BIDDING DOCUMENT

FOR

DESTRINGING OF EXISTING PANTHER CONDUCTOR AND STRINGING OF HTLS CONDUCTOR OF 132 KV KHANDONG-HAFLONG LILO AT 132 kV UMRANGSHO GSS ALONG WITH ASSOCIATED WORKS

(E-Tender)

VOLUME -2

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BID IDENTIFICATION NO:

AEGCL/MD/Tech-1099/DCNEL/Umrangso/HTLS/2025/Bid

ASSAM ELECTRICITY GRID CORPORATION LIMITED

CONTENTS

SECTION-1
SCOPE AND GENERAL TECHNICAL CONDITIONS

1.1.0 INTENT OF THE SPECIFICATION

1.1.1 This volume of the specification deals with the general technical information & criteria for design, manufacture, supply & delivery of equipment/material, erection, testing & commissioning and setting to work of construction on "Design, Supply and Install" basis as defined in Volume-1.

1.1.2 The provisions of this section shall supplement all the detailed Technical Specifications and requirements brought out herein. The CONTRACTOR's proposal shall be based on the use of materials complying fully with the requirements specified herein.

1.2.0 SCOPE

1.2.1 The work involves design, engineering, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, packing, supply, including insurance during transit, delivery at site, subsequent storage and erection & commissioning at site of various equipment and materials including associated works and civil foundations for equipment as specified in subsequent Clauses and Sections.

1.2.2 It is not the intent to specify completely herein all details of design and construction of the equipment and accessories. However, the equipment and accessories shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous operation up to the bidder's guarantees in a manner acceptable to the Purchaser. The Purchaser will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his judgement is not in full accordance therewith.

1.2.3 The major items of works included in the scope of this specification are listed below: -

i) Design & supply of all equipment as per this bidding document/BoQ.
ii) Installation and commissioning services including civil works as specified in BoQ.
iii) Other associated works as specified in BoQ.

1.2.4 The various items of supply are described very briefly in the schedule of Bid Form, Prices & Other Schedules and annexure. The various items as defined in these schedules shall be read in conjunction with the corresponding section in the technical specifications including amendments and, additions if any.

1.2.5 The bidder is required to fill up the BOQ/price schedule as given in the e-tendering portal.

1.3.0 DESIGN IMPROVEMENTS

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

1.4.0 DESIGN CO-ORDINATION

1.4.1 Wherever, the design is in the scope of Contractor, the Contractor shall be responsible for the selection and design of appropriate material/item to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

1.5.0 DESIGN REVIEW MEETING

1.5.1 The contractor will be called upon to attend design review meetings with the Employer, and the consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at Assam or at mutually agreed venue as and when required. Such review meeting will be held generally minimum once a month

or the frequency of these meeting shall be mutually agreed between the Employer and the Contractor. Frequency of Design Review Meetings shall depend upon the project requirement to ensure project implementation as per the Master Programme.

1.6.0 PACKING

1.6.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at Site till the time of erection. The CONTRACTOR shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

1.6.2 The CONTRACTOR shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.

1.6.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing 'up' and 'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.

1.6.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e., fragile, handle with care, use no hook etc. wherever applicable.

1.6.5 Each package shall be legibly marked by the-CONTRACTOR at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the CONTRACTOR etc.

SECTION-2
SCOPE AND GENERAL TECHNICAL CONDITION FOR TRANSMISSION LINES

A. 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 AEGCL Transmission System.

B. 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 —

1. 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.
2. The system will be in continuous operation during the varying atmospheric and climatic conditions occurring at all seasons as mentioned in the bidding document.

2.1.0 SCOPE-

Construction of 400 KV, 220 KV and 132 KV
As indicated in the Bidding Proposal Sheet & scope of work.

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

2.2.0.1 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 paid by the contractor, which will be reimbursed by AEGCL time to time. However, AEGCL shall render all helps in co- ordination with law and order department for solving the same. Forest clearance if any shall be arranged by AEGCL.

2.2.0.2 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.

2.2.0.3 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.
c) 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. The line is far away from telecommunication lines as reasonably possible. Parallelism with these lines shall be avoided as far as practicable.
d) Crossing with permanent objects are minimum but where unavoidable preferably at right angles.
e) Difficult and unsafe approaches are avoided.
f) The survey shall be conducted along the approved alignment only in accordance with IS: 5613 (Part-II/Section-2), 1985.
g) For river crossing/ Crossing of Nallas: Taking levels at 20 metre intervals on bank of river and at 40 metre intervals 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.

h) 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.

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

37.2.0.4 PROFILE PLOTTING AND TOWER SPOTTING

2.2.0.4.1 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.

2.2.0.4.2 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.

2.2.0.4.3 The number of consecutive spans between the section points shall not exceed 10 in case of straight run on a more or less plain stretch.

2.2.0.4.4 Individual span shall be as near as to the normal design ruling span.

2.2.0.4.5 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.

2.2.0.4.6 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.

2.2.0.4.7 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.

37.2.0.5 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.

2.2.1 DETAILED SURVEY/CHECK SURVEY:

The contractor will have to carry out detailed survey of the line for which route map indicating the proposed alignment

of the transmission line will be handed over by the Employer. If the detailed survey is already conducted by the Employer for some portion of the line, the profiles for such portion will be handed over to the Contractor for carrying out check survey. It may please be noted that no check survey is required to be conducted for the portion of line for which detail survey is conducted by the contractor himself.

A. Detailed Survey:-

(a) At the starting point of the commencement of route survey, an angle iron spike 65 x 65 x 1000mm shall be driven firmly into the ground to show only 150mm above the ground level. A punch mark on the top section of the angle iron shall be made to indicate location of the surveying instrument. Teak wood pegs 50 x 50 x 650 mm shall be driven at prominent positions at intervals of not more than 750 meter along the transmission line to be surveyed up to the next angle point. 125 mm wire nails should be fixed on the top of these pegs to show the location of instrument. The pegs shall be driven firmly into the ground to show only 100 mm above ground level. At angle positions, stones shall be put up for easy identification. Paint mark in white lead paint shall be put in, about 300 mm squares with a direction indication, on nearby boulders, rocks, or trees, along the complete line alignment. At peg position, identification marks giving the peg position, with reference to painting marks, shall be given. The white lead paint mark shall indicate to the individual the direction of alignment from either direction.

(b) Routing/Re-routing of transmission line through protected/reserved forest area
should be avoided. In case it is not possible to avoid the forests or areas having large trees completely, then keeping in view of the overall economy, the route should be aligned in such a way that cutting of trees is minimum.

(c) The route should have minimum crossings of Major river, Railway lines, National/State highways, overhead EHV power line and communication lines.

(d) The number of angle points shall be kept to minimum.

(e) The distances between the terminal points specified shall be kept shortest possible, consistent with the terrain that is encountered.

(f) Marshy and low lying areas, river beds and earth slip zones shall be avoided to minimize risk to the foundations.

(g) It would be preferable to utilize level ground for the alignment.

(h) Crossing of power lines shall be minimum. Alignment will be kept at a minimum distance of 300 m from power lines to avoid induction problems on the lower voltage lines.

(i) Crossing of communication line shall be minimized and it shall be preferably at right angle. Proximity and parallelism with telecom lines shall be eliminated to avoid danger of induction to them

(j) Areas subjected to flooding such as nalah shall be avoided.

(k) Restricted areas such as civil and military airfield shall be avoided. Care shall also be taken to avoid aircraft landing approaches.

(l) All alignment should be easily accessible both in dry and rainy seasons to enable maintenance throughout the year.

(m) Certain areas such as quarry sites, tea, tobacco and saffron fields and rich plantations, gardens and nurseries which will present the Employer problems in acquisition of right of way and way leave clearance during construction and maintenance should be avoided.

(n) Angle points should be selected such that shifting of the point within 100 m radius is possible at the time of construction of the line.

(o) The line routing should avoid large habitations, densely populated areas, Forests, Animal/Bird sanctuary, reserve coal belt areas, oil pipe, line/underground inflammable pipe lines etc to the extent possible.

(p) The areas requiring special foundations and those prone to flooding should be avoided.

(q) From the field book entries, the route plan and level profile shall be plotted and prepared to the scales of 1:2000 horizontal and 1:200 vertical on 1 mm/5 mm/1 cm square paper.

(r) If the difference in levels be too high, the chart may be broken up according to requirement. A 400 meter 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 limited to 594x841 mm (Al) size.

(s) After completing the detail survey, profiles shall be submitted to the Employer duly spotted with tower for approval. While submitting the profiles after conducting the detail survey, the contractor will also submit a copy of route alignment on the route map indicating the surveyed route.

B. Check Survey:

(a) The Contractor shall conduct the check survey after the profiles are handed over to the Contractor. The check survey shall include checking of deviation angles, checking of levels at critical points. After completing the check survey, the tower spotting shall be carried out by the Contractor and profiles shall be submitted to the purchaser for final approval. The Contractor shall be responsible for correct setting of stubs. Discrepancies, if any, shall be brought to the notice of purchaser and final approval shall be taken before execution of work.

(b) The requirement of tower site levelling and revetment work, if required, shall also be marked by the Contractor on the profiles while carrying out the detail or check survey work.

(c) If due to site conditions any change in the tower location/provision of extension is considered necessary compared to approve profiles, the contractor shall bring the same to the knowledge of the purchaser well in time and get revised approval of the profile before setting the stubs. The revised approval shall be conveyed to the Contractor by the Purchaser.

C. Soil Resistivity:-

While carrying out detailed/ check survey work, the Soil Resistivity values will have to be measured at convenient points along the route, not exceeding 2.50 Km between adjacent points. The Soil Resistivity will be measured using 4 electrode method with an inter electrode spacing of 50 M.

The following formula shall be used:

$$P = 2 \pi a R$$

Where a = Interelectrode spacing = 50M

R = Earth resistance measured in Ohms

P = Soil Resistivity in Ohm- m

The soil resistivity values shall be submitted duly marked on the route map and also in the form of statement. The quoted rates for detailed survey/ check survey work shall be inclusive of cost of measuring soil resistivity values along the proposed route and the contractor will not be paid separately for this work.

D. RIGHT OF WAY (ROW)

As per bid.

2.2.2 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.

2.2.2.1 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.

2.2.2.2 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.

2.2.3 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.

I. 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.

II. 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.

III. 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.

IV. 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.

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

VI. 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.

VII. Plate Load test shall have to be conducted at special tower location.

2.3.0 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. Ample 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.

1 Natural moisture content, Liquid limit, Plastic limit and Plasticity index.
2 Bulk, dry and buoyant density of soil.
3 Void ratio (e-long P curve shall be submitted)
4 Specific gravity.
5 Grain size distribution (Sieve analysis and hydrometer analysis)
6 Tri-axial and consolidation tests (consolidation undrained and consolidated drained as and when application in table, graph and drawing.
7 Permeability tests
8 Chemical tests for both water and soil samples at different layers.
9 Evaluation of safe bearing capacity at different strata for square footings shall be done for a maximum value of 25-mm. settlements.
10 At depts. From 3M to 10M be different strata.

11 Factor of safety shall be considered as 3 for evaluation of safe bearing capacity of soil.
12 Unconfined compression test for cohesive soil (=0) if encountered.

- **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)

I. Geological information of the region.
II. 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.
III. Procedure of investigations employed and field and field as well as laboratory test results.
IV. Net safe bearing capacity and settlement computation for different types of foundations for various widths and depths of tower.
V. Recommendations regarding stability of slopes, during excavations etc.
VI. Selection of foundation types for towers.
VII. Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.
VIII. 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.
IX. 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.
X. Deformation modulus from plate load test in various test depth/stratification.
XI. Coefficient of earth pressure at rest.
XII. Depth of ground water table and its effect on foundation design parameters.
XIII. Recommendations regarding stability of slopes, during shallow excavation etc.
XIV. Whether piles are necessary or not. If piles are necessary, recommendation of depth, diameter and types of piles to be used.
XV. 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.

- **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 Recognized Standards
1		IS 209-1979	Specification for zinc	ISO/R/752-1968 ASTM B6
2		IS 269-1976	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/A23.3
5	a	IS 398-1982	Specification for aluminium conductor for overhead transmission purpose	IEC 1089-1991 Part I BS 215-1970
	b	IS 398-1982	Aluminium conductor galvanized steel reinforced	BS 215-1970 Part-II, IEC 1089-1919
	c	IS 398-1994	Aluminium alloy	BS 3242-1970
		Part-IV	stranded conductor	IEC 1089-1991 ASTM 8393M86
	d)	IS 398-1982 Part-V	Aluminium conduc- tor 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 fo practice for use of structural steel ingeneral building construction	CSA S 16.1 BS 5950
12. a)	IS802-(2015) part 1/section 1	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)	IS802-(2016) (Part-I/ section 2)	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-Part3	Code of practice for use of structural steel in over-head transmission lines towers: testing	ANSI/ASCE 10-90 (1991) (Part III) IEC 652
13 IS 1139-1966		Hot rolled mild steel, medium tensile steel hogh yield strength deformed bars for concrete reinforcements	CAN/CSA G30.18 ASTM A615 and BS 4449
14 IS 1367-1967		Technical conditions for threaded fastners	
15 IS 1489-1976		Portland pozzolana 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	BS-1559-194
18 IS 1786-1966		Cold twisted steel bars for concrete reinforcement	
19 IS 1778-1980		Reels and drum for bare conductor	
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
21 IS 2071 Part-I-1974 Part-II-1974 Part-III-1976		Method of high voltage tesings	IEC 60

22	IS 2121 I. part II. Part-1981	Specification for conductor and earthwire accessories for overhead power lines	
	I. Part-I-1981 II. Part-II-1981 III. Part-III-1992 IV. Part-IV-1991	Armour rods, binding wires and tapes for conductors. Mid-span joints and repair sleeve for conductors. Accessories for earthwire. Non-tension joints.	ASTM D 1 883
24.	IS 2131-1967	Method of standard penetration test for soils.	
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 galvani- sing 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 amend-ment 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/CSG 164 ASTM A153
35.	IS 5613 (Part-II/Sec-1) -1985 (Part-III/Sec.1) -1989	Code of practice for design, installation and maintenance of overhead power lines	ANSI/ASCE 10-90(1991)
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 insu- lators in respect of polluted conditions.	IEC 815-1986
50.		Tests on insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000 Volts.	IEC 383-1993 (Part I and II)
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 Part VI	Mechanical properties and test methods for bolts, screws and studs with full loadability Mechanical properties and test methos for nuts with full laodability	ISO 898-1 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	
63.	IS 2386-1963 (Part-3)	Methods of test for aggregates for concrete : Specific gravity, density, voids, absorption and bulking	
64. 65.	IS 14000-1994	Quality management and quality assurance standards GRIDCO Safety Manual (draft)-1997	ISO 9000-1994
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

SECTION-3
SPECIFICATION FOR DESIGN AND FABRICATION OF SUBSTATION STEEL STRUCTURES

3.1.0 SCOPE

3.1.1 The scope of this section covers specifications for fabrication, proto-assembly, supply and erection of galvanised steel structures for towers, girders, lightning masts and equipment support structures. Towers, girders and lightning masts shall be lattice type structure fabricated from structural steel conforming to IS 2062 (latest). All equipment support structures shall be fabricated from GI pipe conforming to YST 22 or of higher grade as per IS 806.

3.1.2 Support structure for Circuit breaker and Isolators is not standardized and shall be designed by the Contractor and approved by the Employer. Any other structures of 400kV, 220 kV, 132kV and 33kV class necessary to complete the substation to complete the work in all respects shall be designed by the contractor.

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

3.1.4 The connection of all structures to their foundations shall be by base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 0.610 kg/m2 for anchor bolts / foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of levelling.

3.1.5 In case of equipment support structure, Contractor may require to change the dimensions to match the equipment bus bar height and to match the mounting arrangement of a particular equipment. Further suitable modification shall be carried out in the drawings of equipment support structures by the Contractor in order to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the standard structure fabrication drawings. The Contractor will make these changes without any price implication. The final drawings of mounting structures shall be submitted to Employer for approval.

3.2.0 MATERIALS

3.2.1 Structural Steel

The structures shall be of structural steel conforming to any of the grade, as appropriate, of IS 2062 (latest edition) Steel conforming IS 8500 may also be used.

Medium and high strength structural steels with known properties conforming to any other national or international standards may also be used.

3.2.2 Bolts

Bolts used shall conform to IS12427 or bolts of property class 4.6 conforming to IS 6639 may also be used.

High strength bolts, if used (only with steel conforming to IS 8500) shall conform to property class 8.8 of IS 3757.

Foundation Bolts shall conform to IS 5624.

Step bolts shall conform to IS 10238

3.2.3 Nuts

Nuts shall conform to IS 1363 (Part 3). The mechanical properties shall conform to property class 4 or 5 as the case may be as specified in IS 1367 (Part 6) except that the proof stress for nuts of property class 5 shall be as given in IS 12427. Nuts to be used with high strength bolts shall conform to IS 6623.

3.2.4 Washers

Washers shall conform to IS 2016. Heavy washers shall conform to IS 6610. Spring washers shall conform to type Bof IS 3663 Washers to be used with high strength bolts and nuts shall conform to IS 6649.

3.2.5 Galvanisation

Structural members, plain and heavy washers shall be galvanized in accordance with the provisions of IS 4759.

Spring washers shall be hot dip galvanized as per service grade 4 of IS 4759 or IS 1537.

3.2.6 Other Materials

Other materials used in the construction of the supporting structures shall conform to appropriate Indian Standards wherever available.

3.3.0 DESIGN REQUIREMENTS FOR STRUCTURES

3.3.1 This clause and sub-clauses shall be referred only for structures for which design is in the scope of Contractor.

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

3.3.3 For materials and permissible stresses IS:802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

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

ITEM	Minimum thickness in mm
Leg members, Ground wire Peak members/ other load carrying members	6
Other Members and Redundant members	5

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

3.3.6 Minimum distance from hole center to edge shall be 1.5 x bolt diameter. Minimum distance between center to center of holes shall be 2.5 x bolt diameter.

3.3.7 All bolts shall be M16 or higher as per design requirement.

3.3.8 **Step Bolts:** In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on one leg extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to IS: 10238.

3.4.0 Design Parameters

3.4.1 All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per code IS:875, seismic forces as per code IS:1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including “snatch” in the case of bundled conductors etc. Short circuit forces shall be calculated considering a fault level of 40 kA, 50kA, 63kA or as applicable. IEC-60865 may be followed for evaluation of short circuit forces. Lattice type structures are also accepted, however, AEGCL shall have the right to choose any type structure (lattice/pipe) as per requirement during detailed engineering without any price implication.

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

3.4.1.1 Switchyard structures such as columns, beams and equipment mounting structures shall be designed as per IS 802 but for loading combinations specified hereunder. Computation of wind loading on structural members, conductors, insulators, etc and other parameters shall be as specified in IS 802 except otherwise specified in this Specification.

3.4.1.2 The switchyard structures shall be designed for following loads considered acting simultaneously:

(i) Wire tension
(ii) Wind Load
(iii) Short Circuit Forces
(iv) Weight of supported wires, insulators, equipment etc and self-weight of structures.

An additional load of 3000 N shall be considered acting for weight of lineman and tools. For beams this 3000 N load shall be considered acting at middle of the beam.

3.4.1.3 The design shall be checked for following two loading conditions:

3.4.1.4 The design shall be checked for following two loading conditions:

(A) Normal Conditions (all wires intact)

Under this condition, the loads shall be taken as under:

(i) Wire Tension:- Maximum Wire tension as specified in Clause 3.4.3

(ii) Wind Load:- Loads due to 100% Design Wind Pressure (after accounting for drag coefficient and gust factor) on structures,

wires, insulators, equipment etc. Design wind pressure shall be as per Clause 3.4.2

(iii) Short Circuit Forces: Loading due to a 3 phase short circuit current of 63kA, 50kA, 40 kA and 31.5 kA shall be considered for 400kV, 220 KV,132 kV and 33 kV respectively subject to minimum of 10% of maximum wire tension as considered in (i) above.

(iv) Dead Weight:- All dead loads mentioned in Clause 3.4.1.2 (iv) shall be considered. Conductor and shield wire weight shall

L B) BROKEN WIRE CONDITION

Under this condition design shall be checked with all wires broken on one side and load shall be as under:

(i) Wire Tension:- Wire tension for intact wires shall be taken as 100% of Clause 3.4.1.4 (A) (i). For broken wires it shall be taken as zero.

(ii) Wind Load:-Same wind load as calculated in Clause 3.4.1.4 (A) (ii) shall be considered.

(iii) Short Circuit Forces:- Short circuit forces shall be considered only for intact wires.

(i) Dead Weight: - Same dead load as calculated in Clause 3.4.1.4 (A) (iv) shall be considered.cula

3.4.2 Design Wind Pressure

The Design Wind pressure for the purpose of this Specification shall be taken as 793 N/m2. This wind pressure corresponds to Terrain

3.4.3 Wire Tensions

For design purpose tension in each power and shield wires shall be taken as under

a. For Power Conductors

(i) 400/220 kV Switchyard:	10000 N for each conductor between Line gantry and Dead-End Tower of Transmission Line.
	8000 N for each Bus Bar conductor and other jumpers/jack buses.
(ii) 132 kV and 33 kV switchyard:	8000 N for each conductor between Line gantries and Dead-End Tower of Transmission Line.
	6000 N for each Bus Bar conductor and other jumpers/jack buses.

b. For Shield Wires

(i) 400kV, 220 KV,132 kV and 33 kV Switchyard:	6000 N for shield wire between Line gantry and Dead End Tower of Transmission Line.
	5000 N for shield wires at other Location.

Note: Structures with earth peak shall assume to have two earth wires for design purpose in broken wire condition.

3.4.4 Spans

Following Spans shall be considered in design of all structures as applicable:-

a). Line gantries (structures to terminate lines):

(i) For 400, 220, 132, Switchyard: 200 Meter, wind span
150 Meter, weight span

(ii) For 33 KV Switchyard: 75 Meter, wind & weight span.

b). All other Structures

(i) For 400 KV Switchyard: 75 Meter, wind & weight span

(ii) For 220 KV Switchyard: 75 Meter, wind & weight span

(iii) For 132 KV Switchyard: 50 Meter, wind & weight span

(ii) For 33 KV Switchyard: 20 Meter, wind & weight span.

3.4.5 Deviation Angle

The design of line gantries shall only be checked for a maximum deviation angle of 300 from normal at center of gantries to Dead End Tower.

3.4.6 Conductors and Shield Wires

A) Following sizes of power conductors if not otherwise specified in the drawings, shall be used for design of structures:

a). For 400 kV switchyard:- As indicated in layout drawings.

b). For 220 kV switchyard:-

(i) ACSR 'MOOSE' conductor (two conductors per phase) for Drop Downs, Jumpers and Connection Between Equipments.

c). For 132 kV switchyard:-

(i) ACSR 'MOOSE' conductor (two conductors per phase) for Drop Downs, Jumpers and Connection Between Equipments.

d). For 33 kV switchyard:-

(i) ACSR 'PANTHER' conductor (One conductors per phase) for Connections between equipments and outgoing feeder till

the 33kV Outgoing feeder Gantry.

B) For protection against direct lightning G.I. wires of size 7/3.66 mm conforming to IS 2241 shall be considered for all switch yards.

Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 metric tonnes per phase for 400kV, 2 metric tonnes per phase for 220kV and 1 metric tonne per phase for 132 kV or as per requirements whichever is higher . The distance between terminal gantry and dead end tower shall be taken as 200 metres for 400/220kV and 100m for 132KV. The design of these terminal gantries shall also be checked considering +/- 30 deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.

The beams shall be connected with towers/ columns by bolted joints. Wherever luminaries are proposed to be fixed on gantries, the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.

