoted rates in Price Schedules, to prove the design parameters considered.

The foundation classification criteria shall be as given below, depending upon type of soil and sub-soil water level / presence of surface water :

Normal Dry : To be used for locations where normal dry cohesive or non-cohesive soils are met without encountering sub-soil water table within the depth of foundation.

Wet : To be used for locations,

a) where sub-soil water is met at 1.5 m. or more below the ground level;

b) which are in surface water for long periods with water penetration not exceeding one metre below the ground level e.g. , the paddy field.

Partially Submerged : To be used for the locations where sub-soil water table is met between 0.75 to 1.5 m. below the ground level;

Fully Submerged : To be used for locations where sub-soil water table is met at less than 0.75 m. below the ground level;

Black Cotton Type : To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing the foundation for such locations, the soil is to be considered as fully submerged.

Fissured Rock : To be used at locations where decomposed or fissured rock, hard gravel, kankar, lime-stone, laterite or any other soil of similar nature is met. Under-cut type foundation is to be used for such locations.

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

Hard Rock : To be used for the locations where chiselling, drilling or blasting is required for excavation . For these locations rock anchoring is to be provided to resist the uplift forces.

PILE FOUNDATION-

- a) **SCOPE-** The work involved is to take up the pile foundation work of including stub setting of special type tower. The detailed survey, soil investigation and the design has to be done bidder and the design is to be approved by OPTCL, which shall be strictly followed by the contractor. The contractor shall cast the foundation including stub setting as per the design, the schedule of quantities enclosed and direction of engineer in charge.
- b) 1. The pile foundation shall be of RCC, Cast-in-situ bored piles as per IS:2911 . Pile boring shall be done using Rotary Hydraulic Rigs. Two stage flushing of pile bore shall be ensured by airlift technique duly approved by the Employer
2. Minimum diameters of piles shall be 450/500mm (for under reamed piles)/ 600 mm (for bored cast in situ piles).
3. Only straight shaft piles shall be used. Minimum cast length of pile above cutoff level shall be 1.0 m.
4. The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineer's approval.
5. The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.
6. Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.
- Vertical
Lateral : Minimum of 2 Nos. in each mode
Uplift
7. The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (relevant part).
8. Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter
9. Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :
- (i) Vertical : 0.5% of the total number of piles provided.
- (ii) Lateral : 0.5% of the total number of piles provided.

10. The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.
11. In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.
12. Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.
13. The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.
14. Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the routine load test and not intended to replace the use of static load test. This test is limited to assess the imperfection of the pile shaft and shall be undertaken by an independent specialist agency. The test equipment shall be of TNO or PDI make or equivalent. The process shall confirm to ASTM.
15. Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.
16. The following shall be adhered to **PILE FOUNDATION**:
 - i) The pile foundation shall be of under reamed piles as per IS: 2911 part III or bored cast in situ piles as per IS 2911 part I sec2
 - ii) The minimum diameter of pile shall be 500 mm in case of under reamed piles and 600 mm in case of bored cast in situ piles.
 - iii) Under reamed piles shall be adopted only in case of clay black cotton soil or medium dense sandy soil is encountered. Design of under reamed shall be done strictly as per IS 2911 part III.
 - iv) The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter, reinforcement for job as well as test piles, locations of initial test piles etc.) for Engineer's approval.
 - v) The piling work shall be carried out in accordance with IS:2911 (Relevant part) and accepted construction methodology. The construction methodology shall be submitted by the Contractor for Engineer's approval.
 - vi) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be subject to minimum as under.

Vertical

Lateral

Uplift

Minimum of 2 Nos. in each mode.

vii) The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test (initial test) the method of loading shall be cyclic as per IS:2911 (part IV).

viii) Load test shall be conducted at pile cut of level (COL). If the water table is above the COL the test pit shall be kept dry through out the test period by suitable de-watering methods. Alternatively the vertical load test may be conducted at a level higher than COL. In such a case, an annular space shall be created to remove the effect of skin friction above COL by providing an outer casing of suitable diameter larger than the pile diameter.

ix) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under :

i) Vertical : 0.5% of the total number of piles provided.

ii) Lateral : 0.5% of the total number of piles provided.

x) The routine tests on piles shall be conducted upto test load of one and half times the allowable pile capacity. Piles for routine load tests shall be approved by the Employer.

xi) In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Contractor shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required.