Foundation bolts shall be designed for the loads for which the structures are designed. Height of Lightning masts shall be as per approved structure layout and designed for diagonal wind condition. Lightning masts shall be provided with platforms for mounting lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings. The platforms shall also have protection railing. The details of lighting fixtures would be as per the approved drawings.

3.5.0 DESIGN DRAWINGS AND DOCUMENTS

3.5.1 As and where asked for the relevant drawings for all the towers, beams and equipment mounting structures shall be furnished by the Contractor to the Employer which shall include structural/erection drawings, shop fabrication drawings, Bill of Materials, foundation working drawings.

The structural/erection drawings, Bill of materials and shop fabrication drawings for all the structures shall be submitted in four copies and will be finally approved by the Employer. The fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating structure members correctly lies with the Contractor only and the Contractor shall ensure that all the members can be fitted while erecting without any undue strain on them.

3.5.1.1 The Contractor shall furnish design, drawing and Bill of Materials and shop manufacturing drawings for every member to the Employer for approval after award of the Contract. The design drawing should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case Employer feels that any design drawing, BOM are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the design drawing, BOM as required in the specification.

3.5.1.2 The fabrication drawings to be prepared and furnished by the Contractor shall be based on the design approved by

the Employer. These fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice whether or not given by the Employer. The fabrication drawings shall be submitted to the Employer. Proto shall be made only after approval of fabrication drawings.

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

3.5.1.4 The Mass fabrication work shall start only after the final approval to the proto corrected Fabrication drawing is accorded by the Employer.

3.6.0 ACCESSORIES

3.6.1 Step Bolts

Each column/tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 0.5 meters above the plinth level to the top. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN.

3.6.2 Insulator Strings and Conductor Clamps Attachments

(i) Double suspension and tension insulator string assemblies (for 400kV, 220kV and 132kV) and Single suspension and tension insulator string assemblies (for 33kV) shall be used for jumpering and connection between the equipments.For the attachment of Suspension Insulator string, a suitable strain plate of sufficient thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the insulator string the same shall be supplied by the Contractor.

(ii) At tension points strain plates of suitable dimensions placed on the beams, shall be provided for taking the hooks or D-shackles of the tension insulator strings. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.

3.6.3 Earthwire Clamps Attachment

i. Suspension Clamp

The detailed drawing shall be submitted by the Contractor for Employer's approval. The Contractor shall also supply U-bolts, Dshackles wherever required.

ii. Tension Clamps

Earth-wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.

3.7.0 FABRICATION

3.7.1 The fabrication of substation steel structures shall be in conformity with the following:

(i). Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

(ii). The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

(iii). No angle member shall have the two leg flanges brought together by closing the angle.

(iv). The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

(v). The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

(vi). All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be

permitted in the entire structure.

3.7.2 Drilling and Punching

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

(ii). Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

(iii). Holes must be perfectly circular and no tolerances in this respect are permissible.

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

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

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

3.7.3 Erection mark

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

3.8 FOUNDATION BOLTS

3.8.1 Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

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

3.8.3 All foundation bolts for lattice structure, pipe structure is to be supplied by the Contractor.

3.8.4 All foundation bolts shall be fully galvanised so as to achieve 0.61 kg. per Sq.m. of Zinc Coating as per specifications.

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

3.9.0 GALVANIZING AND PAINTING

3.9.1 Galvanising of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filing, bending and matching are completed. Galvanising shall be done by the hot dip process as recommended in IS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 610 gm per square meter. The preparation for galvanising and the galvanising process itself must not affect adversely the mechanical properties of the treated materials.

3.9.2 All assembly bolts shall be thoroughly hot dip galvanized after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanized, but oiled only.

3.9.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanising test set out in IS 729 or other such authoritative international standards.

3.10 EARTHING

3.10.1 To keep provision in the structures for earthing, holes shall be drilled on two diagonally opposite legs of the towers/columns/mounting structures. The holes shall be suitable for bolting GI strips of size mentioned elsewhere in this specification (Vol II) and shall be such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthing strip.

3.11 TEST AND TEST CERTIFICATE

3.11.1 Each consignment ready for transportation shall be offered to AEGCL for inspection before dispatch giving a minimum time of not less than 30 days. Samples of fabricated structure materials shall be subjected to following tests: -

a. Steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.

b. Galvanising: The galvanising shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanised surfaces shall not be less than 610 gm per square meter.
c. Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

3.11.2 Test at Contractor's Premises

3.11.2.1 The contractor shall fabricate one specimen structure of each type as soon as possible after placement of order and before starting the bulk fabrication of the structures ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design should be suitably modified and the tower re-tested.

3.11.2.2 After the first lot of the structures manufactured, the members forming one structure of each type shall be selected at random from the lots of similar member and assembled in exactly the same manner as to be done at site. The structure then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the structure has been designed.

3.11.2.3 No structure or any member thereof, which failed under the test shall be supplied.

3.12 MODE OF MEASUREMENT

3.12.1.1 The measurement of all lattice and pipe structures for towers, beams, equipment support structure etc. shall be made in numbers for each type of structures. This will include foundation bolts and nuts and therefore no separate payment shall be made for the same. The unit rate quoted for each type of structure shall be inclusive of supply, fabrication, galvanizing, erection, nuts, bolts, wastages etc. complete. Nothing extra shall be payable for substitution necessitated due to non-availability of section. Nothing extra shall be payable for modifications or steel added to suit the contractors fixing arrangements for accessories etc.

SECTION-4
SPECIFICATION FOR DESIGN AND FABRICATION OF TRANSMISSION LINE TOWERS

4.1.1.0 SCOPE

4.1.1.1 This section covers the design, fabrication, galvanizing, supply and delivery, erection, testing and commissioning at site of galvanized steel structures, bolts & nuts, tower accessories etc. for transmission line towers covered under this Bid Document and as per Specification.

Single circuit stringing shall be made possible in the Double circuit towers for any voltage level.

4.1.2.0 GENERAL DESCRIPTION OF THE TOWER

4.1.2.1 General

4.1.2.1.1 The towers shall be of self-supporting hot dip galvanized lattice steel type designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.

4.1.2.1.2 The tower shall be fully Galvanised using mild steel or / and high tensile steel sections. Bolts and nuts with spring washer are to be used for connections.

4.1.2.2 Type of Towers

4.1.2.2.1 Normal Towers

The towers for transmission lines are classified as given below. The bidder shall design and quote for the following four types of towers (Standard/Standard Towers):

Tower type D shall also be used as a Dead-End tower.

Type of Tower	Deviation Limit	Typical Use
A	0 – 2 deg.	To be used as tangent tower with single or Double suspension Insulator String
B	2 - 15 deg.	a) Angle towers with Single / Double Tension insulator string.
C	15 - 30 deg.	a) Angle tower with single or /and double tension insulator string.
		b) Also to be used for locations where uplift exist. c) Section tower for anti cascading condition.
D	30 - 60 deg/ Dead End.	a) Angle tower with Single or / and Double tension insulator string.
		b) Also to be used for locations where uplift exist.
		c) Dead end with 0 deg. to 15 deg. deviation both on line side and sub station side (slack span)

Dead End. a) Angle tower with Single or / and Double tension insulator string.

b) Also, to be used for locations where uplift exist.

c) Dead end with 0 deg. to 15 deg. deviation both on line side and sub station side (slack span)

The angles of line deviation specified are for the design span. The span may however be increased up to an optimum limit with reduced angle of line deviation if adequate ground and phase clearances are available. For this purpose, the Contractor shall prepare a tower rating chart (weight/wind span as function of various angles of deviations).

4.1.2.2.2 Body Extensions Truncations & Unequal Leg Extensions Truncations

a) All Normal towers mentioned in Clause above shall be designed for 3, 6, 9, 12, 15- and 18-meter body extensions for maintaining adequate ground clearance as per the terrain, without reducing the safety margins available in normal towers in any manner. Towers which require more than 18 m extension shall be treated as Special Towers.

b) All above extensions to normal towers shall be treated as part of normal towers only.

c) Prices shall be quoted as per weight (in MT) basis on the guaranteed black weight of towers.
d) Designs and drawings of all type of towers with extensions as mentioned in (a) above along with foundations (all type) shall be submitted for approval of the employer irrespective of whether such requirements are there or not for a particular transmission line.
e) Attached as ANNEXURE

4.1.2.2.3 Special Towers

The towers which will be specially designed for very long spans such as Major River crossings etc. that cannot be crossed by normal tower with extensions shall be special towers.
The Bidder must furnish design of each of these special towers for approval of the Employer. The Contractor shall quote for these towers separately at unit rates by weight per MT of super structure and fittings and will supply the same if so required.

4.1.3.0 SPANS AND CLEARANCES

4.1.3.1 Normal span, Wind Span & Weight Span

The normal ruling span, wind span and weight span to be adopted for lines covered under this Specification are specified in Annexure-1 of this section along with all other parameters.

4.1.3.2 Electrical Clearances

4.1.3.2.1 Ground Clearance

a) The minimum ground clearance of conductors above ground shall not be less than the limits specified in Line Data at Annexure I, at a conductor temperature of 95°C (for AAAC conductors) and 85°C (for ACSR conductors) and in still air. However, to achieve the above clearance the standard tower heights include the following additional allowances:
b) 150 mm sag errors in stringing;
c) Conductor creep as calculated by over tensioning the conductor at a temperature of 30°C lower than the stringing temperature or as determined from the sag-tension tables, which include the final sags including the effects of creep.

4.1.3.2.2 Clearances of live parts form cross arm & towers

The minimum clearances shall be adopted from the following Table.

SL No	**Item**	**Swinging in degrees**	**Minimum electrical clearances for line voltage 132 kV**	**Minimum electrical clearances for line voltage 220 kV**	**Minimum electrical clearances for line voltage 400 kV**
1	SUSPENSION STRINGS				
	(a) Single suspension				
	string	Nil	1530	2130	3050
		15°	1530	1980	3050
	(in mm)	30°	1370	1830	1860
		45°	1220	1675	-
		60°	1070	-	-
	(b) Double suspension	Nil			3050
	(c) Pilot Insualtor	15°	1530	2130	3050
2	Tension string	Nil	1530	2130	3050
	Single/ Double				
3	Jumper	Nil	1530	2130	3050
		10°	1530	2130	3050
		20°	1070	1675	1860
		30°	1070	1675	-

4	Min vertical distance between conductor or X-arm (single/double circuit) (in mm)		3900	4900	8000
5	Min horizontal distance between conductors (single/ double circuit)(in mm)		6800	8400	15000
6	Mid span clearance (in mm)		6100	8500	9000
7	Ground Clearance (in mts)		6.1	7.015	8.84

4.1.3.2.3 Railway Crossings, etc

For railway crossing the clearances from the lowest conductor points to the rail level shall not be less than what is required to comply in all respects with the "Regulation governing the placing of transmission lines across railway tracks" issued by the railway board. In case of trunk road crossings, the clearance from the lowest conductor point to road level shall not contravene the provision of IE rules. Power and Tele-communication line crossings are to be constructed strictly in accordance with provision of IE Rules.

4.1.4.0 DESIGN DRAWINGS

4.1.4.1 The relevant drawings for all the towers and their extension shall be furnished by the Contractor to the Employer which shall include structural/erection drawings, shop fabrication drawings, Bill of Materials, foundation working drawings.

4.1.4.2 The structural/erection drawings, Bill of materials and shop fabrication drawings for all the towers and their extensions shall be submitted as specified in this Bid document. Documents shall be submitted in four copies and will be finally approved by the Employer. The mass/fabrication shall be taken up from the approved shop drawings. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be fitted while erecting without any undue strain on them.

4.1.4.3 The tower accessories drawings like name plate, danger plate, phase plate, anti climbing device, step bolt, D-shackle etc. shall also be prepared by the Contractor and shall be submitted to the Employer, in three copies, along with one reproducible, for record. These drawings shall be prepared in A4 size only.

4.1.4.4 All the drawings shall 'have a proper name plate clearly displaying the name of “Assam Electricity Grid Corporation Ltd ” on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also, all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing: **WARNING: THIS IS PROPRIETARY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH AEGCL. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE EMPLOYER IN WRITING.**

4.1.4.5 While submitting the structural drawings, bill of materials and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing Bid Reference No., Name of the transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies. The Contractor shall be required to submit 15 copies of all relevant drawings for necessary distribution.

4.1.5.0 SLENDERNESS RATIO

4.1.5.1 Slenderness ratio for members shall be computed in accordance with Clause 10 of IS: 802. The limiting values of L/R shall be as follows:

(a) Leg members, G.W. peak and cross arm lower member: 150

(b) Bracings: 150

(c) Redundant members and those carrying nominal stress: 250

(d) Tension member: 400

4.1.6.0 CONDUCTOR CONFIGURATION

4.1.6.1 In case of the double circuit line, the six power conductors shall be square type of formation. For, single circuit stringing on D/C towers, the three power conductors shall be in vertical line formation on one side, at distances suiting to the specified clearance requirements. Earth wire/OPGW shall be provided above the conductors at suitable distance to offer effective shielding and safe clearance.

4.1.7.0 HEIGHT AND LOCATION OF GROUND WIRES

4.1.7.1 Provision of single earth wire / ground wire shall be made in the design of the towers. The height and location of the ground wires will be such that the shield angle is not greater than 30 degrees and 20 degrees for 132KV/ 220 KV and 400 KV respectively (twin peak).

4.1.7.2 The mid-span clearance between the earth wire and conductors shall be kept more than the clearance at the tower. The Contractor shall maintain the sag of the ground wire at least 10 percent less than that of the power conductor under all temperature conditions in still wind at the normal spans so as to give a mid span separation greater than that at the supports.

4.1.8.0 LOADS ON TOWERS

4.1.8.1 The tower members shall be designed for three conditions of loadings. The conditions with their combinations of loadings are as follows:

A) **Reliability Condition (Normal Condition)**

i) Transverse Loads as per as per IS-802-2015, Part 1, sec 1
ii) Vertical Loads as per per IS-802-2015, Part 1, sec 1
iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

B) **Security Condition (Broken wire condition)**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1
ii) Vertical Loads as per IS-802-2015, Part 1, sec 1
iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

C) **Safety Condition (Construction and Maintenance)**

a) **Normal Condition**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1
ii) Vertical Loads as per IS-802-2015, Part 1, sec 1
iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

b) **Broken Wire Condition**

i) Transverse Loads as per IS-802-2015, Part 1, sec 1
ii) Vertical Loads as per IS-802-2015, Part 1, sec 1
iii) Longitudinal Loads as per IS-802-2015, Part 1, sec 1

4.1.8.2 Transverse Loads: Reliability Condition (Normal Condition)

Under these following loads shall be taken into account:

a) Wind Load on Conductor and Ground Wire:

This shall be calculated by taking the basic wind pressure be acting normal to the line.

b) Wind Load on Insulator String:

Wind load on insulator strings shall be determined from the attachment point to the centre line of the conductor in case of suspension towers and up to the end of clamp in case of tension towers. The Design wind pressure shall be considered acting on 50% area of insulator string projected on a plan, which is parallel to the longitudinal axis of the string.

c) Wind Load on Towers:

This shall be calculated considering the wind to be acting normally on face of the tower.

d) Transverses Loads from Mechanical Tension of Conductors and Ground Wire (Due to line deviation):

This is the component of conductor/ground wire tension at tower acting in the transverse direction of the line. In calculating this force; the conductor/ground wire tension is either the tension at every day temperature (32˚C) &100% of full wind pressure or the tension at minimum temperature and 36% of full wind pressure whichever is more.

4.1.8.3 Transverse Loads: security condition

a) **Suspension Towers**

i. Transverse loads due to wind acting on tower structure, conductors, ground wires and insulators shall be taken as nil.

ii. Transverse loads due to line deviation shall be based on component of mechanical tension of conductors and ground wires corresponding to everyday temperature and nil wind condition. For broken wire the component shall be corresponding to 75% of mechanical tension of conductor and 100% of mechanical tension of ground wire at every day temperature and nil wind.

b) **Tension and Dead-End Towers**

i. Transverse loads due to wind action on tower structure, conductors, ground wire and insulators shall be as per Clause: 4.1.8.2 (a) and (b) 60% wind span shall be considered for broken wire and 100% for intact wires.

ii. Transverse loads due to line deviation shall be the component of 100% mechanical tension of conductor and ground wire as defined in Clause: 4.1.8.2 (d).

4.1.8.4 Transverse Loads: safety condition

a) **Normal Condition: -- Suspension, Tension and dead-End Tower**

i) Transverse loads due to wind action on tower structure, conductors ground wires and insulators shall be taken as nil.

ii) Transverse loads due to mechanical tension of conductor or ground wire shall be calculated in same manner as in Clause: 4.1.8.2 (d) but with tension corresponding to everyday temperature and nil wind.

b) **Broken Wire Condition: -- Suspension, Tension and dead-End Tower**

i) Transverse loads due to wind action on tower structure, conductors, ground wire, insulators shall be taken as nil.

ii) Transverse load due to mechanical tension of conductor or ground wire on account of line deviation shall be taken as follows:

$$TM = TI \times \sin \varphi/2, \text{ where,}$$

Where, TM = Load

TI = 50% of tension of conductor and 100% of tension of ground wire at everyday temperature and nil wind for suspension tower and 100% for angle and dead-end towers for both conductor and ground wire.]

Φ = Angle of deviation of tower.

4.1.8.5 Vertical Loads: Reliability Condition (normal condition)

i) Loads due to weight of each conductor and ground based on appropriate weight span, weight of insulator strings and accessories.

ii) Self weight of structures up to tower panel under consideration.

4.1.8.6 Vertical Loads: Security Condition

i) Loads due to weight of each conductor or ground wire based on appropriate weight span, weight of insulator strings and accessories taking broken wire condition where the load due to weight of broken conductor/ground wire shall be considered as 60% of weight span. For intact wire the vertical load shall be considered as given in Clause: 4.1.8.5.

ii) Self weight of structures up to tower panel under consideration.

4.1.8.7 Vertical Loads: Safety Condition

(i) Same as Clause 4.1.8.6 (i) multiplied by overload factor of 2.0

(ii) Same as Clause 4.1.8.6 (ii).

(iii) A load of 1500 N shall be considered acting at each cross-arm tip as a provision for weight of line man with tools.

(iv) An additional load of 3500 N at cross arm tip.

(v) All bracings and redundant members of the towers which are horizontal or inclined up to 150 from horizontal shall be designed to withstand as ultimate vertical load of 1500 N considered as acting at centre, independent of all other loads.

4.1.8.8 Longitudinal Loads: Reliability Condition

A) **Suspension and Tension Towers**

i) Longitudinal loads for Suspension and Tension towers shall be taken as nil.

ii) Longitudinal loads which might be caused on tension towers by adjacent spans of unequal length shall be neglected.

B) **Dead End Tower**

i) Longitudinal loads for Dead End Towers shall be considered corresponding to mechanical tension of conductors and ground wires at every day temperature & design wind pressure or at minimum temperature with 36% of design wind pressure, whichever is more stringent.

4.1.8.9 Longitudinal Loads: Security Condition

A) **Suspension Towers**

The longitudinal loads corresponding to 50% of the mechanical tension of conductor and 100% of mechanical tension of ground wire shall be considered under everyday temperature and no wind pressure for broken wire only.

B) **Tension Towers**

Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 4.1.8.8 (B) for broken wires. For intact wires these loads shall be considered nil.

C) **Dead End Towers**

Horizontal loads in longitudinal direction due to mechanical tension of conductors and ground wire shall be taken for loading criteria mentioned in Clause: 4.1.8.8 (B) for intact wires; however, for broken wires these loads shall be considered nil.

4.1.8.10 Longitudinal Loads: Safety Condition

A) **Normal Condition**

i) **Suspension and Tension Towers**

These shall be taken as nil.

ii) **Dead End Towers**

These loads for Dead End towers shall be considered as corresponding to mechanical tension of conductors/ground wire at every day temperature and nil wind. Longitudinal loads due to unequal spans may be neglected.

B) **Broken wire Condition**

i) Longitudinal loads during construction simulating broken wire condition will be based on stringing of one earth wire or one complete phase conductor at one time.

ii) **Suspension Towers**

Longitudinal loads during stringing on suspension towers should be normally imposed only by the passing restriction imposed during pushing of the running block through the sheave. It will apply only on one complete phase of sub-conductor or one earth wire. It will be taken as 10000 N per sub-conductor or 5000 N per earth wire.

iii) **Tension and Dead-End Tower**

Angle Towers used as dead end during stringing simulating broken wire condition shall be capable of resisting longitudinal loads resulting from load equal to twice the sagging tension (sagging tension is 50% of the tension at every day temperature and nil wind) for one earth wire or one complete phase sub- conductors which is in process of stringing. At other earth wire or conductor attachment points for which stringing has been completed, loads equal to 1.5 times the sagging tension will be considered.

4.1.8.11 Anti Cascading Checks

i) All angle towers shall be checked for the following anti-cascading conditions with all conductors and G.W. intact only on one side of the tower.

ii) Transverse Loads:- These loads shall be taken under no wind condition.

iii) Vertical Loads:- These loads shall; be the weight of conductor/ground wire intact on one side of tower, weight of insulator strings and accessories.

iv) Longitudinal Loads:- These Loads shall be the pull of conductor/ground wire at every day temperature and no wind applied simultaneously at all points on one side with zero-degree line deviation.

4.1.8.12 BROKEN WIRE CONDITIONS

A) **SINGLE CIRCUIT TOWERS**

Any one-phase conductor or earth wire broken, whichever is more stringent for a particular member.

B) **DOUBLE CIRCUIT TOWERS**

i) **SUSPENSION TOWERS**

Any one phase conductor or earth wire broken, whichever is more stringent for a particular member.

i) **ANGLE TOWERS, TYPE-B & C**

Any two phases broken on the same side and same span or any one phase and one ground wire broken on the same side and same span whichever combination is more stringent for a particular member.

ii) ANGLE TOWERS, TYPE-D (Dead End Tower)

Any three phases broken on the same side and same span or any two phases and one ground wire broke on the same side and same span whichever combination is more stringent for a particular member.

4.1.9.0 DESIGN WIND PRESSURE

4.1.9.1 Design Wind Pressure for the purpose of this Specification shall be taken as 793 N/m2 which corresponds to wind velocity at 10 m height. For Design Wind Pressure at other heights reference shall be made to IS: 802 or 'Transmission Line Manual' published by Central Board of Irrigation and Power, New Delhi. The Design Wind Pressure mentioned above is corresponds to Wind Zone-5, Reliability Level-1 and Terrain Category-2 as per IS: 802.

4.1.10.0 OTHER DESIGN PARAMETERS

4.1.10.1 For other design parameters to be adopted for the design of towers reference shall be made to Annexure I of this Specification.

4.1.11.0 MATERIALS

4.1.11.1 Tower Steel Sections

4.1.11.1.1 IS Steel Sections of tested quality of conformity with IS:2062 (Designated Y.S. 250 MPa) or/and IS:8500 (Designated Y.S. 350 Mpa) are to be used in towers, extensions and stub setting templates. The Contractor can use other equivalent grade of structural steel angle sections and plates conforming to International Standards (IS-802(2015/P1 to 3) - Code of practice for use of structural steel in overhead transmission line towers). However, use of steel grade having designated yield strength more than that of EN 10025/BS-4360-50B grade (355MPa) is not permissible.

4.1.11.1.2 Steel plates below 6mm size exclusively used for packing plates/packing washers produced as per IS: 1079 (Grade -0) are also acceptable. However, if below 6mm size plate are used as load bearing plates viz gusset plates, joint splices etc. the same shall conform to IS: 2062 / BS : 4360 or equivalent standard meeting mechanical strength/metallurgical properties corresponding to Fe-410 or above grade (designated yield strength not more than 355MPa), depending upon the type of grade incorporated into design. The chequered plates shall conform to IS: 3502.

4.1.11.1.3 For designing of towers, preferably rationalized steel sections have been 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 to Employer and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Employer before any substitution.

4.1.11.2 Fasteners: Bolts, Nuts and Washers

4.1.11.2.1 All bolts and nuts shall conform to 18-12427. All bolts and nuts shall be galvanized as per IS: 1367 (Part-13)/18:2629 and shall have hexagonal head and nuts, the heads being forged out of the solid truly concentric, and square with the shank, which must be perfectly straight.

4.1.11.2.2 The bolt shall be of 16/24 mm diameter and of property class 5.6 as specified in IS: 1367 (Part-III) and matching nut of property class 5.0 as specified in IS: 136: (Part-VI).

4.1.11.2.3 Bolts up to M 16 and having length up to 10 times the diameter if the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 31 0 MPa minimum as per IS: 12427. Bolts should be provided with washer face in accordance with 18:1363 (Part-I) to ensure proper bearing.

4.1.11.2.4 Nuts should be double chamfered as per the requirement of IS: 1363 Part-II'. It should be ensured by the manufacturer that nuts should not be overlapped beyond 0.4MM oversize on effective diameter for size up to M 16.

4.1.11.2.5 Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.

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

4.1.11.2.7 Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electrogalvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5mm for 24mm bolt.
4.1.11.2.8 To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.
4.1.11.2.9 The bolt positions in assembled towers shall be as per structural drawing.
4.1.11.2.10 Bolts at the joints shall be so staggered that nuts shall be tightened with spanners without fouling.
4.1.11.2.11 To ensure effective in-process Quality control it is essential that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The manufacturer should also have proper Quality Assurance System which should be in line with the requirement of this 5pecification and IS: 14000 series Quality System Standard

4.1.12.0 TOWER ACCESSORIES
4.1.12.1 Arrangement shall be provided for fixing of all tower accessories to the tower at a height between 2.5 meters and 3.5 meters above the ground level.
4.1.12.2 Step Bolts & Ladders
4.1.12.2.1 Each tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top of the tower. The step bolt shall be fixed-on one leg up to waist level and on two diagonally opposite legs above waist level up to top of the towers. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of with standing a vertical load not less than 1.5 KN.
4.1.12.2.2 For special towers, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 2.5m to 30m height of super structure step bolts shall be provided. Suitable platform using 6mmthick perforated chequered plates along with suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm tip and the ground wire support shall also to be provided. The platform shall be fixed on tower by using counter-sunk bolts.
4.1.12.3 Insulator Strings and Earth wire Clamps Attachments
4.1.12.3.1 Single / Double suspension insulator string assemblies shall be used for 'A' type tower as required. For the attachment of Suspension Insulator string, a suitable strain plate of sufficient thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the 1nsulator string the insulator string the same shall be supplied by the Contractor.
4.1.12.3.2 At tension towers strain plates of suitable dimensions placed on the underside of each cross-arm tip, shall be provided for taking the hooks or D-shackles of the tension insulator strings. Full details of the attachments shall be provided to the successful bidder. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the Contractor.
4.1.12.3.3 All important crossing like Railway Tracks, Important Roads, Rivers or any other Crossings of similar nature shall be done with Double Insulator String.

4.1.12.4 Earth wire Clamps Attachment
4.1.12.4.1 Suspension Clamp
The detailed drawing shall be submitted by the Contractor for Employer's approval. The Contractor shall also supply U-bolts, D-shackles wherever required.
4.1.12.4.2 Tension Clamps
Earth wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The contractor shall also supply the U-bolts wherever required and take Employer's approval for details of the attachments before the mass fabrication.
4.1.12.5 Anti-climbing Device
Barbed wire type anti climbing device, as per IS 5613 shall be provided and installed by the Contractor for all towers. The barbed wire shall conform to IS-278 (size designation A 1). The barbed wires shall be given chromatin dip as per procedure

laid down in IS: 160.

4.1.12.6 Danger, Number and Phase plate

Danger Plates, Number plates and phase plates shall be provided and installed by the Contractor.

a) Each tower shall be fitted with a danger plate, number plate and a set of phase plates. The transposition tower should have the provision of fixing phase plates on both the transverse phases.

b) The letters, figures and the conventional skull and bones of danger plates shall conform to IS-2551 and shall be in a signal red on the front of the plate.

c) The corners of the danger, number and circuit plates shall be rounded off to remove sharp edges.

d) The letters of number and circuit plates shall be red enameled with white enameled background.

4.1.12.7 Aviation Requirements

Aviation requirements, if indicated separately in Schedule of Requirements shall be in the scope of the Contractor and the same shall conform to IS: 5613.

4.1.13.0 TOWER FABRICATION

4.1.13.1 The fabrication of towers shall be in conformity with the following:

4.1.13.1.1 Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

4.1.13.1.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

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

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

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

4.1.13.1.6 All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

4.1.13.1.7 Minimum Thickness of Tower Members:

The minimum thickness of galvanised and painted tower members shall be as follows: -

ITEM	Minimum thickness in mm	
	Galvanised	Painted
Leg members & lower members of cross arms in compression	5	6
Other members	5	5

4.1.13.1.8 No tower angle member shall be less than 45x45x5 mm

4.1.13.2 Drilling and Punching

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

4.1.13.2.2 Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

a) Holes must be perfectly circular and no tolerances in this respect are permissible.

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

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

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

4.1.13.3 Erection mark

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

4.1.13.3.2 Erection Mark shall be A-BB-CC-DDD

A = Employer's code assigned to the Contractors -Alphabet

BB = Contractor's Mark-Numerical

CC = Tower Type Alphabet.

DDD= Number mark tube assigned by Contractor -Numerical.

4.1.14.0 QUANTITIES AND WEIGHTS

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

i) Basic Body.

ii) Body Extensions.

iii) Stubs & Cleats

iv) Bolts & Nuts including spring washers and step bolts etc.

During detail engineering, proto assembly of each of the above items shall be inspected, Tested and approved by AEGCL and subsequently shall be released for fabrication and manufacturing as per the Technical Specification by the Contractor.

4.1.15.0 WEIGHTS OF TOWER

4.1.15.1 The Bidder shall furnish the guaranteed weights of each type of tower and stubs. The weight of tower shall mean the weight of tower, calculated by using the standard sectional weights of all steel members of the sizes indicated in the approved fabrication drawings and bill of materials without taking into consideration the reduction in weight due to drilling of bolt holes, skew cuts, chamfering etc. or increase in weight due to galvanizing but taking into considering the weight of the special fillings, bolts, nuts, washers etc.

4.1.15.2 After award of the contract, the bidder shall submit to the Employer for its approval, detailed design calculations and drawings for each type of tower. In case, the weight of the tower, finally approved and accepted by the Employer on the basis of the designs and drawings so submitted is more than the guaranteed weight, no extra amount shall be paid to the contractor.

4.1.15.3 If, however, the weight of the finally approved and adopted tower is less than the guaranteed weight, the payment shall be made on the basis of the finally accepted weights only.

4.1.15.4 The contractor, while designing towers, shall use only such sizes of steel structures, which are easily procurable. If for any reason, the sections approved are not easily procurable, it is the responsibility of the contractor to procure the alternative sizes, which are satisfactory from the point of view of design, fabrication, galvanising and supply the same at no additional cost. The finally accepted weight shall mean the weight of each type of tower, design of which has been accepted.

4.1.16.0 STUB TEMPLATE

4.1.16.1 Stub templates shall be designed, and the Bidder shall quote unit rate for each type of tower. These stub templates shall be painted with two coats of red-oxide zinc chromate primer as per relevant IS.

4.1.17.0 GALVANIZING AND PAINTING

4.1.17.1 Galvanizing and painting of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filing, bending and matching are completed. Galvanizing shall be done by the hot dip process as recommended in IS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 900 gm per square meter (130 microns). The preparation for galvanizing and the galvanizing process itself must not affect adversely the mechanical properties of the treated materials.

4.1.17.2 All assembly bolts shall be thoroughly hot dip galvanized after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanized, but oiled only.

4.1.17.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanising test

set out in IS 729 or other such authoritative international standards.

4.1.17.4 The portion of the stub angle from 150 mm below the plinth level shall be black and the remaining portion shall be galvanised.

4.1.17.5 The parts, which are to be painted, shall be thoroughly cleaned. Two coats of a good quality primer shall be applied to produce a smooth void less surface before applying one coat of approved quality aluminium paint at works. The final coating of aluminium paint shall be applied after erection at site.

4.1.18.0 EARTHING

4.1.18.1 To keep provision in the towers for earthing, two holes of 17.5 mm diameter and about 50 mm apart shall be drilled on each of the legs of the towers, such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthing strip.

4.1.19.0 TEST AND TEST CERTIFICATE

4.1.19.1 Each consignment ready for transportation shall be offered to the Employer for inspection before dispatch. Samples of fabricated tower materials shall be subjected to following tests: -

a. Tower steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.

b. Galvanising: The galvanizing shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanized surfaces shall not be less than 900 gm per square meter (130 microns).

c. Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

4.1.19.2 Test at Contractor's Premise:

The contractor shall fabricate one specimen tower of each type as soon as possible after placement of order and before starting the bulk fabrication of the towers ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design should be suitably modified and the tower re-tested.

After manufacture of first lot, finished members forming each type of towers shall be selected at random and tested for quality. The tower then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the tower has been designed.

No tower or any member thereof, which failed under the test shall be supplied. No tests need to be carried out on the special towers and the 3 meter and 6 meter extensions. As such, they shall be very carefully designed on the basis of the results of the other types of towers.

If desired by the Employer, destruction test on towers shall be conducted. The Employer reserves the right to witness any and all of the tests carried out as above and so should be given 30 days advance notice of the dates on which such tests are scheduled to be carried out.

4.1.20.0 LIST OF STANDARDS AND GUIDES

List of Indian Standards and other related Publications

Sl. No	Indian Standards	Title
1	IS: 209-1992	Specification for Zinc
2	IS 278-1991	Galvanised Steel Barbed wire
3	IS 800-1991	Code of Practice for Steel in General Building Construction.
4	IS: 802 - 2015 (Part1, 2,3)	Code of Practice for use of Steel in Overhead Transmission Line
5	IS: 808-1991	Dimensions for Hot Rolled
6	IS: 875-1992	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures

Sl. No	Indian Standards	Title
7	IS: 1363-1990	Coe of Practice for Design Loads (other than Earthquakes) for Buildings and Structures
8	IS: 1367-1992	Technical Supply Conditions for Threaded Steel/ Fasteners
9	IS: 1477-1990	Code of practice for Painting of Ferrous Metals in Buildings
10	IS: 1573-199	Electro-Plated Coatings of zinc on iron and Steel
11	IS: 1852-1993	Rolling and Cutting Tolerances of Hot Rolled Steel Products
12	IS-1893-1991	Criteria for Earthquake Resistant Design of Structures
13	IS: 2016-1992	Plain Washers ISO/R887
14	IS:2062-1992	Steel for general structural purposes
15	IS: 2074-1992	Ready Mixed Paint. Air Drying Red Oxide, Zinc Chrome, Red Oxide, Zinc Chrome Priming Specification
16	IS:2551-1990	Danger Notice Plates
17	IS: 2629-1990	Recommended Practice for Hot Dip Galvanizing of iron and steel
18	IS: 2633-1992	Method of Testing Uniformity of Coating of Zinc Coated Articles
19	IS: 3043-1991	Code of Practice for Earthing
20	IS: 3063-1994	Single coil Rectangular section Spring Washers for Bolts, Nuts Screws
21	IS:3757-1992	High Strength Structural Bolts
22	IS: 4759-1990	Specification for Hot zinc coatings on structural steel and other Allied products
23	IS: 5369-1991	General Requirements for Plain Washers
24	IS:5613-1993	Code of Practice for Design installation and Maintenance of overhead Power Lines
25	IS:6610-1991	Specification for Heavy Washers for Steel structures
26	IS: 6623-1992	High Strength Structural Nuts
27	IS: 6639-1990	Hexagon Bolts for Steel Structure
28	IS: 6745-1990	Method for Determination of weight of Zinc coated iron and Steel Articles
29	IS: 8500-1992	Specification for Wieldable Structural Steel (Medium & High Strength Qualities)
29	IS: 10238-1989	Step Bolts for Steel Structures
30	IS: 12427-1988	Bolts for transmission Line Towers
31		Indian Electricity Rules
32	Publication No.19 (N)700	Regulation for Electrical Crossing of Railway Tracks
33	CBIP Publication No-	Transmission Line Manual

Annexure I

1.1.1 Basic System Data for Transmission Lines

SL. No	Description	132 KV	220 KV	400 KV
I	II	III	IV	V
1.	Nominal system voltage KV rms	132	220	400

SL. No	**Description**	**132 KV**	**220 KV**	**400 KV**
I	**II**	**III**	**IV**	**V**
2.	Highest system voltage KV rms	145	245	420
3.	System of grounding	Solidly Grounded	Solidly Grounded	Solidly Grounded
4.	Impulse insulation level KV peak	650	1050	1425
5.	Power frequency withstand (wet) KV rms	260	460	650
6.	Protective shielding angle against direct lightning	NOT EXCEEDING 30^0	NOT EXCEEDING 30^0	NOT EXCEEDING 20^0
7.	Creepage Distance	27 mm/ KV	27 mm/ KV	27 mm/ KV
8.	Minimum Corona extinction voltage at 50Hz AC system Dry condition (phase to earth)	Not less than 154 kV	Not less than 156 kV	Not less than 320 kV
9.	Accessories for conductor and Earth wire	i. Preformed armour rods ii. Mid-Span compression joints iii. Repair sleeves iv. Flexible copper bonds v. Vibration dampers vi. Suspension clamps for earth wire vii. Tension clamp for earth wire		
10	Insulator String Hardware	i. Anchor shackle ii. Chain link iii. Yoke plate iv. Ball clevis v. Arcing horn holding plate vi. Socket clevis vii. Arcing horns viii. Clevis eye ix. Free centre type/armour grip suspension clamp for suspension strings x. Compression type dead end clamp xi. Balancing weight		

1.1.2 Basic Design Parameters for 132KV TL

Item	**Particulars**	**132 kV Line (Single/double-3phase) with AAAC**
1. SPAN	(i) Normal span (Design Span)	335 M
	(ii) Wind span	335 M

Item	**Particulars**	**132 kV Line (Single/double-3phase) with AAAC**	
	(iii) Weight span, both span (total)	Suspension	Tension
	a) Maximum	505 M	505 M
	b) Minimum	185 M	0 M
	(iv) Weight span, one span	Suspension	Tension
	a) Maximum	315 M	315 M
	b) Minimum	100 M	-200 M
2.Temparature Range		Conductor	Earth Wire
	(I) Maximum	85^0C	53^0C
	(ii) Minimum	0^0C	0^0C
	(iii) Every Day	32^0C	32^0C
3. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. Conductor	(i) Material	AAAC Panther	
	(ii) Number of strands & size	37/3.15 mm	
	(iii) No. of conductor per phase	1	
5.Ground Wire	(i) Type	OPGW	
	(ii) Size	7 / 3.15 mm	
	(iii) No. of earth wire	1	
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2	
8.Ground Clearance (Under maximum sag)	(i) Rough country	6100 mm plus sag corrections	
	(ii) Across and along all roads and paths	6100 mm Plus sag corrections & allowances	
9. Insulators	(i) Type	Ball & Socket Type (16 mm for 90 kN disc &20 mm for 120 kN disc) / Long rod porcelain insulators	
	(ii) Size of disc	255mm x 145 mm / as per IS 2486, IEC: 60120	
	(i) Number of disc in each insulator		
	(a) Suspension	9 no.	
	(b) Tension	10 no.	
	(ii) Electro-mechanical strength		
	(a) Suspension	90 kN	
	(b) Tension	120 kN	
10. Tension Limits	(a) For conductor and ground wire	25 % of UTS	
	(i) at 32^0 C &no wind	70 % of UTS	
	(ii) at 32^0 C &full wind	70 % of UTS	
	(iii) at 0^0 C &36% of full wind		

1.1.3 Basic Design Parameters for 220 KV TL

Item	Particulars	**220 kV Line (Single/double- 3phase) with AAAC/ACSR**	
1. SPAN	(i) Normal span (Design Span)	350 M	
	(ii) Wind span	350 M	
	(iii) Weight span, both span (total)	Suspension	Tension
	c) Maximum	525 M	525 M
	d) Minimum	200 M	0 M
	(iii) Weight span, one span	Suspension	Tension
	c) Maximum	315 M	315 M
	d) Minimum	100 M	-200 M
2. TEMPARATURE RANGE	(I) Maximum	85^0C	
	(ii) Minimum	0^0C	
	(iii) Every Day	32^0C	
3. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. CONDUCTOR	(iv) Material	AAAC	
	(v) Number of strands & size	37/4.00 mm	
	(vi) No. of conductor per phase	1	
5. GROUND WIRE	(iv) Type	OPGW	
	(v) Size	7 / 3.15 mm	
	(vi) No. of earth wire	1	
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2	
8.GROUND CLEARANCE (Under maximum sag)	(i) Rough country	7000 mm plus sag corrections	
	(ii) Across and along all roads and paths	7000 mm Plus sag corrections & allowances	
9. INSULATORS	(i) Type	Ball & Socket Type (20 mm) / Porcelain long rod insulator	
	(ii) Size of disc	255mm x 145 mm/ as per IS 2486 / IEC: 60120	
	(iii) Number of disc in each insulator		
	(c) Suspension	14 no.	
	(d) Tension	15 no.	
	(iv) Electro-mechanical strength		
	(c) Suspension	90 kN	
	(d) Tension	120 kN	

Item	Particulars	**220 kV Line (Single/double- 3phase) with AAAC/ACSR**
10. Tension Limits	(b) For conductor and ground wire (iv) at 32^0 C & no wind (v) at 32^0 C & full wind (vi) at 0^0 C & 36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

1.1.4 Basic Design Parameters for 400 KV TL

Item	Particulars	**400 kV Line (Single/double- 3phase) with ACSR/AAAC**	
1. SPAN	(i) Normal span (Design Span)	400 M	
	(ii) Wind span	400 M	
	(iii) Weight span, both span (total) e) Maximum f) Minimum	Suspension	Tension
		600 M 200 M	600 M 0 M
	(iii) Weight span, one span e) Maximum f) Minimum	Suspension	Tension
		360 M 120 M	360 M -360 M
2. TEMPARATURE RANGE	(I) Maximum	85^0C	
	(ii) Minimum	0^0C	
	(iii) Every Day	32^0C	
3. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
4. CONDUCTOR	(vii) Material	ACSR Moose	
	(viii) Number of strands & size	54/3.53 mm Al 7/3.53 mm Steel	
	(ix) No. of conductor per phase	2	
5. GROUND WIRE	(vii) Type	Galvanised steel stranded wire, OPGW	
	(viii) Size	7 / 4 mm	
	(ix) No. of earth wire	2	
6. Wind Speed Zone	Wind Speed Zone	Zone – 5 as per IS : 875	
7. Wind pressure	Maximum wind pressure up to a height of 10 M about mean retarding force	793 N/m^2	
8.GROUND CLEARANCE (Under maximum sag)	(i) Rough country	8840 mm plus sag corrections	

Item	Particulars	**400 kV Line (Single/double- 3phase) with ACSR/AAAC**
	(ii) Across and along all roads and paths	8840 mm Plus sag corrections & allowances
9. INSULATORS	(i) Type	Ball & Socket Type (20 mm)/Porcelain long rod insulators
	(ii) Size of disc	255mm x 145 mm/ as per IS 2486 , IEC: 60120
	(v) Number of disc in each insulator (e) Suspension (f) Tension	 14 no. 15 no.
	(vi) Electro-mechanical strength (e) Suspension (f) Tension	 120kN 160 kN
10. Tension Limits	(c) For conductor and ground wire (vii) at 32^0 C & no wind (viii) at 32^0 C & full wind (ix) at 0^0 C & 36% of full wind	 25 % of UTS 70 % of UTS 70 % of UTS

SECTION- 5
TOWER FOUNDATION FOR 220KV & 132KV TRANSMISSION LINES & PILE FOUNDATION

5.1.1.1 SCOPE
This section covers the specifications for design of foundations for various types of towers and special structures under different soil condition described herein after.

5.1.1.2 STANDARDS
For design of foundations reference shall be made to IS 4091 and relevant IS codes. Reference shall also be made to 'Transmission Line Manual' issued by Central Board of Irrigation and Power, New Delhi.

5.1.1.3 Foundations
Foundation includes supply of all labour, tools & machineries, excavation of soil, disposal and backfilling, formwork, shuttering & strutting, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, concreting, dewatering etc.

5.1.2 Type of Foundations
The foundation shall be of open cast type or as per BOQ. Plain Cement Concrete/Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall be 3.0 to 3.5meters. For Hard Rock type and also where specific site conditions / properties demand foundation of different depths (lower or higher), the same shall be adopted.

5.1.3 TYPE OF FOUNDATION
5.1.3.1 Most of the paddy fields of Assam remain under water for more than 3 months in a year. During the remaining period of the year sub-soil water is normally found near the surface below the ground level. The Contractor shall note this factor while designing the foundation of towers.

5.1.3.2 It is expected that the type of foundations defined in following Clause shall be suitable for use at various locations of all the Transmission Lines covered in this Bid Document. The Contractor shall examine the suitability of the type of the foundation assigned for each location depending on the soil investigation reports and the same shall be approved by the Employer based on the suggested design of the foundation prepared as per the relevant soil investigation report. Under no circumstances the approved design shall be altered by the contractor nor the employer shall be under any obligation to approve a change in the design and employer is not liable for additional payement arising under that circumstances.

5.1.3.3 The Contractor shall design and quote for the following four types of foundations and all the foundations shall be RCC type.

(i) **Dry type foundation:** Design of this type of foundation shall be normally for dry / rocky / hard soil for which, (a) weight of earth shall be assumed to be 1600 kg/cum. (b) The Limit Bearing Capacity of the soil shall be 22000 kg/square meter. (c) The angle of repose shall be 30 deg.

(ii) **Wet type foundation (Suitable for paddy field location):** Design of this type of foundation shall be for locations where sub-soil water level is found below 1.5 meters from the ground level. This design shall also be suitable for paddy fields in Assam. The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 1.5 meter shall be taken as mentioned in (i) above and same for earth beyond 1.5-meter depth shall be taken as per (iv) below.

(iii) **Semi sub-merged type foundation:** Design of this type of foundations shall be for locations where sub-soil water level is found below 0.75 meter from the ground level. The weight, the limit bearing capacity, the angle of repose and the ultimate bearing capacity of soil up to depth of 0.75 meter shall be taken as mentioned in (i) above and same for earth beyond 0.75-meter depth shall be taken as per (iv) below.

(iv) **Sub-merged type foundation:** Design of this type of foundations shall be for locations where sub-soil water level is found at less than 0.75 meter from the ground level including completely sub-merged locations. (a) The weight of earth shall be assumed to be 850 kg/cum. (b) The limit bearing capacity of the soil shall be 11000 kg/sq. meter. (c) The angle

of repose shall be 15°.

5.2.1 Design of Foundations

5.2.1.1 Design of foundations as classified under Cl. 5.1.3.1 for all towers and towers with extensions shall be developed by the Contractor based on their soil investigation report and approved thereof by Employer.

5.2.1.2 Depending on the site conditions other types of foundations shall also be designed suggested by the contractor suitable for Intermediate conditions under the above classifications to affect more economy or to suit specific site conditions encountered.

5.2.1.3 The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and duly approved by employer.

5.2.1.4 The pile foundations if required shall also be designed by the contractor based on detailed soil investigation report. The working drawing of these foundations shall be provided by the contractor to the employer prior to execution stage based on requirements.