xii) Testing of piles and interpretation of pile load test results shall be carried out as per IS:2911 (Part-4). Contractor shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory / institute prior to their use. Settlement / movement of the pile top shall be made by Linear Variable Differential Transducers (LVDT) having a least count of 0.01mm.

xiii) The test load on initial test piles shall be applied by means of reaction from anchor piles / rock anchors alone or combination of anchor piles / rock anchors and kentledge.

xiv) Contribution of frictional resistance of filled up soil if any, shall not be considered for computation of frictional resistance of piles.

a) MATERIALS- Contractor shall supply cement, steel rod and stubs and all other materials required. All coarse aggregates, fine aggregates are to be of very good quality and to be approved by the engineer in charge.

b) Watch and Ward- The cost of watch and ward, site store, making of Islanding/platform for the pile boring, stabilization of bore hole and all other activities incidental to successful construction of the pile foundation are to be included in the cost of the tender and no additional cost shall be paid separately on any additional component.

The cement, steel shall be supplied to the contractor at the nearest store and the contractor shall have to receive the same at designated stores and transport to site at his own cost.

The piling shall be done in presence of the engineer in charge and due certification to be done at the spot only.

Standard followed and to be followed-

Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:1080-1990	Codes of Practice for Design and Construction of Simple Spread Foundations	
IS: 1498-1992	Classification and Identification of Soils for General Engineering Purposes.	ASTM D 2487/ ASTM D 2488
IS: 1892-1992	Code of Practice For Design and Construction of Foundation in Soils : General Requirements.	
IS: 2131-1992	Method of Standard Penetration Soils	ASTM D 1586
IS: 2132-1992	Code of Practice For Thin Walled Sampling of Soils	ASTM D 1587
IS: 2720-1992	Method of Test For Soils (Relevant Parts).	ASTM D 420
IS: 2809-1991	Glossary of Terms And symbols Relating to Soil Engineering	ASTM D 653
Indian Standards(IS)	Title	International and Internationally

		Recognize Standard/Code
IS: 2911-1980	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: 3043-1991	Code or Practice for Indexing and Storage Of Drill Cores.	
IS: 4091-1987	Code of Practice for Design and Construction Of Foundations for Transmission Line Towers and Poles.	
IS: 4434-1992	Code of Practice for in-situ Vane Shear Test for Soils.	ASTM D 2573/ ASTM D 4648
IS: 4453-1992	Code of Practice for Exploration by Pits, Trenches, Drifts and Shafts.	
IS: 4464-1990	Code of Practice for Presentation of Drilling Information and core Description in Foundation Investigation	
IS: 4968 - (Part-II) – 1992	Method for Subsurface sounding for soils, dynamic method using cone and Bentonite slurry	
IS: 5313-1989	Guide for Core Drilling Observations.	
Indian Standards(IS)	Title	International and Internationally Recognize Standard/Code
IS:6403-1990	Code of Practice for	

Diamond Core Drilling
for Site Investigation
for River Valley Projects.

IS: 6935-1989	Method of Determination of water level in a Bore Hole.	
IS: 7422-1990	Symbols and Abbreviations for use in Geological Maps Sections and subsurface Exploratory Logs (Relevant Parts).	
IS:8009 (Part-I)-1993	Code of Practice for Calculation of Settlements of Foundations (Shallow Foundations subjected to symmetrical Vertical Loads).	
IS:8764-1991	Method of Determination of Point Load Strength Index of Rocks.	
IS: 9179-1991	Method of Determination of Unconfined compressive Strength of Rock Materials.	ASTM D 2938
IS: 9179-1991	Method of Preparation of Rock Specimen for Laboratory Testing.	ASTM D 4543
IS: 9259-1992	Specification for Liquid Limit apparatus.	ASTM D 4318
IS: 9640-1992	Specification for Split Spoon Sampler	ASTM D 1586
IS: 10050-1992	Method of Determination of Slake Durability Index of Rocks.	ASTM D 4644
IS: 11315- (Part-II)-1991	Description of Discontinuities in Rock Mass-Core Recovery	

TESTS

Tests as indicated in this specification and as may be requested by the Owner, shall be conducted. There tests shall include but may not be limited to the following :

- a) **Tests of undisturbed and disturbed samples**
 - Visual and engineering classification;
 - Sleeve 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);
 - Tri-axial shear tests (depending on the type of soil and field conditions on undisturbed or remoulded samples):
 - i) Unconsolidated untrained;
 - ii) 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)