5.2.2 Construction of Tower Foundation, Stub Setting and Earthing

5.2.2.1 Excavation

5.2.2.1.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise / section wise after obtaining approval from employer for the proposed stretch wise / section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

5.2.2.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be carried out considering the slope stability as well as ground water table. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

5.2.2.1.3 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) Dry Soil

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

b) Wet Soil

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

c) Dry Fissured Rock

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) Wet Fissured Rock

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

e) Hard Rock

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

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

5.2.2.1.5 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of

concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner.

5.2.2.1.6 The Contractor shall arrange & supply requisite blasting material and permission from statuary body and be responsible for its storage and use, without any extra cost to the Owner.

5.2.2.1.7 Indian Standard IS:3764 snd relevant codes shall be followed regarding safety of excavation work.

5.2.3 UNIT RATES AND MEASUREMENT FOR FOUNDATION

5.2.3.1 The indicative shape of RCC foundations are enclosed in this Specification. The bidder is required to quote the unit rates for different foundation activity as a whole for geo-technical investigation, excavation for different types of soils, shuttering & shoring, concreting, backfilling, supply and placement of reinforcement steel, dewatering and all other incindential items for completion of the work.

5.2.3.2 The unit rates of RCC foundation for each type of soil shall include excavation along with all associated activities like shoring, shuttering, dewatering till completion of foundation work stock piling, dressing, back filling of foundations after concreting with excavated/borrowed earth (irrespective of lead) and consolidation of earth, carriage of surplus earth to the suitable point of disposal as required by the employer or any other activity required for to completion of foundation work in all respect.

5.2.3.3 Form boxes shall be used for casting of foundations. The unit rate of concreting shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related / required for completion of concreting works of foundation. The payment for this item shall be made as per the actual volumes of concreting completed but limited to design volume based on unit rates indicated in the letter of award.

5.2.3.4 The unit rate of RCC foundation shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work.

5.2.4 Setting of Stubs

5.2.4.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and levelling instruments. Stubs setting shall be done in the presence of Owner's representative available at site where required and for which adequate advance intimation shall be given to Owner by Contractor. Tolerances as per provisions of IS:5613 shall be allowed for stub setting.

5.2.4.2 Setting of stub at each location shall be approved by Owner.

5.2.4.3 However, in hilly region for towers with unequal leg extensions and for river crossing towers, props may be used with complete accuracy and high skilled supervision, subject to prior approval from Owner.

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

5.2.5 Stub Setting Templates / Props

5.2.5.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations where use of prop is approved by the Owner. Stub templates / props should be painted.

5.2.5.2 The Contractor shall deploy sufficient number of templates / props for timely completion of the line without any extra cost to Owner.

5.2.5.3 However following minimum number of stub setting templates may be deployed by the Contractor for every 100km of line length subject to minimum of 5 templates for suspension tower.

Templates for tower type	Nos. to be deployed
i) A/DA	10
ii) For each type of B/DB, C/DC and D/DD type	3
iii) For A/DA +18/25 M	1
iv) for D/DD+18/25 M	1

However, if more templates are required for timely completion of the lines, the Contractor shall deploy the same without any extra cost to Owner. The number of sets of prop (if permitted) to be supplied, will depend as per actual site condition and completion schedule of line.

5.2.5.4 One set of each type of stub setting template / props (if used) shall be supplied to the Owner, on completion of the project, at no extra cost to Owner.

5.2.6 Mixing, Placing and Compacting of Concrete

5.2.6.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

5.2.6.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

5.2.6.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad.

5.2.6.4 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. However, in case of difficult, terrain, manual compaction may permit at the discretion of the Owner. Monolithic casting of foundations must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Owner.

However, nothing extra shall be paid to the Contractor for providing such construction joints. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

5.2.6.5 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

5.2.6.6 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Owner before the foundation is back filled.

5.2.6.7 The concrete foundation for transmission line towers shall consists of two portions viz. (i) pyramid & (ii) chimney. In chimney portion, the thickness of the concrete cover should be such that it provides minimum cover of not less than 10 cm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations, limiting the minimum section of chimney to 30.5 cm. Sq. In respect of all wet locations, the section of chimney should be 45.72 cm. Sq. uniformly for all sizes of stub angle.

5.2.6.8 The chimney top or muffing must be 23 cm above ground level in dry locations, 38 cm in irrigated field and 15.24 cm above maximum water level in tank beds.

5.2.6.9 The size of the bottom portion of the foundation viz. Pyramid should be designed according to the nature of the sub soil met with at the design depth for the stub angles.

The maximum base thickness in the pyramid portion in case of sub-merged foundation may be taken as 200 mm.

5.2.7 Curing

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers not exceeding 200mm thickness and thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the critical 10 days period.

5.2.8 Backfilling and Removal of Stub Templates

5.2.8.1 After opening of formwork and removal of shoring, timbering, etc., backfilling shall be started after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it is a clay type or it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80-mm. At locations where borrowed earth is required for backfilling, Contractor shall bear the cost irrespective of leads & lift.

5.2.8.2 The backfilling materials shall be clean and free from organic or other foreign

materials. A clay type soil with a grain size distribution of 50% or more passing the no. 200 sieve are unacceptable for backfilling. The earth shall be deposited in maximum 200mm layers, levelled, wetted if necessary and compacted properly before another layer is deposited. The moisture content for compaction shall be based on the Proctor compaction test results given in the Geo-technical Report, Clause 3.0 of section III. The density of the compacted backfill material may further be verified to the satisfaction of the Owner based on the sand-cone method described in the ASTM D1556-82 standard.

5.2.8.3 The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level to drain out water. After backfilling 50mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

5.2.9 Benching

When the line passes through hilly/undulated terrain, levelling the ground may be required for casting of tower footings at no extra cost to the Employer. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Owner. Benching shall be resorted to only after approval from Owner. Volume of the earth to be cut shall be measured before cutting and approved by Owner for payment purposes.

Further, to minimise benching, unequal leg extensions shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Owner.

5.2.10 Protection of Tower and Tower Footing

5.2.10.1 Tower shall be spotted such that the quantity of revetment are optimum. For tower locations in undulated terrain such as hill / mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. Shall be explored by the contractor for optimizing the need for revetment & benching.

5.2.10.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank / bed, undulated terrain, protection of uphill / downhill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are to be prepared by contractor duly approved by Employer.

5.2.10.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted shall include the required lead and consolidation and levelling of earth after backfilling.

5.2.10.4 The quantities for protection work of foundations are provisional only. The unit rates shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

5.2.10.5 The unit rates for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:6) random masonry and unit rate for top sealing with M-15 concrete. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom to top sealing coat and paid at the unit rates indicated in the Letter Of Award. No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

5.2.10.6 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/mesh of 8 SWG wire and 152 square (maxm.) mesh are to be provided. These stones shall be provided in crates size of 2.0mx2.0m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/stack measurements.

5.2.11 SEISMIC CONDITION

Each foundation shall be provided with the tie beam for each type of tower to take care of seismic conditions. Force due to earthquake shall be assumed to be vertical 0.1g and horizontal 0.2g.

5.2.12 OVER LOAD FACTOR

The magnitude of limit loads for foundation should be taken as 10% higher than those of the corresponding towers.

5.2.13 LOADS ON FOUNDATIONS

5.2.13.1 The foundation shall be designed to withstand the loads of the superstructure for the full footing reactions obtained from the structure as per analysis in conformity with the relevant factors of safety. The reactions on the footings shall be composed of the following types of loads for which they shall be required to be checked.

1. Maximum tension or uplift
2. Maximum compression of down thrust
3. Maximum horizontal shear or side thrust

5.2.13.2 The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and the embedded steel parts will also be taken into account adding to the down thrust.

5.2.14 GUARANTEED VOLUME OF FOUNDATIONS

5.2.13.1 The Bidder shall furnish guaranteed volumes of concreting and re-enforcement rods for each type of foundation for each type of towers along with their bids

5.2.13.2 For the purpose of evaluations and comparisons, these guaranteed volumes shall be taken into consideration and the different types of foundations.

5.2.13.3 After award of the contract, the bidder shall submit to the Employer for its approval, detailed design calculations and drawings for each type of foundation. In case, the volume of the foundation, finally approved and accepted by the Employer on the basis of the designs and drawings so submitted is more than the guaranteed volume, no extra amount shall be paid to the contractor. If, however, the volume of the finally approved and adopted foundation is less than the guaranteed volume, the payment shall be made on the basis of the finally accepted volume only.

5.2.13.4 The contractor may be asked at any time during the execution of the works to submit designs for special types of foundations for different towers in different locations if required.

5.3 CONSTRUCTION OF BORED CAST IN-SITU-PILE FOUNDATION

5.3.1 General Requirement

5.3.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. Work shall be executed according to the IS Codes, best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

5.3.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacity of some key equipments are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project.

Sl.No.	Description	Capacity
1.	Tripod height	6m. to 10m. (clear drop)
2.	Rig (winch)	capacity 3 T to 5T
3.	Weight of chisel	2T to 3T
4.	Mud pump	capacity 15 HP to 25 HP
5.	Dia. of outlet pipe for bentonite	2.5 inch
6.	Rotary drilling rig Minimum torque 12T	

(Hydraulic) along with all accessories

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to AEGCL.

5.3.2 Layout and Levels

5.3.2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and drawings. The contractor shall be solely responsible for the correctness of layout and levels.

5.3.3 Site Preparation

This section of the specification covers site preparation of the areas.

5.3.3.1 Reference Points and Bench Marks

5.3.3.1.1 Permanent reference pillars have to be established and under no circumstances shall the Contractor remove or disturb any permanent mark without the approval of the Employer. The Contractor shall carefully maintain and protect all bench marks and reference points and shall layout all his work by accurate reference thereto. The Contractor shall remove all vegetation, excluding trees, from the site areas as directed by the Employer.

5.3.3.1.2 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

5.3.4.0 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items. All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

5.3.4.1 Coarse aggregates/Stone

5.3.4.1.1 All coarse aggregates shall be as per IS:383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. A coarse aggregate shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

5.3.4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required**.**

5.3.4.1.3 Grading of coarse aggregate shall generally conform to IS:383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

5.3.4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

i) Reinforced concrete with very narrow space - 10mm.

ii) Reinforced concrete & Plain Concrete - 20mm.

iii) Lean Concrete M15 -40mm.

5.3.4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the Indian Standard Code IS:8112 or IS:12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS;1489 or Portland Slag Cement conforming to IS:455 can also be used. The Contractor shall submit the manufacturer's Test certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS:456, as per Geotechnical investigation report and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

5.3.4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36 mm. Sand for concrete shall conform to IS:383.

5.3.4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS:456 . Average 28 days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

5.3.4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall be of epoxy coated complying the appropriate Indian Standards from Primary Producer e.g TATA Steel, SAIL, Jindal, RINL, or equivalent as per IS 13620:1993 or latest version. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer.

5.3.5.0 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS:4082 .All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

5.3.5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

5.3.5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

5.3.5.3 Reinforcement

Reinforcement steel shall be stored consignment wise and size wise, off the ground and under cover. It shall be protected from rusting, oil grease and distortions. If directed by the Employer, the reinforcement steel may have to be coated with cement wash before stacking, to prevent scale and rust at no extra cost to the Employer. The stacks shall be easily measurable. Only steel needed for immediate use shall be removed from storage. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion & deterioration.

5.3.6.0 Cement Concrete

5.3.6.1 General

5.3.6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

5.3.6.1.2 The provisions of IS:456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

5.3.6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

5.3.6.2 Admixtures

5.3.6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose, shall be used only after the written permission from the Employer. The Admixtures shall conform to IS:9103.

5.3.6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to form harmful compounds nor increase the risk of corrosion of reinforcement.

5.3.6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

5.3.6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

5.3.6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

5.3.6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

5.3.6.3 Grades of Concrete

5.3.6.3.1 The minimum grade of concrete to be used for piling shall be **M-25** with minimum cement content 400 kg/m3 and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS:456 . In addition, nominal mixes of 1:3:6 and 1:4:8 (with aggregates of nominal size 40mm maximum, by weight converted to equivalent volume shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall confirm to IS:456.

The slump of concrete shall be maintained between 150 to 200 mm.

5.3.6.3.2 The Contractor shall carry out concrete mix design in accordance with IS:10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS:456 to ensure concrete of the minimum specified strength at requisite workability(i.e.slump).

5.3.6.4 Workmanship

All workmanship shall be according to the current Industry standard and best practices. Before starting a pour, the Contractor shall obtain the approval of the Employer in a “Pour Card” maintained for this purpose. He shall obtain complete instructions about the material and proportions to be used, Slump / workability, Quantity of water per unit weight

of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

Mixing of Concrete

5.3.6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.

5.3.6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of sand, coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight.

However, for a faster progress at site, quantities of the cement, sand and coarse aggregates can be converted to equivalent volume. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.

5.3.6.4.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.

5.3.6.4.3 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.

5.3.6.5 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed. During very hot or cold weather, if directed by the Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

5.3.6.6 Placing of Concrete

a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, rehandling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the

initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.

b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.

c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shovelling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures,

reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is not already hardened. Blending of under layer if any, shall be effectively removed.
d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

5.3.6.7 Inserts
All anchors, anchor bolts, inserts, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring
operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

5.3.6.8 Blockouts
Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

5.3.6.9 Repairs and Finishes of Concrete
All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborundum stone and defects patched up with a paste of 1 part sand and 1 part cement and cured. The finish shall be made to the satisfaction of the Employer. The unit rate of concrete work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

5.3.7.0 Reinforcement Steel
This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

5.3.7.1 General Requirements
5.3.7.1.1 Reinforcement steel of same type & grade shall be used for structural reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing .
5.3.7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.
5.3.7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

5.3.7.2 Bending
5.3.7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS:2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.
5.3.7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Rebending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

5.3.7.3 Placing in position

5.3.7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag preceptibly between adjacent spacers.

5.3.7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one part cement: two parts sand) by volume and cured for at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

5.3.7.3.3 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.

5.3.7.3.4 The minimum diameter of the links or spirals bar shall be 10mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.

5.3.7.3.5 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/pile bore by providing necessary laps as per IS:456.

5.3.7.3.6 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100mm for the full depth of cage, unless otherwise specified.

5.3.7.3.7 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.

5.3.7.3.8 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).

5.3.7.3.9 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.

5.3.7.3.10 Minimum clear cover to the reinforcement shall be 75mm unless otherwise mentioned.

5.3.7.3.11 Unless otherwise specified by the Employer reinforcement shall be placed within the following tolerance as specified in IS:456:2000.

a) For effective depth 200mm or less +10mm.

b) For effective depth more than 200mm +15mm.

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

5.3.7.3.12 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer.

5.3.8.0 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

5.3.8.1 Excavation

5.3.8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

5.3.8.1.2 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

5.3.8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorised, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.
5.3.8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.
5.3.8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.
5.3.8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.
5.3.8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer. However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.
5.3.8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.
5.3.8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.
5.3.8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.
5.3.8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders are included and no separate payment shall be made for different type of soils encountered.

5.3.8.4 Form work
5.3.8.4.1 General
5.3.8.4.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform to the shape, alignment and dimensions as shown in the drawings. Form work shall be composed of steel and/or best quality shuttering wood of non- absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.
Supports or props should not be supported on an unpropped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.
5.3.8.4.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid

retaining walls/slabs for the purpose of securing and aligning the formwork should not be used.

5.3.8.4.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.

5.3.8.4.2 Cleaning and Treatment of Forms

5.3.8.4.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes, brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

5.3.8.4.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

5.3.8.4.2.3 If formwork for pedestal/chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

5.3.8.4.3 Removal of Forms

5.3.8.4.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

5.3.8.4.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.

5.3.8.4.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer. However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

5.3.8.4.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, when necessary repaired and inside surface treated as specified. Formwork shall not be used/re-used, if declared unfit or unserviceable by the Employer.

5.3.8.5 Back Filling

5.3.8.5.1 General Requirement

5.3.8.5.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.

5.3.8.5.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.

5.3.8.5.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.

5.3.8.5.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement

or damage.

5.3.8.5.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.

5.3.8.5.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.

5.3.8.5.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

5.3.8.6 Construction Joints

a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints.

Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following :

i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.

ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.

iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.

b) Before the fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any
other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.

c) The unit rate of concrete work shall include the cost of construction joints.

5.3.8.7 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground
containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete. All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by ponding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing
with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

5.3.9.0 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria, technical specifications and the directions of the Employer.

5.3.9.1 Equipment and Accessories

5.3.9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.

5.3.9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

5.3.9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

5.3.9.2 Installation Criteria

5.3.9.2.1 The Contractor while boring the pile bores, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in
the soil investigation report. Should there be any variation between the two-soil classification, these shall be immediately reported to the Employer.

5.3.9.2.2 Whenever the rock strata is encountered in the pile bore, the Contractor shall immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/approval of the Employer. Since the piles are required to be terminated in the firm/hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

5.3.9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling is necessary to be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to AEGCL and no time extension will be permitted on this account.

5.3.9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

5.3.9.3 Control of position and alignment

Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS-2911 (Part I/Sec.2), as reproduced below.

5.3.9.3.1 Maximum permissible deviation in alignment is 1.5% . Piles should not deviate more than 75mm or D/10 whichever is less from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size(as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

5.3.9.4 Boring

5.3.9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water table. Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

5.3.9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tools shall have

suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.

5.3.9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.

5.3.9.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in IS/IEC.

5.3.9.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is recirculated back to the boring. The bentonite slurry mixing and recirculation plant shall be suitably designed and installed.

5.3.9.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.

5.3.9.4.7 The size of cutting tools shall not be less than the diameter of the pile as specified in the drawing and not more than 75mm.

5.3.9.5 Chiseling

5.3.9.5.1 Chiseling, if required, may be resorted to with the permission of the Employer below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

5.3.9.6 Cleaning of Pile bore

5.3.9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

5.3.9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

5.3.9.6.3 Pile bore spoil along with used drilling mud shall be disposed off from site up to 2 Km. or as directed by the Employer.

5.3.9.7 Adjacent Structures

5.3.9.7.1 When working near existing structures care shall be taken to avoid any damage to such structures.

5.3.9.8 Concreting

5.3.9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/approved founding depth.

5.3.9.8.2 The time between the completion of boring and placing of concrete shall not exceed 6 hrs. In case the time interval exceeds 6 hrs the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

5.3.9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

5.3.9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concerting.

5.3.9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS:2911 Part I/Sec.2.Drilling mud shall be maintained sufficiently above the ground water level.

5.3.9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess density more than 1.25 T/Cu.m. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.

5.3.9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.

5.3.9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.
5.3.9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.
5.3.9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.

5.3.9.9 Cut-off-level (COL)
5.3.9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.
5.3.9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.
5.3.9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.
5.3.9.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.

5.3.9.10 Sequence of Piling
5.3.9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.
5.3.9.10.2 The convenience of installation may be taken into account while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

5.3.9.11 Building up of Piles
5.3.9.11.1 If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the cast pile top level is less than the specified level or for any other reason, then the pile shall be built up by using M-20 grade of concrete with minimum cement content 400kg/m3, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

5.3.9.12 Breaking off of Piles
5.3.9.12.1 If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

5.3.9.13 Preparation of Pile head
5.3.9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.
5.3.9.13.2 The exposed part of concrete above the COL, shall be removed/chipped off and made square at COL not before seven days of casting of pile.
5.3.9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.
5.3.9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.
5.3.9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed off up to a lead of 2km or as directed by the Employer.

5.3.9.14 Rejection and Replacement of Defective Piles

5.3.9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

5.3.9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete M15 so that no cavity remains in the bore hole of the abandoned pile.

Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be borne by the contractor.

5.3.9.15 CRITERIA FOR TERMINATING THE PILES

5.3.9.15.1 The piles can be terminated at a depth based on design developed by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified `N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.

5.3.9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 M above the specified pile termination depth and there after @ 1m. up to the pile termination depth.

5.3.9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:

The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 650 N hammer having a free fall of 0.75 M. The sampler shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier. At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be collected from the split spoon sampler for identification/classification of soil. The sample shall be visually classified and recorded at the site. The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS:2131.

5.3.9.16 Recording of Piling Data

5.3.9.16.1 The Contractor shall record all the information during installation of piles.

Typical data sheet for recording pile data as shown in Appendix D of IS:2911 Part I/Sec.2 shall be maintained by the contractor. The pile data shall also include all the details. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

5.3.9.17 Check for Pile bore

5.3.9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

5.3.9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted. A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

5.3.9.18 Properties of drilling mud

5.3.9.18.1 Properties of drilling mud shall be checked as per requirements indicated in IS/IEC prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3

specimens shall be tested.
5.3.9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

5.3.10.0 Erection of Steel Embedded Parts
5.3.10.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.
5.3.10.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/stubs, as the case may be, will be supplied by tower contractor.
5.3.10.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work etc. shown on the drawing or as required by the Employer.
Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.
5.3.10.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and these specifications including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS : 816.
5.3.10.5 Exposed surface of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.

5.3.11.0 Installation
5.3.11.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.
5.3.11.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above. Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

5.3.12.0 Protection Against Damage in Transit
5.3.12.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates. These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

5.3.13.0 Foundations Bolts
5.3.13.1 The foundation bolts / stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after

finalisation of alignments. The unit rate of concreting shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

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

5.3.13.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

5.3.14.0 Stability of Structure

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

5.3.14.2 Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy. Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

5.3.15.0 Grouting and under Pinning

5.3.15.1 General requirement

5.3.15.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.

5.3.15.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

5.3.15.1.3 Cement and alluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer's specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. Admixture should be according to IS:9103.

5.3.15.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

5.3.15.1.5 Under pinning It shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows :

Less than 40mm Dry packed cement mortar Over 40mm Dry packed fine concrete Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. Sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases

minimum 28 days cube strength should not be less than 25N/mm2. Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

5.3.15.1.6 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.

5.3.15.1.7 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.

5.3.15.1.8 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

5.3.15.2 Materials

5.3.15.2.1 Cement shall conform to the stipulations contained in IS:8112and shall have a fineness (specific surface of cement) not less than 225 sq.m./kg when tested for fineness by Blaine's air permeability method as per IS:4031.

5.3.15.2.2 Sand shall conform to the stipulations contained in IS:383.

5.3.15.2.3 Water shall be clean and fresh and shall be of potable quality.

5.3.15.2.4 Aluminium powder or anti-shrinkage admixture like 'Groutex' CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

5.3.15.3 CURING

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

5.3.16.0 Bar Grips

5.3.16.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.

5.3.16.2 The Contractor shall furnish and install the bar grips for various dia. of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

5.3.17.0 Splicing

5.3.17.1 a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.

b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.

c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the unpresented end of the sleeve and pressed in-situ.

5.3.17.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

5.3.17.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.

5.3.17.4 The length of the sleeve should be adequate, that it is safe under the pull-out loading conditions.

5.3.17.5 One percent representative samples of each dia. bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.

5.3.17.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

5.3.18.0 MS Liner

MS liner (minimum 10 mm thick) shall be provided in line with Geo-Technical investigation report relevant IS Codes wherever included in the construction drawings Approved by the Employer and/or otherwises required by the Employer.

NOTE:

At the time of execution, the soil strata should match with the parameters considered in the design of pile foundation. For that req. standard penetration tests will be carried out by contractor to ascertain the design parameters. Any change req. in design will have to be carried out with the prior approval of Engineer-in-charge.

SECTION-6
ERECTION OF TRANSMISSION TOWER

TECHNICAL SPECIFICATIONS FOR ERECTION OF TRANSMISSION LINES

6.01 INDIAN STANDARDS/ CODE :

The material and services under this section shall conform to the requirements of the latest revisions and amendments available at the time of placement of order of all the relevant Indian standards/codes listed here under or equivalent International Standards, except as modified in this document.

S.No.	Indian standards	Title
1	IS:5613-1995 (part- II)	Code of practice for design, installation and maintenance of overhead power lines. Sec.-1 - Designs. Sec.-2 - Installation & Maintenance
2	IS:269-1967	Ordinary rapid hardening and low heat Portland cement.
3	IS:456-2000	Code of practice for plain and reinforced concrete
4	IS:1786-1966	Cold twisted steel bars for concrete reinforcements
5	IS:4091-1967	Code of practice for design & construction of foundation for transmission line towers & poles

6.02 LINE MATERIALS:

6.02.1 Conductor:

The Conductor used in the line will be ACSR Moose Conductor. The Conductor size is 54/3.53mm A1. + 7/3.53 mm Steel.

6.02.2 Ground-wire (OPGW):

The Ground-wire to be used on the line shall be 7/3.66 mm; 95 kg/mm2 quality galvanized steel stranded wire.
For OPGW please refer to this bid document.

6.02.3 Insulator Strings with Hardware Fittings:

(i) Single suspension and double tension strings will be used on the line as under:

(a) At Suspension Locations:

23 Disc single suspension strings having 120KN E&MS of 255x145 mm size Disc Insulators with AGS type clamps will be used.

(b) At Tension Locations :

i. 24 Disc double tension strings with 160 KN E&MS Disc insulators of 280x170 mm size Disc Insulators will be used with compression type dead end clamp.
ii. Pilot strings will be used at deep angle tower locations for restraining the swing of jumpers.
iii. In cases of Railway/Road/River/Other transmission line crossings, double suspension insulator strings will be used.

6.02.4 Conductor Accessories:

(i) AGS (armour grip suspension) type suspension clamps shall be used with suspension strings.
(ii) Vibration Dampers (4-R type) and Spacers or Spacer-Dampers shall be used for Conductors.

6.02.5 Miscellaneous Items:

Enamelled Number Plates, Phase Plates and Danger Board, Bolts and Nuts, Spring washers, Pack washers and other tower accessories like 'D' Shackle, Hanger, U-Bolts and fasteners etc., shall be provided with the tower by the Contractor. The Contractor shall supply anticlimbing device (including Barbed wire) separately. Copper earth bond will be used for connecting Ground wire suspension and tension clamp with tower body, which shall also be provided by the Contractor.

6.03 APPROVED PROFILE:

(Applicable for check survey only)

6.03.1 The detailed survey has been conducted by the Purchaser or any other agency appointed by the Purchaser and the profiles shall be handed over to Contractor progressively for carrying out check survey and submission of profiles for approval of the purchaser. The profiles shall be prepared on cm. graph paper on scale 1:2000 horizontal and 1:200 vertical.

6.03.2 The route alignment surveyed by the Purchaser shall be marked at angle points. At angle points concrete blocks shall be provided and in the straight alignment marking will be done by pegs.

6.03.3 The Contractor will be responsible for the correct setting of towers as shown in approved profiles. If towers after erection are found to be out of the approved alignment/position in the profile, the Contractor will dismantle and re-erect them correctly fully at his own cost and without extension of time.

6.04 INSULATOR HOISTING:

Suspension insulator strings shall be used on suspension towers and tension insulator strings on angle and dead-end towers. They shall be fixed on all the towers just prior to the stringing. Damaged Insulators and fittings, if any, shall not be used in the assemblies. Before hoisting, all Insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the Insulator, but in no case shall any oil be used for the purpose. Security clips shall be fitted in position for the Insulators before hoisting. Arcing Horns shall be fitted in an approved manner. Torque wrench shall be used for fixing different line materials and their components, like suspension clamps etc. For Conductor and Ground-wire etc.

6.05 HANDLING OF CONDUCTOR AND EARTHWIRE:

6.05.1 The Contractor shall be entirely responsible for any damage caused to the towers or Conductors during stringing. While running out the Conductors, proper care shall be taken ensuring that the Conductors do not touch and rub against the ground or objects which could cause scratches or damage to the Conductor strands. The Conductors shall be run out of the drums from the top in order to avoid damage due to chafing. The drum stand shall be provided with a suitable braking device to avoid damage, loose running out and kinking of Conductor. Proper care shall be taken to avoid injury to Conductor while making it pass over the bull wheel of tensioner. After the tensioner, the Conductor will be pulled by pull cable and consequently pass over the running out blocks. The groove of the running out blocks will be of such a design that the seat is semi-circular and larger than the diameter of the Conductor and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to Conductor and shall be mounted on properly lubricated bearings.

6.05.2 The running blocks shall be suspended in a manner to suit the design of the cross arm. All running out blocks especially those at the tensioning end, will be fitted on the cross arm with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work. The Conductor shall be continuously observed for loose or broken strands or any other kind of damage. When approaching towards end of a drum length, at least three coils shall be left when the stringing operations are to be stopped. These coils are to be removed carefully if another length is required to be run out, new length may be joined to the length already run out by the compression joint in approved manner. The Conductor joints and clamps shall be erected in such a manner that no bird caging, over tensioning of individual wires or layers or other deformities or damage to the conductor shall occur. Clamps or bracing devices shall under erection conditions allow no relative movement of strands or layers of the conductors.

6.05.3 Repairs of Conductors, in the event of damage being caused to isolated strands of a conductor during the course of erection, if necessary, shall be carried out during the running out operations, with repair sleeves. Repairing of Conductor surface with repair sleeve shall be done only in case of minor damage, scuff marks etc., keeping in view both electrical and mechanical safety requirements. Number of damaged strands shall not exceed 1/6th of the total strands in the outer layer. The final Conductor surface shall be clean, smooth and shall be without any projections, sharp points, cuts, abrasions etc. Repair sleeves may be used when the damage is limited to the outermost layer of the Conductor and is equivalent to the severance of not more than one third of the strands of the outermost layer. No repair sleeve shall be fitted within 30 m of tension or suspension clamp or fittings. Further, more than one repair sleeve per Conductor shall not be normally used in any single span.

6.05.4 Conductor splices shall be so made that they do not crack or get damaged in the stringing operation. The Contractor shall use only such equipment/ methods during Conductor stringing which ensures complete compliance in this regard.

6.05.5 Derricks shall be used where roads, rivers, canals, telecommunication or overhead power lines, railway lines, fences or walls have to be crossed during stringing operations. It shall be seen that normal services are not interrupted, and no damage is caused to property. Shut down shall be obtained when working at crossing of overhead power lines.
6.05.6 The sequence of running out shall be from top to downwards, i.e. the Ground-wire shall be run out first followed by the Conductors in succession. Imbalances of loads on towers shall be avoided as far as possible i.e. both Ground-wires, then both bundles of top Conductor and then both bundles of middle Conductor followed by both bundle Conductors of bottom Cross-arm should be strung.

6.05.7 The proposed transmission line may run parallel for certain distance with the existing 400/220/132KV lines which will remain energized during the stringing period. As a result, there is a possibility of dangerous voltage build up due to electromagnetic and electrostatic coupling in the pulling cables, Conductors and Ground-wires, which although comparatively small in magnitude during normal operations, can be severe during switching and ground fault conditions on the energised lines. It shall be the Contractor's responsibility to take adequate safety precautions to protect his employees and others from this potential danger.

6.06 STRINGING OF CONDUCTOR AND EARTHWIRE:

6.06.1 The stringing of the Conductor shall be done by control in tension method by means of tension stringing equipments. The equipments shall be capable of maintaining a continuous tension. The maximum tension imposed on a conductor during stringing operations shall not exceed than that necessary to clear obstructions on the ground. The contractor shall indicate in their offer, the sets of tension stringing equipment he is having in his possession and the sets of stringing equipment he would deploy exclusively for this work.

6.06.2 After being pulled, the Conductor/Ground-wire shall not be allowed to hang in the stringing blocks for more than 96 hours before being pulled to the specified sag.

6.06.3 The Contractor shall give complete details of the stringing methods, which he proposes to follow. At least one month in advance of the commencement of stringing, the Contractor will submit the stringing charts for the Conductors and Ground-wire showing the initial and final sags and tension for various temperatures and spans, alongwith equivalent spans in the lines, for the approval of the purchaser. The stringing shall be carried out as per the stringing charts approved by the purchaser and in accordance with relevant IS. All the tolerances for the line shall conform to IS :5613 (Part-2/Sec-2) 1995.

6.06.4 In hilly terrain and thick forest, where deployment of tension stringing machine is not possible, manual stringing may be adopted after getting approval of Purchaser's site Engineer. The contractor shall deploy appropriate tools/equipments/machinery to ensure that the stringing operation is carried out without causing damage to conductor/earth wire and conductor/earth wire is installed at the prescribed sag-tension as per the approved stringing charts.

6.07 JOINTING:

6.07.1 The number of joints in Conductor/Ground-wire shall be kept to minimum possible by properly selecting the drums from available lot of respective drums. All the joints on the Conductor and Ground-wire shall be of compression type. Each part of the joint shall be cleaned by wire brush to make it free of rust or dirt etc. and properly greased with anti-corrosive compound, as approved by our Engineer before the final compression is done with the compressors. The cost of such grease etc. used for joints shall not be paid extra and shall be deemed to be included in the stringing rates.

6.07.2 All joints shall be made at least 30 meters away from the structures. No joints shall be made in the spans crossing

over the main roads, railways, rivers etc. Not more than one joint per Conductor shall be allowed in one span. Care shall be taken to mark the conductor for properly centering the compression clamp before compressing. During compression operation, the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After pressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

6.07.3 Suitable protector shall be used during stringing of Conductor to avoid any damage to the joint while it passes over the reveller.

6.08 SAGGING IN OPERATION:

6.08.1 The Conductors shall be pulled up to the desired sag and left in running block for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductor from the running out blocks to the suspension clamps. The Conductors shall be clamped within 36 hours of sagging in.

6.08.2 The sag will be checked in the first and the last span of the section in case of sections up to eight spans and in one intermediate span also for sections with more than eight spans. The sag shall also be rechecked when the Conductor have been drawn up and transferred from running blocks to the insulator clamps.

6.08.3 The running out blocks, when suspended from the transmission structure for sagging shall be so adjusted that the Conductors on running out blocks will be at the same height as that of the suspension clamps to which it is to be secured.

6.08.4 At sharp vertical angles, the sags and tensions shall be checked on both sides of the angle. The Conductor and Ground-wire shall be checked on the running out blocks for equality of tension on both sides. The suspension insulator assemblies will normally assume vertical positions when the Conductor is clamped.

6.08.5 Tensioning and sagging operations shall be carried out in calm weather, when rapid changes in temperature are not likely to occur.

6.09 TENSIONING & SAGGING OF CONDUCTOR AND EARTHWIRE:

The tensioning and sagging shall be done in accordance with the approved stringing charts before the Conductor and Ground-wire is finally attached to the towers through the insulator strings for the Conductor and Ground-wire clamps for the Ground-wire Dynamometers shall be used for measuring tension in the Conductor and Ground-wire.

6.10 CLIPPING IN:

6.10.1 Clipping of the Conductors in position shall be done in accordance with the method approved by our Engineer. At suspension location free center type suspension clamp with Armour rod set or AGS type suspension clamp shall be used.

6.10.2 The jumpers at the section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator string shall be used, if necessary, to restrict the jumper swings to the design values. Jumper connections of transposition towers shall be so made that adequate clearances are available from tower body as well as phase conductors.

6.10.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

6.11 FIXING OF CONDUCTORS AND EARTHWIRE ACCESSORIES:

Spacers, spacer dampers, Vibration dampers (4-R type) and other Conductor and Ground-wire Accessories supplied by the purchaser shall be installed by the Contractor as per the design/drawing requirement and as per instructions of the Engineer. Spacers shall be fitted within 24 hours of the Conductor clamping. While installing the Conductor and Ground-wire Accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and no damage shall occur to any part of the Accessories.

6.12 REPLACEMENT:

If any replacements are to be affected after stringing and tensioning or during maintenance, members and bracing shall not be removed without reducing the tension on the tower with proper guying or releasing the Conductor. If the replacement of cross arms becomes necessary after stringing, the Conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

6.13 FINAL CHECKING TESTING AND COMMISSIONING:

After completion of the works, final checking of the line shall be done by the Contractor to ensure that all the foundation works, tower erection, and stringing have been done strictly in accordance with the specification and as approved by the purchaser. All the works shall be thoroughly inspected keeping in view the following main points:

(a) Sufficient back-filled earth is lying over each foundation pit and it is adequately compacted.

(b) Concrete chimneys and their copings are in good finely shaped conditions.

(c) All the tower members are correctly used, strictly according to approved drawing and are free from defects or damages, whatsoever.

(d) All bolts are properly tightened and punched/tack welded as per this specification.

(e) The stringing of the Conductors and Ground-wire has been done as per the approved sag and tension charts and desired clearances are clearly available.

(f) All Conductor and Ground-wire Accessories are properly installed.

(g) All other requirements to complete the work like fixing of Danger Plate, Phase Plate, Number Plate, Anti-climbing devices, Aviation Signal (wherever required) etc. are properly installed and the painting has been done wherever required as per Aviation Rules.

(h) It should be ensured that revetment is provided, wherever required.

(i) The line insulation is tested by the Contractor by providing his own equipment labour etc. to the satisfaction of the purchaser to ascertain the insulation condition of the line.

(j) Conductor continuity test is carried out to verify that each Conductor of the overhead line is properly connected electrically also.

The line may be charged at a low value of Power Frequency Voltage for the purpose of testing.

SECTION-7
TECHNICAL SPECIFICATION FOR CONSTRUCTION WORKS IN SUBSTATIONS

7.1.0 GENERAL

7.1.1 The intent of this Section of the Specification is to cover requirements which are to be followed in construction of switchyards including civil works in the switchyard.

7.1.2 The work shall be generally carried out as per approved drawings.

7.1.3 The Contractor shall be required to prepare his own drawings based on project with modifications as and if required and shall submit those for Employer's scrutiny.

7.2.0 SURFACE PREPARATION AND STONE SPREADING

7.2.1 Before taking up PCC base (pro-1:4:8) and stone filling at the location in the construction site, the area shall be thoroughly de-weeded including removal of roots as directed by the Engineer-in-Charge.

7.2.2 After all the structures, equipment & earthing system are erected and after construction of cable trenches, the surface of the switchyard area shall be maintained, rolled/ compacted to the lines and grades as decided by Engineer-in-Charge. De-weeding including removal of roots shall be done before rolling is commenced. Engineer-in-Charge shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the drawing using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface.

7.2.3 A base layer of PCC of 80 mm thickness with proportion of 1:4:8 shall be provided before spreading of crushed rocks. PCC base shall be done in panels of 4 m x 4 m with expansion gap of 25 mm between panels. The gap shall be filled with bitumen. Each panel shall be provided with four (4) numbers of PVC pipes (per panel) of 100 mm dia of length 450 mm for soaking of water. The pipes will be provided with gratings at the top and the same will be flushed with the PCC top.

7.2.4 Over the PCC layer, a surface course of minimum 100mm thickness of 20mm nominal size river pebbles or (single size ungraded) broken stone shall be spread.

7.3.0 CABLE TRENCHES AND CABLE TRAYS

7.3.1 Construction of cable trenches with pre-cast removal R.C.C cover (with lifting arrangement) as per drawings supplied with the Bid Documents shall be carried out by the Contractor.

7.3.2 The Contractor shall provide embedded steel plates of adequate size on the walls of concrete cable trench for supports for cable trays. Insert plates will be provided at an interval of 2000mm.

7.3.3 If asked for, the cable trench walls shall be designed for following loads: -
(a) Dead load of 155 kg/M length of cable support (tray) + 75 kg on one tier at the end.
(b) Triangular earth pressure + uniform surcharge pressure of 2T/m2.

7.3.4 RCC cable trench cover shall be designed for self-weight of slab + UDL of 2000 kg/m2 + a concentrated load of 200 kg at center of span on each slab panel.

7.3.5 Cable trench inside the Control Room shall be covered with 6 mm thick chequered plates with lifting arrangement.

7.3.6 Cable trench crossing the road/rails shall be designed for class AA. Loading of IRC/relevant IS Code and should be checked for transformer loading.

7.3.7 Trenches shall be drained. Necessary sumps be constructed and sump pumps if necessary, shall be supplied. Cable trenches shall not be used as storm water drains.

7.3.8 All metal parts inside the trench shall be connected to the earthing system.

7.3.9 Cables from trench to equipment shall run in hard conduit pipes.

7.3.10 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

7.3.11 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

7.3.12 All the construction joints of cable trenches i.e., between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall and all the expansion joints shall be provided with approved quality PVC water stops of approx. 230 x 5 mm size for those sections where the ground water table is expected to rise above the junction of base slab and vertical wall of cable trenches.

7.3.13 Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12 mm thick 1:6 cement sand mortar.

7.3.14 Cable Trays

(i). The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2 mm.

(ii). The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)

The test shall be done as per approved standards.

b) Deflection Test: (Type Test)

A 2.5 metre straight section of 300mm, wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

7.4.0 FOUNDATION AND RCC CONSTRUCTION

7.4.1 General

7.4.1.1 Work covered under this Clause of the Specification comprises the design and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, control cubicles, bus supports, transformer, marshalling kiosks, auxiliary equipment and systems, buildings, tanks, boundary wall or for any other equipment or service and any other foundation required to complete the work.

7.4.1.2 Concrete shall conform to the requirements mentioned in IS: 456 and all the tests shall be conducted as per relevant Indian Standard Codes as mentioned in Standard field quality plan appended with the specification.

A minimum grade of M20 concrete shall be used for all structural/load bearing members as per latest IS 456.

7.4.1.3 If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of the structures to compensate for such slopes.

7.4.1.4 The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

7.4.1.5 Minimum 75 mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches, etc., to provide a base for construction.

7.4.1.6 Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

7.4.1.7 The design and detailing of foundations shall be done based on the approved soil data and subsoil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

7.4.1.8 If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre cast or under reamed type as per relevant parts of IS Code 2911. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

7.4.2 Design

7.4.2.1 All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS: 456 and minimum grade of concrete shall be M-20.

Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Employer.

7.4.2.2 Limit state method of design shall be adopted unless specified otherwise in the specification.

7.4.2.3 For detailing of reinforcement IS: 2502 and SP: 34 shall be followed. Cold twisted deformed bars (Fe- 415 N/mm2) conforming to IS: 1786 shall be used as reinforcement. However, in specific areas, mild steel (Grade-I) conforming to IS: 432 can also be used. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 150 mm and above. Clear cover to reinforcement towards the earth face shall be minimum 40 mm.

7.4.2.4 RCC water retaining structures like storage tanks, etc., shall be designed as uncracked section in accordance with IS: 3370 (Part I to IV) by working stress method. However, water channels shall be designed as cracked section with limited steel stresses as per IS: 3370 (Part I to IV) by working stress method.

7.4.2.5 The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and or equipment and or superstructure and other conditions, which produces the maximum stresses in the foundation or the foundation component and as per the relevant IS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

7.4.2.6 Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

7.4.2.7 Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/ harmful to the concrete foundations.

7.4.2.8 RCC columns shall be provided with rigid connection at the base.

7.4.2.9 All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in

relevant IS Codes or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

7.4.2.10 Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable).

However, for the design of sub-structures of any underground enclosures, earth pressure at rest shall be considered.

7.4.2.11 In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, sub-structure of any underground hollow enclosure, etc., for the vehicular traffic in the vicinity of the structure.

7.4.2.12 Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure and ground water pressure and surcharge pressure from outside (application only to structures, which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

7.4.2.13 The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

7.4.2.14 The foundations of transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

7.4.2.15 The tower and equipment foundations shall be checked for a factor of safety of 2.0 for normal condition and 1.50 for short circuit condition against sliding, overturning and pull out. The same factors shall be used as partial safety factor overloads in limit state design also.

7.4.3 Admixtures & Additives

7.4.3.1 Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

7.4.3.2 Admixtures in concrete shall conform to IS: 9103. The water proofing cement additives shall conform to IS: 2645. Employer shall approve concrete Admixtures/Additives.

7.4.3.3 The Contractor may propose and the Employer may approve the use of a water-reducing set retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

7.4.3.4 The water reducing set-retarding admixture shall be an approved brand of Ligno- sulphonate type admixture.

7.4.3.5 The water proofing cement additives shall be used as required/advised by the Employer.

7.5.0 SUBMISSION

7.5.1 The following information shall be submitted for review and approval to the Employer as far as Civil Works are concerned:

(a) Design criteria shall comprise the codes and standards used, applicable climatic data including wind loads,

earthquake factors maximum and minimum temperatures applicable to the building locations, assumptions of dead and live loads, including equipment loads, impact factors, safety factors and other relevant information.

(b) Structural design calculations and drawing (including constructions / fabrication) for all reinforced concrete and structural steel structures.

(c) Any other data, drawings and information required to be submitted as per various clauses of the specification.

Approval of the above information shall be obtained before ordering materials or starting fabrication or construction as applicable

7.6.0 BUS BARS AND BUS BAR SUPPORTS

7.6.1.1 The bus bars shall be outdoor strung bus bars with ACSR conductor supported on lattic.

7.6.1.2 If asked for, the substation steel structures shall be designed as per ***Section-3*** of this specification.

7.7.0 ACSR CONDUCTORS

7.7.1 The Conductor shall conform to IS: 398 (latest edition) except where otherwise specified herein.

7.7.2 The details of the ACSR Moose, ACSR Zebra and ACSR Panther conductors are tabulated below:

Sl. No.	DESCRIPTION	ACSR 'MOOSE'	ACSR 'ZEBRA'	ACSR 'PANTHER'
1	Code name	MOOSE	ZEBRA	PANTHER
2	Number of strands & size	Al: 54/ 3.53 mm St: 7/ 3.53 mm	Al: 54/ 3.18 mm St: 7/ 3.18 mm	Al: 30/ 3.00 mm St: 7/ 3.00 mm
3	Overall diameter	35.05 mm	28.62 mm	21.00 mm
4	Breaking load	136.38 kN	130.32 kN	130.32 kN
5	Weight of conductor	2004 Kg/km	1621 kg/km	974 kg/km
6	Co-efficient of linear expansion	$23x10^{-6}$ / ºC	$19.35x10^{-6}$ / ºC	$19.35x10^{-6}$ / ºC
7	Number of strand			
	Steel centre	1	1	1
	1st Steel Layer	6	6	6
	1st Aluminium Layer	12	12	12
	2nd Aluminium Layer	18	18	18
	3rd Aluminium Layer	24	24	-
8	Sectional area of Aluminium	528.50 mm²	428.90 mm²	212.10 mm²
9	Total sectional area	597.00 mm²	484.50 mm²	261.50 mm²
10	Calculated D.C. resistance at 20º C	0.05552 ohm/km	0.06869 ohm/km	0.1400 ohm/km
11	Ultimate tensile strength	161.2 kN	130.32 kN	89.67

7.8.0 ELECTRICAL CLEARANCES

7.8.1 Following minimum electrical clearances (outdoor) shall be maintained in the switchyard:

Sl. N	Clearance	220 KV	132 KV	33 KV

o.				
1	Phase to Phase	2400 mm	1300 mm	320 mm
2	Phase to Earth	2400 mm	1300 mm	320 mm
3	Sectional Clearance	5000 mm	4000 mm	2800 mm
4	Live part to ground	5500 mm	4600 mm	3700 mm
5	Base of insulator (supporting live part) to ground	2500 mm	2500 mm	2500 mm

7.9.0 EARTHING SYSTEM

7.9.1 General

(a) Earthing system shall be installed as per drawings provided with this bidding document.

(b) The main earthing system for the switch yard shall consist of a mesh made out of Galvanised MS flats of size not less than 65 mm in width and12 mm thick covering the entire switchyard area and earth electrodes distributed all over the mesh. The earth electrodes shall also be placed all around the periphery of the mesh at regular intervals.

(c) The earth mat shall be created by laying the earthing conductor (Galvanised MS flats) in both directions perpendicularly. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

(d) Minimum depth of burial of main earthing conductors shall be 600 mm from FGL.

(e) Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

(f) The earthing system must conform to requirements of the Indian Electricity Rules and the provisions of IS: 3043.

(g) All earth electrodes and risers for equipment and other earthing must be connected at mesh points of the earth mat. All such connections shall be welded.

(h) All metallic supporting structures and non-current carrying metallic parts of all equipment shall be provided with double earthing.

(i) All LAs, VTs, CVTs and all transformer neutrals must be earthed through separate earth electrodes and in turn these electrodes shall be connected to the main earth grid.

(j) One number 40mm dia, 3000 mm long MS earth electrode with test link, CI frame and cover shall be provided to connect each down conductor of surge arresters, capacitive &inductive voltage transformers, lightning masts and towers with peak.

(k) 50mm x 6mm MS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both ends and at an interval of 30 mtrs. The M.S. flat shall be finally painted with two coats of Red oxide primer and two coats of Post Office red enamel paint.

(l) The earthing system in the Control Room must also be connected to the main station grid. For this purpose, earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building which in turn shall be connected to the main earth grid by two runs of 65mm x 12mm GI flats.

(m) Each earthing lead from the neutral of the power transformers shall be directly connected to two pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in Cement Concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points. These electrodes must also be connected to the Main Earth Mat of the substation.

7.9.2 Summary of Earthing System

Sl. No.	**Item**	**Size**	**Materials**
1	Main Earthing Conductor to be buried in ground	65mm x 12	GI Flat

		mm	
2	Conductor above ground & earthing leads (for equipment)	65mm x 12 mm	GI Flat
3	Conductor above ground & earthing leads (for columns & aux. structures)	65mm x 12 mm	GI Flat
4	Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes & Lighting Panels etc.	50mm x 6 mm	GI Flat
5	Rod Earth Electrode	40mm dia, 3000 mm long	Mild Steel
6	Pipe Earth Electrode (in treated earth pit) as per IS 3043	40mm dia, 3000 mm long	Galvanised Steel

7.10.0 PROTECTION AGAINST DIRECT LIGHTNING

7.10.1 Protection against direct lightning shall be provided by stringing GI shield wires and/or by lightning masts (SPIKES) as per layout drawings attached.

7.10.2 Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

7.10.3 Down conductors shall be cleated on the structures at 2000 mm interval. For grounding of lightning spikes and shield wires, 7/3.66 mm GI steel wires shall be used.

7.10.4 Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earth-mat.

7.10.5 Two runs of down conductors shall be used for grounding of each Lightning Spikes. For that, lugs with bolts shall be provided at base of spikes.

G.I. wires for shielding shall conforming to IS 2141.Parameters of galvanised steel wires shall be as follows:

a) No of Strand: 7
b) Diameter of single strand: 3.66 mm
c) Minimum Breaking Load: 6970 KG
d) Overall Diameter: 10.98 mm
e) Area: 72.25 mm2

7.11.0 BAY MARSHALLING KIOSK

7.11.1 **1 (One)** number of bay marshalling **kiosk** shall be **provided for each 132 kV bay** under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -

(i) Incoming:

To receive **2(two)** incoming 415V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and

(ii) Outgoing:

(a) To distribute **4(four)** outgoing 415V, 16 Amps 3 phase AC supplies to be controlled by MCB.
(b) To distribute **3(three)** outgoing 240V, 16 Amps single phase supplies to be controlled by MCB.
(c) To distribute **3(three)** outgoing 240V, 10 Amps single phase supplies to be controlled by MCB

7.11.2 The steel sheet thickness of BMK shall be minimum 3.15 mm and painting shall be as per Clause 7.15.0.

7.11.3 The BM shall be protective Class of IP 55.

7.11.4 The BMK shall have a minimum of 700 mm clearance to switchyard floor.

7.12.0 INSULATOR AND HARDWARE FITTINGS

7.12.1 General

a) The Contractor shall supply insulators of suspension, tension and post type as required complete with all necessary hardware and accessories, including fittings for fixing insulators to steel structures as required.

b) The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed.

c) Unless otherwise specified, the glaze shall be brown colour. The glaze shall cover all the porcelain parts of the insulators except those areas which serve as support during firing or are left unglazed for purpose of assembly.

d) The design of the insulator shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to deterioration. The porcelain shall not engage directly with hard metal.

e) Cement use in the construction of insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing. The cement shall not give rise to chemical reaction with metal fitting and its thickness shall be as uniform as possible.

f) Pins and caps shall be made of drop forged steel, duly hot dip galvanized as per IS 2629.These shall not be made by jointing, welding, shrink fitting or any other process.

g) Security clips/split pins shall be made of good quality of stainless steel.

h) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings.

i) Post type insulators shall be of long rod type or solid core type and preferably of single piece type for all voltage classes. These shall be complete with necessary fittings to hold Aluminium tubes or ACSR conductor as required.

j) The items of hardware and fittings shall make complete assemblies which are necessary for their satisfactory performance. Such parts shall be deemed to be within the scope of this specification.

7.12.2 Disc Insulator Strings

Each insulator string shall consist of following numbers of Disc & parameters.

Sl. No.	Description	No of Disc Insulator Unit for		
		220 kV	**132 kV**	**33 kV**
1	No. of Disc, Suspension String	14	9	3
2	No. of Disc, Tension String	15	10	4
3	Creepage Distance of complete String (min)	6125 mm	3625 mm	900 mm

7.12.3 Parameters

7.12.3.1 Disc Insulators

a) Type : Ball and Socket
b) Colour : Brown
c) Surface : Glazed
d) Locking Device : W or R type security clip
e) Size of Disc : 255 mm x 145 mm
f) Size of Pin Ball : 16 mm or 20 mm

g) Creepage Distance

(Min subjected requirement of clause 7.19.2): 31 mm/kV

h) Electro mechanical Strength : 70 KN, 90 kN, 120kN (as per requirement)

i) Power frequency withstand test voltage : 75 KV Dry

j) Minimum dry Impulse withstand : 125 KV peak Test voltage (+/- wave)

k) Puncture Voltage : 1.3 X actual dry flash over voltage.

7.12.3.2 Post Insulators

Sl. No.	**Parameters**	**220 kV**	**132 kV**	**33 kV**
1	Highest system voltage	245 kV	145 kV	36 kV
2	Dry one minute power frequency test voltage	510 kV	275 kV	75 kV
3	Wet one minute power frequency test voltage	460 kV	275 kV	75 kV
4	Impulse voltage withstand test	510 kV	650 kV	170 kV
5	Minimum Creepage Distance	31mm/kV	31mm/kV	31mm/kV
6	Minimum Bending Strength (upright)	6 kN	4 kN	3 kN

7.13.0 CLAMPS, CONNECTORS AND SPACERS

7.13.1 Clamps and connectors shall conform to IS 2121 unless otherwise mentioned hereunder.

7.13.2 Clamps and connectors shall be made of materials listed below: -

(i) For connecting ACSR: Aluminium alloy casting conforming to designation A6 of IS 617.

(ii) For connecting equipment: Bimetallic connectors made from aluminium alloy terminals made of copper casting conforming to designation A 6 of IS 617.

(iii) For connecting GI Shield wire: Malleable iron casting.

(iv) Expansion Connectors: Copper lamination to grade FRTP-2 of IS 191.

(v) Bolts, nuts, plain washers: Hot dip galvanised mild steel and spring washers for items (i), (ii) and (iii).

(vi) Clamp and connector shall be suitable for ACSR or HTLS conductor as per site requirement.

7.13.3 Spacers

Spacers shall conform to IS 10162. Spacers for bundle conductors (where specified) shall be provided at but not limited to the following locations:

(i) At intervals not exceeding 2.5 meters in case of strung bus bars or other bundled strung conductors.

(ii) At one meter interval in case of jumper connections.

No magnetic material shall be used in fabrication of spacers except for the GI bolts and nuts.

Spacer shall be shall be suitable for ACSR or HTLS conductor as per site requirement.

7.13.4 <u>T Clamp and Equipment Clamps</u>

a) <u>T Clamps:</u>

i. Standard Specification and tests shall be as per IS:5561.

ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.

iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.

iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.

v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.
xi. Clamp shall be suitable for ACSR or HTLS conductor as per site requirement.

b) <u>Equipment Clamps (CVT, CB, ISOLATOR, CT, etc.):</u>

i. Standard Specification and tests shall be as per IS:5561.
ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanized.
iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
x. Clamp shall be suitable for ACSR or HTLS conductor as per site requirement.

From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

7.14.0 ILLUMINATION SYSTEM

7.14.1 The Contractor shall design, supply and install illumination system for the entire substation.

The average illumination level and limiting glare index for different parts of the substation shall be as follows:

Sl. No.	Location/Area	Average Illumination Level, 'Lux'	Limiting Glare Index
1	Control Room	300	19
2	Battery Room	100	19
3	Carrier Room	300	
4	Office/Conference Room	300	
5	Stairs and Corridors	100	
6	Air Conditioning Plant	150	
7	Outdoor Switchyard	20	
8	Approach Road	20	
9	Store Room	100	

7.14.2 The lighting system of a particular area whether indoor or outdoor shall be designed such a way that uniform illumination level is achieved. In outdoor switchyard illumination shall be aimed as far as possible towards

transformers, circuit breakers, isolators etc.

7.14.3 Following types of lamps shall be used for various location of the substation:

Sl. No.	**Location/Area**	**Type of Lamp**	**Type of Fitting**
1	Control Room, Office, Carrier Room	LED	Decorative
2	Battery Room	Fluorescent	Acid Proof, Industrial
3	Outdoor Switchyard	LED	Water Tight Flood Light
4	External Lighting on Buildings	LED	Water Tight Flood Light
5	Gate Lighting	LED	Post type, water tight Flood Light

7.14.4 Provisions shall be made in the switchyard steel structures for mounting of lamps for switchyard.

7.15.0 PAINITNG

7.15.1 All surfaces of ferrous materials used for construction of outdoor equipment and enclosures such as instrument transformer main tanks and equipment, marshalling boxes, kiosk, operating boxes, metallic enclosures etc. shall be cleaned and painted as given below if not specified otherwise in respective Sections. The quality of paint such that its colour should not fade even if it is exposed to temperature up to 1200-degree C.

Description	**Surface preparation**	**Primer coat**	**Intermediate undercoat**	**Finish coat**	**DFT**	**Colour Shade**
CT & PT Main tanks of CT, PT and other oil filled equipment, etc. (**External surface)**	Shot Blast cleaning Sa 2½ (ISO 8501-1)	Epoxy base zinc primer (30-40 mm)	Epoxy high build micaceous iron oxide (75 mm)	Aliphatic Polyurethane 2 coats (25 mm/coat)	Minimum 155 mm	Shade No. 631 of IS:5
do (**Internal surfaces)**	Shot Blast cleaning Sa 2½ (ISO 8501-1)	Hot oil resistant, non-corrosive varnish or paint or epoxy			Minimum 30 mm	Glossy white or paint
Marshalling boxes, operating	Chemical/Shot Blast cleaning Sa	Epoxy base zinc primer (30-40 mm)				

7.15.2 All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

7.15.3 In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting/touchup shall be supplied by the contractor.

7.15.4 The paint work done shall be guaranteed for a minimum period of 5 years from the date of receipt of the equipment.

7.15.5 1(One) coat of additional paint to the exposed exterior surfaces shall be given at site prior to commissioning in

presence of the Employer's representative.

7.16.0 SUPPLY OF CONSTRCUTION MATERIALS BY THE CONTRACTOR

7.16.1 The contractor has to make his own arrangements for procurement, supply and use of construction materials like cement, M.S. rounds, H.B.G. metal and sand.

7.16.2 Cement

The contractor has to make his own arrangements for the procurement of cement to required specifications required for the work subjected to the follows:

a) The contractor shall procure cement (approved BSI marked of PPC of Grade 53), required for the works only from reputed cement factories (Main producer) acceptable to the Engineer-in-Charge. The contractor shall be required to be furnished to the Engineer in-Charge bills of payment and test certificates issued by the manufacturers to authenticate procurement of quality cement from the approved cement factory.

The contractor shall make his own arrangement for adequate storage of cement.

b) The contractor shall procure cement in standard packing of all 50 kg per bag from the authorized manufacturers. The contractor shall make necessary arrangement at his own cost to the satisfaction of Engineer-in-Charge for actual weighment of random sample from the available stock and shall conform with the specification laid down by the Indian Standard Institution or other standard foreign institutions laid down by the Indian Standard Institution or other standard foreign institutions as the case may be. Cement shall be got tested for all the tests as directed by Engineer-in-Charge at least one month in

advance before the use of cement bags brought and kept on site Stores. Cement bags required for testing shall be supplied by the contractor free of cost. If the tests prove unsatisfactory, then the charges for cement will be borne by the Contractor.

c) The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the Engineer-in-Charge. The Contractor shall forthwith remove from the works area any cement that the Engineer-in-Charge may disallow for use, an account of failure to meet with required quality and standard.

d) The contractor shall further, at all times satisfy the Engineer-in-Charge on demand, by production of records and books or by submission of returns and other proofs as directed, that the cement is being used as tested and approved by Engineer-in-Charge for the purpose and the Contractor shall at all times, keep his records up to date to enable the Engineer-in-Charge to apply such checks as he may desire.

e) Cement which has been unduly long in storage with the contractor or alternatively has deteriorated due to inadequate storage and thus become unfit for use in the works will be rejected by the department and no claim will be entertained. The Contractor shall forthwith remove from the work area, any cement the Engineer-in-Charge may disallow for use on work and replace it by cement complying with the relevant Indian Standards.

7.16.3 Steel

The Contractor shall procure mild steel reinforcement bars, high yield strength deformed (HYSD) bars, rods and structural steel, etc., required for the works, only from the main or secondary producers manufacturing steel to the prescribed specifications of Bureau of Indian Standards or equivalent and licensed to affix ISI or other equivalent certification marks and acceptable to the Engineer-in-Charge. Necessary ISI list certificates are to be produced to Engineer-in-Charge before use on works. The unit weight and dimensions shall be as prescribed in the relevant Indian Standard specification for steel.

7.17.0 SUPPLY OF CONSTRCUTION MATERIALS BY THE EMPLOYER

7.17.1 As it is a single responsibility contract supply, and/or arrange all materials and services including construction

and testing equipment to complete the works in all respects described in the specification, shall be under the scope of the Contractor unless otherwise specifically mentioned elsewhere in the bidding document.

7.18.0 MISCELLANEOUS GENERAL REQUIREMENTS

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

7.18.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting.

The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

7.18.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

7.18.4 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

7.18.5 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75kg/cm2 compressive strength before submitting his offer.

7.18.6 Angles 50 x 50 x 6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/ openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole pre-cast cover and any other place where breakage of corners of concrete is expected.

7.18.7 Anti- termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS: 6313 and other relevant Indian Standards.

7.18.8 Items/components of equipment/materials/components etc. not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

SECTION- 8
TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

8.1.0 SCOPE

8.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, and accessories for Power Conductors.

8.2.0 POWER CONDUCTOR

8.2.1 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

8.2.2 STANDARD TECHNICAL PARTICULARS

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

All the aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

8.2.3 MATERIAL

i. The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

ii. The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.

iii. The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC : 60888.

iv. The zinc used for galvanizing shall be electrolytic High Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

8.2.4 JOINTS IN WIRE

In the Aluminium wires no joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the Steel wires there shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

8.2.5 STRANDING

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements as per IS 398.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

8.2.6 TYPE/ROUTINE/ACCEPTANCE TESTS

Type Test:

The following tests shall be conducted on a sample/samples of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a) DC resistance test on stranded conductor
b) UTS test on stranded conductor
c) Corona extinction voltage test (dry)
d) Radio interference voltage test (dry)

Acceptance Test:

a) Visual and dimensional check on drum
b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c) Measurement of diameters of individual Steel and Aluminium strands

1. Galvanizing test on steel strands
2. Check for lay Ratios of various layers
3. Torsion and Elongation tests on steel strands
4. Breaking load test on steel and Aluminium strands
5. Wrap test on Steel & Aluminium strands
6. DC resistance test on Aluminium strands
7. Procedure qualification test on welded joint of Aluminium strands
8. Drum strength test (steel drum)
9. Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests shall be witnessed by AEGCL's representative.

Routine Tests:

a) Check to ensure that the joints are as per Specification
b) Check that there are no cuts, fins etc. on the strands
c) Check that drums are as per Specification
d) All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

Tests During manufacture:

a) Chemical Analysis of Zinc used for galvanising
b) Chemical Analysis of Aluminium used for making Aluminium Strands
c) Chemical Analysis of Steel used for making Steel Strands.

8.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

8.2.8 PACKING

All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

8.2.9 TECHINCAL DATA SHEET FOR CONDUCTOR

ACSR MOOSE

Sl. No	DESCRIPTION	PARTICULARS
I	II	III
1	Type of Conductor	Aluminium Conductor Steel Reinforced (ACSR)
2	No of Strand x size	54 x 3.53 mm
3	Conductor over all diameter	31.77 mm
4	Total sectional area	597 mm^2
5	Approx. weight	2004 kg/km
6	Minimum UTS	161.2 kN
7	Modulus of Elasticity (Final)	0.7034 kg/cm^2
8	Coefficient of linear expansion	19.3 x 10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.05552 ohms/km
10	Layer and No of Wire	
	Steel core	1
	1st steel layer	6
	1st Aluminium layer	12
	2nd Aluminium layer	18
	3rd Aluminium layer	24
11	**Aluminum strands after stranding**	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.55
	Minimum	3.51
(b)	Minimum breaking load of strand	
	Before stranding	1.57
	After stranding	1.49
12	**Steel strand after stranding**	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.59
	Minimum	3.47
(b)	Minimum breaking load of strand	
	Before stranding	12.86
	After stranding	12.22
13	DC resistance of the conductor at 20°C	0.05552
14	Direction of lay of outer layer	Right Hand
15	Linear mass of the conductor	
	Standard	2004
	Minimum	1969
	Maximum	2040

ACSR Zebra

1.	Code Name	ZEBRA
2.	Equivalent area of Aluminium (sq.mm.)	418.6
3.	Wire Strand (Al./Steel)	54/7

4.	Nominal diameter of strand (Al./Steel)(mm.)	3.18/3.18
5.	Weight (Kg/Km)	1621
6.	Co-eff. of linear expansion per oC	19.30x10 $^{-6}$
7.	Ultimate Tensile Strength (kgf.)	13316
8.	Maxm. DC resistance at 20°C (Ω/Km) (Calculated from maxm. Value of resistivity and min. Cross-sectional area)	0.0680
9.	Zinc coating of steel :	
	i) No. of one minute dip	3
	ii) Min. wt. of zinc.(gm.m^2)	260
	iii) Purity of zinc (%)	99.95
10.	Diameter of conductor (mm)	28.62
11.	Standard Length (meter)	1100

ACSR Panther

Sl. No.	DESCRIPTION	ACSR 'PANTHER'
1	Code name	PANTHER
2	Number of strands & size	Al: 30/ 3.00 mm St: 7/ 3.00 mm
3	Overall diameter	21.00 mm
4	Breaking load	130.32 kN
5	Weight of conductor	974 kg / km
6	Co-efficient of linear expansion	19.35x10^{-6} /^{0}C
7	Number of strand	
	Steel centre	1
	1st Steel Layer	6
	1st Aluminium Layer	12
	2nd Aluminium Layer	18
	3rd Aluminium Layer	-
8	Sectional area of Aluminium	212.10 mm^2
9	Total sectional area	261.50 mm^2
10	Calculated d.c. resistance at 20^0 C	0.1400 ohm/km
11	Ultimate tensile strength	89.67

8.3.0 GROUND WIRES

Optical ground wire (OPGW) shall be used as per bid specification.

8.4 FITTINGS AND ACCESSORIES FOR CONDUCTORS

The accessories for conductors shall conform to IS: 2121 and 2486 (Latest version) in all respects

- **Mid Span Compression Joint**

• Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistivity less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

• The joint shall be made of steel and aluminium sleeves for jointing the steel core and aluminium wires respectively. The steel sleeve should not crack or fail during compression. The steel sleeve shall be hot dip galvanised. The aluminium sleeve shall have aluminium of purity not less than 99.5%. The dimensions and dimensional tolerances of mid span compression joint shall be as per Standard Technical Particulars.

- **T-Connector**

T-Connector of compression type shall be used for jumper connection at transposition tower. It shall be manufactured out of 99.5% pure aluminium and shall be strong enough to withstand normal working loads. The T-connector shall have a resistivity across jumper less than 75% resistivity of equivalent length of conductor. The T-connector shall not permit slipping off, damage to or failure of complete conductor. The welded portions shall be designed for 30 kN axial tensile load. Leg sleeve of T-connector should be kept at an angle of 15 deg. from vertical and horizontal plane of the conductor in order to minimise jumper pull at the welded portion. The dimensions and dimensional tolerances of T-connector shall be as per Standard Technical Particulars.

- **Repair Sleeve**

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium and shall have a smooth surface. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions and dimensional tolerances of repair sleeve shall be as per Standard Technical Particulars.

- **Vibration Damper (Applicable for 400kV D/C (Twin Moose), 220kV & 132kV Lines)**

• Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified Aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s shall be used at suspension and tension points on each conductor in each span along with bundle spacers to damp out Aeolian vibration as mentioned hereinafter.

• Alternate damping systems or “Dogbone” dampers offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid.

• One damper minimum on each side per Conductor/Sub-conductor for suspension points and two dampers minimum on each side per conductor/sub-conductor for tension points shall be used for ruling design span.

• The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

• The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.

• The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under

all service conditions.

- Preformed type armoured rods shall be provided for the conductors at all suspension points. Vibration dampers of stock bridge type shall be used for power conductors.

➢**Bundle Spacer (for Twin Bundle Conductor) & Rigid Spacer (for Hexa/Quad / Triple/ Twin Bundle Conductor)**

- Armour grip bundle spacers shall be used to maintain the spacing of 450 mm (for 400 kV voltage level line twin bundle conductor) 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 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.
- Spacer shall restore normal spacing of the sub conductors after displacement by wind, electromagnetic and the electrostatic forces under all operating conditions including the specified short circuit level without permanent deformation damage either to conductor or to the assembly itself. They shall have uniform grip on the conductor
- For spacer requiring retaining rods, the retaining rods shall be designed for the specified conductor size. The preformed rods shall be made of high strength, special aluminium alloy of type 6061/65032 and shall have minimum tensile strength of 35 kg/sq.mm. The ends of retaining rods should 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 number of rods shall be applied on each clamp to hold the clamp in position. The minimum diameter of the rods shall be 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 should be forged from aluminium alloy of type 6061/65032. 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.
- For the spacer 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 5 kN. 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.
- 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 tube shall be made of aluminium alloy of type 6061/65032 or 6063/63400. If fasteners of ferrous material are used, they shall conform to and be galvanised conforming to relevant Indian Standards. The spacer involving ferrous fasteners shall not have magnetic power loss more than that stipulated in the Standard Technical Particulars.
- Elastomer, if used, shall be resistant to the effects of temperature up to 95 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 spacer assembly shall have electrical continuity. 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/reinstallation without any damage.
- The spacer assembly shall be capable of being installed and removed from the energised line by means of hot line technique.

8.5 FITTINGS AND ACCESSORIES FOR GROUND WIRES

Fittings and accessories for OPGW shall be used as per bid specification.

SECTION-9
TECHNICAL SPECIFICATION FOR INSULATOR STRING HARDWARE

9.1.0 HARDWARE

Each insulator string assembly shall generally include the following hardware:

Anchor shackle for attachment of suspension string assembly to the tower hanger and tension string assembly to the tower strain plate. Suitable top and bottom yoke assemblies with the arrangement of fixing a set of arcing horns.

- Set of arcing horns
- Suspension or tension clamp
- Bolts, nuts, washers, split pins etc.
- Other fitting s necessary to make the strings complete such as ball clevis, socket clevis, chain links etc.

The tenderer shall be responsible and satisfy himself that all the hardware included in strings are entirely suitable for the conductor offered.

9.2.0 SUSPENSION CLAMP

The suspension clamps shall be made of malleable iron or aluminium alloy, hot dip galvanised and shall be suitable to accommodate the conductor together with one set of preformed armour rods. Suitable sheet aluminium liners shall be provided. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor. The lips shall be rounded off and the seating and the bell mouths shall be smooth to avoid corona and radio interference noises. The suspension clamps shall be suitable to carry the bottom part of the arcing horn and to receive the fittings of the insulator string.

The suspension clamps shall be such that the conductor should not slip at a load of 25% of the breaking load of the conductor. The ultimate strength of the clamp for vertical load shall not be less than the failing load of the Disc Insulators.

9.2.1 STRAIN CLAMP

The bolted strain clamps shall also be made of malleable iron or aluminium alloy; hot dip galvanised, lined with sheet aluminium liners and shall be suitable to accommodate the conductor with necessary binding tapes etc. The lips shall be rounded off carefully and conductor seating and the ball mouth shall be smooth to avoid corona and radio interference noises. Suitable attachment for receiving one side of arcing horns and for connecting to the insulator strings shall be provided.

The strain clamps shall be such that the conductor should not slip at a load of 90% of the breaking load of the conductor. The ultimate strength of the clamp for horizontal load shall not be less than the ultimate strength of the conductor

9.2.2 ARCING HORNS:

Arcing horns of approved size and dimensions shall be provided for every string of insulators. The performance data for arcing horns to be supplied shall be made available to the Employer.

9.2.3 OTHER INSULATOR STRING HARDWARE:

The strength of other string hardware namely anchor shackle, yoke plates, socket-clevis etc. shall be co-ordinated with insulator disc strength.

9.3.0 Interchangeability

The hardware together with ball and socket fittings shall be of standard design, so that this hardware is interchangeable with each other and suitable for use with disc insulators of any make con1orming to relevant Indian/International Standard.

9.4.0 Corona and RI Performance

Sharp edges and scratches on all the hardware fittings shall be avoided. All surfaces must be clean, smooth, without cuts and abrasions or projections. The Contractor/Manufacturer must give suitable assurance about the satisfactory corona and radio interference performance of the materials offered by him.

9.5.0 Maintenance

The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be

generally bare hand method & hot stick method. The Bidder should clearly establish in the bid, the suitability of his fittings for hot line maintenance.
The line side yoke plate shall have a notch & a working hole of suitable size. The design of corona control rings/grading ring shall be such that it can be easily replaced by employing hot line maintenance technique.

9.6.0 Designation

Ball and Socket Designation

The dimensions of the ball and socket shall be 16 mm (Alt-B) designation for 70 KN &90KN Insulators, 20 mm designation for hardware with 120kN & 160 kN Insulators, in accordance with the standard dimensions stated in IS: 2486-(Part-II) /IEC:120. The dimensions shall be checked by the appropriate gauge after galvanising only.

9.7.0 Security Clips and Split Pins

9.7.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking 9f the coupling as per IS: 2486-(Part-III)/IEC: 372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow separation of fittings.

9.7.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall neither be less than 50 N (5 kg) nor more than 500 N (50 kg).
Split pins shall be used with bolts & nuts.

9.8.0 Arcing Horn for EHV Strings

9.8.1 The arcing horn shall be provided on tower side of the hardware fittings. The same shall be either ball ended rod type or tubular type.

9.8.2 The spark gap shall be so adjusted to ensure effective operation under actual field conditions.

9.9.0 Yoke Plates

- The strength of yoke plates shall be adequate to withstand the minimum ultimate tensile strength as specified in the bid drawings.
- The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing corona control rings/grading ring/arcing horn. All the corners and edges should be rounded off with a radius of atleast 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the Contractor/Manufacturer. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS:800-2007.

9.10.0 Corona Control Rings/Grading Ring (For 220 kV & above voltage level line)

- The Corona control rings/grading ring shall be provided with hardware fittings and shall be of such design that it should cover at least one disc insulator in disc insulator strings/ metal polymer junction point in composite insulator strings so that they will reduce the voltage across the insulator units. It shall also improve corona and radio interference performance of the complete insulator string along with hardware fittings.
- The corona control rings/grading ring shall be made of high strength heat treated aluminium alloy tube of minimum 2.5 mm wall thickness. If mild steel brackets are used then the brackets shall not be welded to the pipe but shall be fixed by means of bolts and nuts on a small aluminium plate attachment welded to the pipe. The welded center of the corona control ring/grading ring shall be grinded before buffing. Alternately, Aluminium tube/flats of suitable dimensions welded to the corona control rings/grading rings may be used for connection to yoke plate.
- The Corona control rings/grading ring should have a brushed satin finish and not a bright glossy surface. No blemish should be seen or felt when rubbing a hand over the metal.
- Bidder may quote for grading ring with armour grip suspension assembly. The grading ring shall be of open type

design with a gap of 125 mm. The open ends shall be suitably terminated. The outside diameter of the tube shall be 75 mm. The ends of grading ring tube shall be sealed with welded aluminum cap duly buffed.

9.11.0 Sag Adjustment Plate (For 400 kV voltage level line)

- The sag-adjustment plate to be provided with the double tension hardware fitting (for 400kV (Twin) line) shall be of three plate type. The sag adjustment plate shall be provided with a safety locking arrangement. The device shall be of such design that the adjustment is done with ease, speed and safety.
- The maximum length of the sag adjustment plate from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible and the steps of adjustment shall be clearly indicated in the drawing. An adjustment of 150 mm minimum at the interval of 6 mm shall be possible with the sag adjustment plate.
- Design calculations for deciding the dimensions of sag adjustment plate shall be furnished by Contractor/Manufacturer. The hole provided for bolts should satisfy shear edge condition as per Clause No. 10.2.4.2 of IS:800-2007.

9.12.0 Turnbuckle

9.12.1 The turn buckle is to be provided with single tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

9.12.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 380 mm for 132KV and 220KV Line and 520mm for 400KV Line. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing submitted with the bid. An adjustment of 135 mm minimum for 132KV and 220KV Line and 150mm minimum for 400KV Line shall be possible with turnbuckle.

9.13.0 Suspension Assembly

9.13.1 The suspension assembly shall include free center type suspension clamp along with standard preformed armour rods or armour grip suspension clamp; except for Pilot insulator string for which only suitable Envelope type suspension clamp shall be used.

9.13.2 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

9.13.3 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth and without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

9.13.4 The suspension assembly/clamp shall be so designed so that it minimises the static and dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs and have required level of Corona/AIV performance.

9.14.0 Free Center Type Suspension Clamp

For the Free Center Suspension Clamp seat shall be smoothly rounded and curved into a bell mouth at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together.

9.15.0 Standard Preformed Armour Rod Set

9.15.1 The Preformed Armour Rod Set suitable for Conductor shall be used to minimise the stress developed in the sub-conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localised heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

9.15.2 The preformed armour rods set shall have right hand lay and the inside diameter of the helices shall be less than the outside diameter of the conductor in order to gently but permanently grip the conductor. The surface of the armour

rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions, etc.

9.15.3 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

9.15.4 The conductivity of each rod of the set shall not be less than 12% of the conductivity of the International Annealed Copper Standard (IACS).

9.16.0 Armour Grip Suspension Clamp

• The armour grip suspension clamp shall comprise of retaining strap, support housing, elastomer inserts with aluminum reinforcements and AGS preformed rod set.

• Elastomer insert shall be resistant to the effects of temperature up to 95oC, Ozone, ultraviolet radiations and other atmospheric contaminants likely to be encountered in service. The physical properties of the elastomer shall be of approved standard. It shall be electrically shielded by a cage of AGS performed rod set. The elastomer insert shall be so designed that the curvature of the AGS rod shall follow the contour of the neoprene insert.

• The length of the AGS preformed rods shall be such that it shall ensure sufficient slipping strength as specified in the Standard Technical Particulars and shall not introduce unfavourable stress on the conductor under all operating conditions.

9.17.0 Envelope Type Suspension Clamp

• The seat of the envelope type suspension clamp shall be smoothly rounded & suitably curved at the ends. The lip edges shall have rounded bead. There shall be at least two U-bolts for tightening of clamp body and keeper pieces together. Hexagonal bolts and nuts with split-pins shall be used for attachment of the clamp.

9.18.0 Dead End Assembly

9.18.1 The dead-end assembly shall be suitable for Conductor as detailed in the document.

9.18.2 The dead-end assembly shall be compression type with provision for comprising the jumper terminal at one end. The angle of the jumper terminal to be mounted should be 30º with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

9.18.3 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

9.19.0 Fasteners: Bolts, Nuts and 'Washers

9.19.1 All bolts and nuts shall conform to IS: 6637. All bolts and nuts shall be galvanised as per IS-1367 -(Part 13)/IS-2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

9.19.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties arid effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS-12427. Bolts should be provided with washer face in accordance with IS: 1363 Part-1 to ensure proper bearing.

9.19.3 Nuts should be double chamfered as per the requirement of IS: 1363 Part-III. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size up to M16

9.19.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

9.19.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further .it shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

9.19.6 For parts/ components requiring grip strength viz. arcing horn, corona rings & dead-end jumper assembly, fully threaded bolts can be used as an alternative. Bolts & nuts for these parts/ components shall be of minimum 4.6 grade

conforming to IS 6639 or equivalent International standards.

9.19.7 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro-galvanised. The thickness of washers shall conform to IS: 2016.

9.19.8 The Bidder shall furnish bolt schedules giving thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

9.19.9 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

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

9.19.11 Fasteners of grade higher than 8.8 are not to be used.

9.20.0 Materials

The materials of the various components shall be as specified hereunder. The Bidders hall indicate the material proposed to be used for each and every component of hardware fitting stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 302 or 304-L/ IS-1385	
2	Arcing Horn	Mild Steel Rod/ Tube Type	Hot dip galvanised	As per IS-226 or IS-2062	
3	Ball Fittings, Socket, all shackles links cleves	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
4	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
5	Sag Adjustment plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
6(a).	Corona Control ring/ Grading ring	High Strength Al. Alloy tube (6061/ 6063/1100 type or 65032/ 63400 Type)	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be less than 20 KN
6(b).	Supporting Brackets & Mounting Bolts	High Strength Al Alloy 7061/ 6063/ 65032/63400 Type) or Mild Steel	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or IS:2062	
7(a).	Envelope type Clamp: Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032 or 6063/63400	Casted or forged & Heat treated	IS:617 or ASTM-B429	
7(b).	Envelope type Clamp: Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	As per IS-226 or IS-2062	
7(c)	Envelope type Clamp: U Bolts	Stainless Steel or High Strength Al alloy 6061/ 6063 or 65032/63400	Forged & Heat treated	AISI 302 or 304-L ASTM-B429	
8(a).	Dead End Assembly: Outer Sleeve	EC grade Al of purity not less than 99.50%			

Sl. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
8(b).	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/ IS-2062	
9.	AGS clamp (a) Supporting house	High strength corrosion resistant Al. alloy LM6, 4600 or equivalent 6061	Cast/forged heat treated.	IS:617 or equivalent	
	(b) Al insert and retaining strap	High strength Al alloy type 6061 or equivalent	Forged and Heat treated	ASTM:B429	
	(c) Elastomer cushion	Moulded on Al reinforcement			
10.	P. A. rod	High strength Al alloy type 6061 or equivalent	Heat treatment during manufacturing	ASTM:B429	Min. tensile strength of 35 kg/mm2
11.	Turn Buckle	Class-II Steel	Forged hot dip galvanized	IS:2004	

9.21.0 Workmanship

9.21.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for rated voltage of transmission lines and will give continued good performance.

9.21.2 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and comers to limit corona and radio-interference, best resistance to corrosion and a good finish.

9.21.3 All ferrous parts including fasteners shall be hot dip galvanized, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanizing and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall he done in accordance with IS: 2629 / IS-1367 (Part 13) or equivalent International Standards and shall satisfy the tests mentioned in IS: 2633-1986or equivalent International Standards. Fasteners shall withstand four dips while spring washers shall withstand three dips of one-minute duration in the standard Preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 610 gm / sq.m shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard price test for galvanizing.

9.21.4 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 dimensions below the design requirements.

9.21.5 The zinc coating shall be perfectly adherent of uniform thickness, smooth, reasonably bright. Continuous and free from imperfections such as flux, ash, rust, stains, bulky white deposits and blisters. The zinc used for galvanizing shall be grade Zn 99.95 as per IS: 209or equivalent International Standards.

9.21.6 Pin balls shall be checked with the applicable “GO” gauges in at least two directions. one of which shall be across the line of die flashing, and the other 90o to this line. "NO GO" gauges shall not pass in any direction.

9.21.7 Socket ends, before galvanizing, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions, of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486or equivalent International Standards.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

9.21.8 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm

9.21.9 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

9.21.10 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the inductor in any way during erection or during continuous operation which would product high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.
9.21.11 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.
9.21.12 All fasteners shall have suitable corona free locking arrangement to guard against Vibration loosening.
9.21.13 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process. Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed. There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

9.22.0 Bid Drawings
9.22.1 The Bidder shall furnish full description and illustrations of materials offered.
9.22.2 Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following arrangements shall be furnished in five (5) copies along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.
(i) Attachment of the hanger or strain plate.
(ii) Yoke Plate
(iii) Suspension or dead-end assembly.
(iv) Arcing horn attachment to the string
(v) Hardware fittings of ball and socket type for inter connecting units.
(iv) Corona control rings/grading ring attachment to conductor and other small accessories.
9.22.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:
(i) Dimensions and dimensional tolerance.
(ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
(iii) Catalogue No.
(iv) Marking
(v) Weight of assembly
(vi) Installation instructions
(vii) Design installation torque for the bolt or cap screw.
(viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
(ix) The compression die number with recommended compression pressure.
(x) All other relevant terminal details.
9.22.4 After placement of award, the Contractor shall submit fully dimensioned drawings including all the components in four (4) copies to the Employer for approval. After getting approval from the Employer and successful completion of all the type tests, the Contractor shall submit thirty (10) more copies of the same drawings to the Employer for further distribution and field use at Employer's end.

9.23.0 Completeness of works
Bidder shall assess the complete requirement of line hardware, hardware accessories and assemblies in complete for the erection of the lines as per the recommended erection practices.
The hardware assemblies shall be supplied complete with components, sub-components, nuts, bolts, washer etc. fittings and accessories for conductor & earth wire like Mid Span Joints, Repair Sleeves, and Stockbridge Vibration Dampers.
The Contractor shall also supply all line and tower accessories.

9.24.0 Standards

9.24.1 The Hardware Fittings, conductor and earth wire accessories shall conform to the following Indian Standards or equivalent International Standards, which shall mean latest revisions, amendments/changes adopted and published unless specifically stated otherwise in the specification.

1.	IS: 209	Specification for Zinc.
2.	IS: 398	Specification for Aluminum Conductors. for Overhead Transmission Purposes,
3.	IS: 1327	Method of Determination of Weight of Zinc Coating on Tin Plate.
4.	IS: 1573	Electroplated Coating of Zinc on Iron and Steel
5.	IS: 2121	Specification for Conductors and Earthwire Accessories for Overhead Power Lines
	(Part-1)	Armour Rods, Binding Wires and Tapes for Conductors
	(Part-2)	Mid-span joints and Repair Sleeves for Conductors
6.	IS : 2486	Specification for Insulator Fittings for Overhead Power Lines With a Nominal Voltage Greater than 1 000 V
	(Part 1)	General Requirements and Tests
7.	IS:2629	Recommended Practice for Hot Dip Galvanizing of Iron and Steel
8.	IS:2633	Method of Testing Uniformity of Coating on Zinc Coated Articles
9.	IS:4826	Galvanized Coating on Round Steel Wires
10.	IS : 6639	Hexagonal Bolts for Steel Structures
11.	IS: 6745	Methods for Determination of Weight of Zinc Coating on Zinc Coated Iron and Steel Articles
12.	IS : 8263	Method for Radio Interference Tests on High Voltage Insulators
13.	IS : 9708	Specification for Stock Bridge vibration Dampers for Overhead Power Lines

9.25.0 TESTS

The insulator discs and hardware fittings shall be subjected to the tests before despatch, in accordance with the relevant standards. The successful contractor shall submit the test results in quadruplicate to the Employer.

9.26.0 MARKING

Each insulator disc shall be legibly and indelibly marked with the following:

- Name or trade mark of the manufacturer.
- Month and year of manufacture.
- Minimum failing load in Newton.
- Country of manufacture
- Standard certification mark, if any.

The marking of the porcelain shall be printed and shall be applied before firing.

9.27.0 STANDARDIZED TECHNICAL PARAMETERS

A. 220 kV Transmission Line with ACSR ZEBRA conductor

1. Suspension hardware fittings for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value		
			Single "I" Suspension Fittings with	**Double "I" Suspension Fittings with**	**Single suspension Pilot Fitting**

							with
			AGS clamp	**Free Centre clamp**	**AGS clamp**	**Free Centre clamp**	**Envelope clamp**
1.	Maximum magnetic power loss of one suspension assembly at sub-conductor current of 500 amperes	Watt	2	2	2	2	4
2.	Slipping strength of suspension assembly	KN	16-24	16-24	16-24	16-24	16-24
3.	Particulars of standard/ AGS preformed armour rod set for suspension assembly						
	a) No. of rods per set	No.	12	12	12	12	NA
	b) Direction of lay		Right hand	Right hand	Right hand	Right hand	NA
	c) Overall length after fitting on conductor	mm	2080	2540	2080	2540	NA
	d) Diameter of each rod	mm	7.87	7.87	7.87	7.87	NA
	e) Tolerance in						
	i) Diameter of each rod	±mm	0.10	0.10	0.10	0.10	NA
	ii) Length of each rod	±mm	25	25	25	25	NA
	iii) Difference of length between the longest and shortest rod in a set	±mm	13	13	13	13	NA
	f) Type of Aluminium alloy used for manufacture of PA rod set		6061/ 65032	6061/ 65032	6061/ 65032	6061/ 65032	NA
	g) Minimum UTS of each rod	Kg/mm^2	35	35	35	35	NA
4.	**Particulars of Elastomer (For AGS Clamp only)**						
	a) Type of elastomer		Chloroprene/ Neoprene Rubber	NA	Chloroprene /Neoprene Rubber	NA	NA
	b) Shore hardness of elastomer		65 to 80	NA	65 to 80	NA	NA
	c) Temperature range for which elastomer is designed		Upto 95^o C	NA	Upto 95^o C	NA	NA
	d) Moulded on insert		Yes	NA	Yes	NA	NA
5.	Mechanical strength of suspension fitting(excluding suspension clamp)	KN	70		2 x 70		70
6.	Mechanical strength of suspension clamp	KN	70		70		70
7.	Galvanising						
a)	Weight of Zinc coating for steel parts	gm/m^2	600				
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209: 1992) or 98.5 (IS 13229:1991)				
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute				

2. Tension hardware fittings for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value	
			Single Tension	**Double Tension**
1.	Mechanical strength of Tension fitting(excluding dead end clamp)	KN	120	2x120
2.	Type of dead end assembly		Compression	
3.	Compression pressure	MT	100	
4.	Maximum electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	75	
5.	Slip strength of dead end assembly	KN	123.80	
6.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute	

B. Accessories for ACSR ZEBRA conductor for 220 kV transmission line

1. Mid span compression Joint for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value	
			Aluminium Sleeve	Steel Sleeve
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200	
3.	**Dimension of sleeve Before compression**		Aluminum sleeve	Steel sleeve
i)	Inside diameter	mm	31.00 ± 0.5	10.00 ± 0.2
ii)	Outside diameter	mm	48.00 ± 1.0	20.00 ± 0.5
iii)	Length	mm	710 ± 5	241 ± 5
4.	**Dimensions of Sleeve after compression**		Aluminum sleeve	Steel sleeve
i)	Outside dimension(Corner to corner)	mm	47.00 ± 0.5	19.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5	16.00 ± 0.5
5.	Slip strength	KN	123.8	
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare conductor.	%	75	
7.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154	
8.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000	
9.	Galvanising			
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600	
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)	
c)	Min. No. of dips in standard preece test the ferrous parts can withstand	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute &	

	(wherever applicable)		c) all others: 6 dips of 1 minute

2. Repair sleeve for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value
1.	**Material**		Aluminium of minimum purity 99.5%
2.	**Dimension of Aluminum sleeve Before compression**		
i)	Inside diameter	mm	31.00 ± 0.5
ii)	Outside diameter	mm	48.00 ± 1.0
iii)	Length	mm	275.00 ± 5.0
3.	**Dimensions of Aluminum Sleeve after compression**		
i)	Outside dimension(Corner to corner)	mm	47.00 ± 0.5
ii)	Outside dimension (face to face)	mm	41.00 ± 0.5
4.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154
5.	Maximum Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000

3. Vibration Damper for ACSR ZEBRA Conductor

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	KN	5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	KN	2.5
	(b) After fatigue test	KN	2
7.	Resonance frequencies range	Hz	5 to 45
8.	Maximum magnetic power loss per vibration damper watts for 500 amps, 50 Hz Alternating Current	Watts	1
9.	Minimum corona Extinction voltage kV (rms) under dry condition	kV	154
10.	Maximum Radio Interference Voltage (RIV) at 1 MHz for phase to earth voltage of 154 kV (rms) under dry condition	Micro Volts	1000
11.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
12.	Percentage variation in power dissipation after fatigue test in	%	+/-40 (Maximum)

	comparison with that before fatigue test		
13.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

C. Accessories for 7/3.15 mm GS Earthwire for 220 kV and 132 kV transmission line

1. Mid span compression Joint for 7/3.15 mm GS Earthwire

Sl.	**Description**	**Unit**	**Particulars/ Value**		
			Aluminium / Filler Sleeve	Steel Sleeve	
1.	**Material of Joint**		Aluminium of minimum purity 99.5%	Mild Steel(Fe-410, IS:2062)	
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	From 100 to 200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	315 ± 5	230 ± 5	25 ± 2
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	53.20		
6.	Maximum resistance of the compressed unit expressed, as percentage of the resistance of equivalent length of bare Earthwire	%	75		
7.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute		

2. Flexible Copper Bond for 7/3.15 mm GS Earthwire

Sl.	**Description**	**Unit**	**Particulars/ Value**
1.	Stranding		19 (12+6+1) / dia 2.54
2.	Cross sectional area	Sq.mm	95
3.	Minimum copper equivalent area	Sq.mm	750 + 5
4.	Length of copper cable	mm	Aluminium alloy

5.	Material of lugs		19 (12+6+1) / dia 2.54
6.	Bolt Size		
	i) Diameter	mm	16
	ii) Length	mm	40

3. Vibration Damper for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	Type of Damper		4R-Stockbridge type
2.	Materials of components		
	a) Damper masses		Cast iron/ mild steel hot dip galvanised / Zinc alloy
	b) Clamp		Aluminum alloy 4600
	c) Messenger cable		High tensile strength galvanized steel
3.	Number of strands in stranded messenger cable	Nos.	19
4.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	135
5.	Slip strength of stranded messenger cable (mass pull off)	kN	2.5
6.	Slipping strength of damper clamp		
	(a) Before fatigue test	kN	2.5
	(b) After fatigue test	kN	2
7.	Resonance frequencies range	Hz	10 to 60
8.	Percentage variation in reactance after fatigue test in comparison with that . before fatigue test	%	+/-40 (Maximum)
9.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	+/-40 (Maximum)
10.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

4. Suspension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value
1.	**Material of components**		
	(a) Shackle		Forged Steel
	(b) Clamp Body & Keeper		Malleable cast iron / SGI
	(c) U- Bolt		Mild Steel (Fe 410, IS 2062)
2.	Total Drop (Maximum)	mm	150
3.	Breaking Strength (Minimum)	kN	25
4.	Slipping Strength	kN	9 to 14
5.	Galvanising		
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute

5. Tension Clamp for 7/3.15 mm GS Earthwire

Sl.	Description	Unit	Particulars/ Value		
1.	**Material of components**				
	(i) Anchor Shackle		Forged Steel		
	(ii) Compression Clamp				
	a) Steel Sleeve		Mild Steel (Fe 410, IS 2062)		
	b) Aluminium sleeve		Aluminium of purity 99.5%		
	c) Aluminium Filler sleeve		Aluminium of purity 99.5%		
2.	Range of Hardness of the steel sleeve (Brinnel hardness)	BHN	100-200		
3.	**Dimension of sleeve Before compression**				
			Aluminium Sleeve	Steel Sleeve	Alu filler sleeve
i)	Inside diameter	mm	22.00 ± 0.5	10.00 ± 0.2	11.50 ± 0.2
ii)	Outside diameter	mm	30.00 ± 0.5	21.00 ± 0.5	21.00 ± 0.5
iii)	Length	mm	220 ± 5	180 ± 5	25 .0+2
4.	**Dimensions of Sleeve after compression**				
			Aluminium Sleeve	Steel Sleeve	
i)	Outside dimension(Corner to Corner)	mm	29.40 ± 0.5	20.20 ± 0.5	
ii)	Outside dimension (face to face)	mm	25.00 ± 0.5	17.50 ± 0.5	
5.	Slip strength	KN	53.20		
6.	Minimum Breaking strength of assembly (excluding clamp)	KN	70		
7.	Compression Pressure	Ton	100		
8.	Galvanising				
a)	Minimum weight of Zinc coating for steel parts	gm/m^2	600		
b)	Purity of Zinc used for galvanising	%	99.95 (IS 209) or 98.5 (IS 13229)		
c)	Min. No. of dips in standard preece test the ferrous parts can withstand (wherever applicable)	No.	a) Fasteners: 4 dips of 1 minute b) Spring washers: 3 dips of 1 minute & c) all others: 6 dips of 1 minute		

SECTION-10
TECHNICAL SPECIFICATION OF DISC INSULATORS FOR SUBSTATION AND TRANSMISSION LINE WORKS

10.1.0 SCOPE.

10.1.1 This specification provides for design, manufacture, engineering, inspection and testing before dispatch, packing and delivery at site, testing and commissioning for manufacturers of disc Insulators as per technical requirements furnished in this specification.

These insulators are to be used in suspension and tension insulator strings for the suspension and anchoring of the conductors on EHV transmission line towers.

10.1.2 Following are the list of documents constituting this package.

(i) Technical specification.

(ii) Technical data sheet.

(iii) Drawings of insulators

10.1.3 All the above volumes along with amendments there of shall be read and interpreted together. However, in case of a contradiction between the "Technical Specification" and any other volume, the provisions of this volume will prevail.

10.1.4 The insulators shall conform in all respects to high standards of engineering, design, workmanship and latest revisions of relevant standards at the time of offer and purchaser shall have the power to reject any work or material which in his judgment, is not in full accordance therewith.

10.2.0 STANDARDS:

10.2.1 Except as modified in this specification, the disc/porcelain long rod insulators shall conform to the following Indian Standards, which also includes latest revisions and amendments if any. Equivalent International and Internally recognized standards to which some of these standards generally correspond are also listed below.

Sl. No.	Indian Standard	Title.	International Standard.
1.	IS: 206	Method for Chemical Analysis of Slab Zinc.	
2.	IS: 209	Specification for Zinc.	BS: 3436
3.	IS: 731	Porcelain insulators for overhead power lines with a normal voltage greater than 1000V	BS: 137(I&II); IEC 60274 IEC 60383
4.	IS: 2071 Part-(I)	Method of High Voltage Testing.	
	Part-(II) Part-(III)		
5.	IS: 2121 (Part-I)	Specification of Conductors and Earth wire Accessories for Overhead Power lines. Armour Rods, Binding wires and tapes for conductor.	
6.	IS: 2486	Specification for Insulator fittings for overhead power lines with a nominal voltage greater than 1000V.	
	Part – I	General Requirement and Tests.	BS: 3288
	Part – II	Dimensional Requirements.	IEC: 60120
	Part – III	Locking devices.	IEC: 60372
7.	IS: 2629	Recommended practice for Hot Dip Galvanisation for iron and steel.	
8.	IS: 2633	Testing for Uniformity of Coating of Zinc coated articles.	
9.	IS: 3138	Hexagonal Bolts & Nuts.	ISO/R 947 & ISO/R 272

10.	IS: 3188	Dimensions for Disc Insulators.	IEC: 60305
11.	IS: 4218	Metric Screw Threads	ISO/R 68-1969 R 26-1963, R 262-1969 & R965-1969
12.	IS: 6745	Determination of weight of zinc coating on zinc coated iron and steel articles.	
13.	IS: 8263	Methods of RIV Test of HV insulators.	IEC 60437 NEMA Publication No.107/1964 CISPR
14.	IS: 8269	Methods for switching impulse Test on HV insulators.	IEC: 60506
15.		Thermal mechanical performance test and mechanical performance test on string insulator units.	IEC: 60575
16	IEC	Ceramic Long Rod Insulators	IEC: 60433

10.2.2 The standards mentioned above are available from

Reference.	Name & Address:
BS	British Standards, British Standards Institution, 101, Pentonvile Road, N- 19 ND,U.K
IEC / CISPR	International Electro technical commission Electro Technique International. 1, Rue de verembe Geneva SWITZERLAND.
IS	Bureau of Indian Standards, Manak Bhavan, 9 Bahadurshah Zafar Marg, New Delhi-110001,
ISO	International Organisation for Standardization. Danish Board of Standardization Dansk Standardizing Sraat Aurehoegvej- 12 DK-2900 Helleprup DENMARK.

10.3.0 PRINCIPAL PARAMETERS.

10.3.1 DETAILS OF DISC INSULATORS:

10.3.1.1 The Insulator strings shall consist of standard discs for use in three phases. 50 Hz effectively earthed 33/132/220 KV transmission system of AEGCL in a moderately polluted atmosphere. The discs shall be cap and pin, ball and socket type. Radio interference data and have characteristics as shown in Table-I and all ferrous parts shall be hot dip galvanized as per the latest edition of IS 2629. The zinc to be used for making sleeves shall be 99.95 % pure.

10.3.1.2 The size of disc insulator, minimum creepage distance the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware shall be as follows:

PRINCIPAL PARAMETERS OF THE DISC INSULATORS:-

Sl. No.	Type of String.	Size of disc. Insulator (mm)	Minimum creepage distance of each disc (mm),	No. of standard discs 132 KV /220 KV/400kV	Electro-mechanical strength of insulator string fittings (KN)
1.	Single suspension	255 x 145	320	1x9/1x14 /-	70 KN/90 KN Normal Disc Insulator

2.	Double suspension.	-do-	-do-	2x9/2x14 /-	70 KN/90 KN Normal Disc Insulator
3	Single suspension	255 x 145	430	1x9/1x14 /-	70 KN/90 KN Antifog Insulator
4	Double suspension.	-do-	-do-	2x9/2x14 /-	70 KN/90 KN Antifog Disc Insulator
5.	Single Suspension	280 x 145	430	1x10/1x15 /-	120 KN Anti fog Disc insulator
6.	Double suspension	280 x 145	430	2x10/2x15 /-	120 KN Anti fog Disc insulator
7.	Single Tension	305 X 170	475	1x10/1x15/1x25	160 KN Anti fog Disc insulator
8.	Double Tension	305 X 170	475	2x10/2x15/2x25	160 KN Anti fog Disc insulator
9.	Single Suspension	280 x 145	430	1x10/1x15/1x25	120 KN Anti fog Disc insulator
10.	Double suspension	280 x 145	430	2x10/2x15/2x25	120 KN Anti fog Disc insulator

10.3.2 SPECIFICATION DRAWINGS:

10.3.2.1: The Specification in respect of the disc insulators are described, the specification is 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 in line with the specification.

10.4.1 Porcelain glaze:

The finished porcelain shall be glazed in brown colour. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

10.4.2 METAL PARTS:

10.4.2.1 Cap and Ball Pins:

Ball pins shall be made with drop forged steel caps with malleable cast iron. They shall be in one single piece and duly hot dip galvanized. They shall not contain parts or pieces joined together welded, shrink fitted or by any other process from more than one piece of materials. The pins shall be of high tensile steel, drop forged and heat-treated. The caps shall be cast with good quality black heart malleable cast iron and annealed. Galvanizing shall be by the hot dip process with a heavy coating of zinc of very high purity. The bidder shall specify the grade composition and mechanical properties of steel used for caps and pins. The cap and pin shall be of such design that it will not yield or distort under the specified mechanical load in such a manner as to change the relative spacing of the insulators or add other stresses to the shells. The insulator caps shall be of the socket type provided with nonferrous metal or stainless-steel cotter pins and shall provide positive locking of the coupling.

10.4.2.2 Security Clips:

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

10.4.3 FILLER MATERIAL:

Cement to be used, as a filler material be quick setting, fast 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.

10.4.4 MATERIALS DESIGN AND WORKMANSHIP:

10.4.4.1 GENERAL:

(I) All raw materials to be used in the manufacture of these insulators shall be subject to strict raw material 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 voltages.

10.4.4.2 INSULATOR SHELL:

The design of the insulator shells 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 mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

10.4.4.3 METAL PARTS:

i) The pin and cap shall be designed to transmit the mechanical stress 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 pinball shall be suitably designed so that when the insulator 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.

ii) 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 part or irregularities, which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stress uniformly. Pins shall not show any microscopically visible cracks, inclusions and voids.

10.4.4.4 GALVANIZING:

All ferrous parts, shall be hot dip galvanized in accordance with IS: 2629. The zinc to be used for galvanizing shall conform to grade Zn 99.95 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.

10.4.4.5 CEMENTING:

The insulator design shall. Be such that the insulating medium shall not directly engaged with hard metal. The surface of porcelain and coated with resilient paint to offset the effect of difference in thermal expansions of these materials. High quality Portland cement shall be used for cementing the porcelain to the cap & pin.

10.4.4.6 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 spreading after installation to prevent complete withdrawal from the socket. The locking device shall 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, which placed in position, and under no circumstances shall it allow separation of insulator units and fittings. „W" type security clips are also acceptable. The hole for the security clip shall be counter sunk 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 positions shall not be less than 50 N (5 kg.) or more than 500 N (50 kgs.).

10.4.4.7 MARKING:

Each insulator shall have the rated combined mechanical and electrical strength marked clearly on the porcelain surface. Each insulator shall also bear symbols identifying the manufacturer, month, and year of manufacture. Marking on porcelain shall be printed, not impressed, and shall be applied before firing

10.4.5 BALL AND SOCKET DESIGNATION:

The dimensions of the ball and sockets for 70 and 90 KN insulator strings shall be of 16 mm and for 120 KN and 160 KN insulator strings shall be of 20 mm designation in accordance with the standard dimensions stated in IS: 2486 (Part-II).

10.4.6-DIMENSIONAL TOLERANCE OF INSULATOR DISCS:

It shall be ensured that the dimensions of the disc insulators are within the limits specified below:

Sl. No.	Diameter of Disc (mm)	Standard in Mm	Maximum	Minimum
1.	70 KN/90 KN & 120 KN	**255/255 & 280**	As per IS	As per IS
2.	160 KN	305	As per IS	As per IS
(b)				
Sl. No.	Ball to Ball spacing Between Discs (mm)	Standard in Mm	Maximum	Minimum
1.	70 KN/90 KN/120 KN	**145**	As per IS	As per IS
2.	160 KN	170	As per IS	As per IS

NOTE: Tolerance as per relevant IS (Latest edition).

(**10.4.7**) GUARANTEED TECHNICAL PARTICULARS FOR ANTIFOG DISC INSULATORS

Sl. No.	DESCRIPTION	70 KN	90 KN	120KN	160 KN
1.	Manufacture‟s name &address				
2	Type of Insulator	Ball & Socket	Ball & socket	Ball & socket	Ball & socket
3	Size of ball & socket	16B	16B	20	20
4	Dimensions				
(a)	Disc diameter	255	255	280	305
(b)	Unit spacing	145	145	145	170
(c)	Creepage distance of the single insulator-mm	430	430	430	475
5	Electro-mechanical strength of single insulator-kN	70	90	120	160
6	Materials of shell	Porcelain	Porcelain	Porcelain	Porcelain
7	**Electrical value**				
7.1	Power frequency Withstand Voltage Disc				
	(a) Dry-kV (rms)	80	80	85	90
	(b) Wet-kV (rms)	45	45	50	50
7.2	Power frequency Flashover Voltage Disc				
	(a) Dry-kV (rms)	85	85	90	95
	(b) Wet-kV (rms)	50	50	55	55
7.3	Impulse Withstand Voltage Disc				
	1.2/50 micro second				
	(a) Positive – kV(Peak)	125	125	130	135
	(b) Negative – kV(Peak)	125	125	130	135
7.4	Impulse Flashover Voltage Disc				
	1.2/50 micro second				
	(a) Positive – kV(Peak)	135	135	140	145

	(b) Negative – kV(Peak)	130	130	135	140

10.4.8 INTERCHANGEABILITY:
The insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with hardware fittings of any make conforming to relevant Indian Standards.
10.4.9 CORONA AND RIV PERFORMANCE:
All surfaces shall be even, smooth, without cuts, abrasions or projections. No part shall be subject to excessive localized pressure. The metal parts and porcelain shall not produce any noise-generating corona under all operating conditions
10.5.0 SUITABILITY FOR LIVE LINE MAINTENANCE:
The insulator shall be compatible for use with hot line or live line maintenance techniques so that usual hot line operation can be carried out with easy speed and safety.
10.5.1 FREEDOM FROM DEFECTS:
Insulators shall have none of the following defects:
1) Ball pin shake.
2) Cementing defects near the pin like small blow holes, small hair cracks lumps etc.
3) Sand fall defects on the surface of the insulator.
10.5.2 INSULATOR STRINGS:
10.5.2.1 TYPE AND RATING:
The insulator strings shall be formed with standard discs described in this specification for use on 3 phases 132/220 KV 50 Hz effectively earthed systems in an atmosphere with pollution level as indicated in project synopsis. Suspension insulator strings for use with suspension/tangent towers are to be fitted with discs 70/90 KN EMS rating while tension insulator strings for use with Anchor/ Tension towers are to be fitted with discs of 120 KN / 160 KN EMS level rating.
10.5.2.2 STRING SIZE:
The sizes of the disc insulator, the number to be used in different types of strings, their electro-mechanical strength and minimum nominal creep age distance shall be as given in clause 10.3.1.2.
10.5.3 STRING CHARACTERISTICS
10.5.3.1 The characteristics of the complete string shall be as follows:

Sl. No.	**Description.**	**Suspension.**		**Tension.**	
		132KV	**220kV**	**132KV**	**220KV**
I	Switching surge withstand voltage (dry& wet) KV Peak	-	-	-	-
II	Lighting impulse withstand voltage (dry) KV Peak.	650	1050	650	1050
III	Power frequency without voltage (wet) KV r.m.s.	275	460	275	460
IV.	Corona extinction voltage level KV rms	-	176	-	176
V	Max. RIV for comp. Etc. strong including corona rings at 156 KV (rms). … hours clamps etc. at 1.1. times maximum knee to ground voltage (micro volts).	-	500	-	500
VI.	Mechanical failing load for each string (kgf)	6500	11500	11500	15500
VII.	No deformation load for each string (kgf)	-	7705	-	10385
VIII	Max. voltage across any disc.	13%	13%	13%	13%

10.5.3.2 Insulator units after assembly shall be concentric and coaxial within limits as permitted by Indian Standards.
10.5.3.3 The strings design shall be such that when units are coupled together there shall be contact between the shell of one unit and metal of the adjacent unit.

SECTION-11
TECHNICAL SPECIFICATION OF PORCELAIN LONG ROD INSULATORS

11.1.1 Details of Long Rod Insulators

11.1.2 The insulator string shall consist of standard porcelain long rod insulators with normal sheds for a three phase, 50 Hz, effectively earthed 132/220/400 kV transmission system. Insulators shall be long rod type with Ball and socket connections.

11.1.3 Insulators shell has normal sheds/alternate sheds with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC-60815.

11.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as follows:

11.1.5 Description of long rod insulator string (equivalent to disc insulator string)

Sl. No.	System Voltage (kV)	Type of String.	Length of Porcelain long rod Insulator (mm)	Minimum creepage distance of Porcelain long rod Insulator(mm),	No. of Porcelain long rod Insulator units per string	Electro- mechanical strength of Porcelain long rod Insulator string fittings (KN)
1.	132	Single Suspension	1305	2628	1 X 1	1 X 70kN
2.	132	Double Suspension	1305	2628	2 X 1	2 X 70kN
3.	132	Single Tension	1450	2920	1 X 1	1 X 120kN
4.	132	Double Tension	1450	2920	2 X 1	2 X 120kN
5.	132	Single Suspension	1305	3625	1 X 1	1 X 70kN
6.	132	Double Suspension	1305	3625	2 X 1	2 X 70kN
7.	132	Single Tension	1450	3625	1 X 1	1 X 120kN
8.	132	Double Tension	1450	3625	2 X 1	2 X 120kN
9.	132	Single Tension	1700	3625	1 X 1	1 X 160kN
10.	132	Double Tension	1700	3625	2 X 1	2 X 160kN
11.	220	Single Suspension	2030	4088	1 X 2	1 X 90kN
12.	220	Double Suspension	2030	4088	2 X 2	2 X 90kN
13.	220	Single Tension	2175	4380	1 X 2	1 X 120kN
14.	220	Double Tension	2175	4380	2 X 2	2 X 120kN
15.	220	Single Suspension	2030	5180	1 X 2	1 X 90kN
16.	220	Double suspension	2030	5180	2 X 2	1 X 90kN
17.	220	Single Tension	2175	5550	1 X 2	1 X 120kN
18.	220	Double Tension	2175	5550	2 X 2	2 X 120kN
19.	220	Single Tension	2550	5550	1 X 2	1 X 160kN

20.	220	Double Tension	2550	5550	2 X 2	2 X 160kN
21.	400	Single Suspension	3335	9200	1 X 3	1 X 120kN
22.	400	Double suspension	3335	9200	2 X 3	2 X 120kN
23.	400	Single Tension	3910	9200	1 X 3	1 X 160kN
24.	400	Double Tension	3910	9200	2 X 3	2 X 160kN

(i) Bidders may quote for the relevant strings.

(ii) Length of long rod insulator strings shall be matching with the corresponding disc insulator strings.

11.2.1 STANDARD TECHNICAL PARTICULAR FOR 132 KV LONG ROD INSULATORS

Sl.	**Description**	**Unit**	**Standard Technical Particular value**		
			70 KN/ 90KN Insulator	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**				
a)	Size and Designation of ball & Socket assembly	mm	16 mm Alt-B as per IS 2486 / IEC: 60120	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**				
a)	Core diameter	mm	55 to 75	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	(0.04d+1.5)	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal	mm	2628	2920	-----
	2. Anti Fog		3625	3625	3625
3.0	Colour of glaze of finished porcelain insulator		Brown	Brown	Brown
4.0	Mechanical Strength of Long Rod	kN	70	120	160
5.0	**Minimum electrical values**				
a)	Power frequency **Withstand** voltage	kV rms	310/275	310/275	310/275
b)	Power frequency **Flashover** voltage (DRY/WET)	kV rms	325/295	325/295	325/295
c)	Impulse **Withstand** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(pea k)	650/650	650/650	650/650
d)	Impulse **Flashover** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(pea k)	670/670	670/670	670/670
6.0	Eccentricity of Long Rod				
a)	Max. axial/radial run out		1.2 % of insulator length	1.2 % of insulator length	1.2 % of insulator length

b)	Max. angular displacement	deg	15	15	15
7.0	Galvanizing				
a)	Minimum mass of zinc coating	Gm/ sq.m.	600	600	600
b)	Minimum no. of one-minute dips in the standard preece test	Nos.	6 dips	6 dips	6 dips
c)	Minimum purity of zinc used for galvanizing	%	99.95	99.95	99.95

11.2.2 STANDARD TECHNICAL PARTICULAR FOR 220 KV LONG ROD INSULATORS

Sl.	**Description**	**Unit**	**Standard Technical Particular value**			
			70 KN Insulator	**90 KN Insulator**	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**					
a)	Size and Designation of ball & Socket assembly	mm	-----	16 mm Alt- B as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**		-----			
a)	Core diameter	mm	-----	55 to 75	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	-----	(0.04d+1.5)	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal 2. Anti Fog	mm	----- -----	4088 5180	4380 5550	----- 5550
3.0	Colour of glaze of finished porcelain insulator		-----	Brown	Brown	Brown
4.0	Mechanical Strength of Long Rod	kN	-----	90	120	160
5.0	**Minimum electrical values**		-----			
a)	Power frequency **Withstand**	kV	-----	500/460	500/460	500/460
b)	Power frequency **Flashover**	kV	-----	520/480	520/480	520/480
c)	Impulse **Withstand** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	1050/1050	1050/1050	1050/1050
d)	Impulse **Flashover** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	1100/1100	1100/1100	1100/1100

e)	Corona extinction voltage level	kV	-----	156	156	156
f)	Max. RIV for string including corona rings at 156kV rms	micro volts	-----	500	500	500
6.0	**Eccentricity of Long Rod**					
a)	Max. axial/radial run out			1.2 % of insulator length	1.2 % of insulator length	1.2 % of insulator length
b)	Max. angular displacement	deg	-----	15	15	15
7.0	Galvanizing					
a)	Minimum mass of zinc coating	Gm/ sq.m.	-----	600	600	600
b)	Minimum no. of one minute dips in the standard preece test	Nos.	-----	6 dips	6 dips	6 dips
c)	Minimum purity of zinc used for galvanizing	%	-----	99.95	99.95	99.95

11.2.3 STANDARD TECHNICAL PARTICULAR FOR 400 KV LONG ROD INSULATOR STRING

Sl.	**Description**	**Unit**	**Standard Technical Particular value**			
			70 KN Insulator	**90 KN Insulator**	**120 KN Insulator**	**160 KN Insulator**
1.0	**General**					
a)	Size and Designation of ball & Socket assembly	mm	-----	-----	20 as per IS 2486/ IEC: 60120	20 as per IS 2486/ IEC: 60120
2.0	**Dimensions**		-----	-----		
a)	Core diameter	mm	-----	-----	60 to 75	75 to 85
b)	Tolerance on core diameter	± mm	-----	-----	(0.04d+1.5)	(0.04d+1.5)
c)	Minimum nominal creepage distance 1. Normal	mm	-----	-----	-----	-----
	2. Anti Fog		-----	-----	9200	9200
3.0	Colour of glaze of finished porcelain insulator		-----	-----	Brown	Brown
4.0	Mechanical Strength of Long Rod	kN	-----	-----	120	160
5.0	**Minimum electrical values**		-----	-----		
a)	Power frequency **Withstand** voltage	kV rms	-----	-----	720/680	720/680
b)	Power frequency **Flashover** voltage	kV rms	-----	-----	740/700	740/700
c)	Impulse **Withstand** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	-----	1550/1550	1550/1550

d)	Impulse **Flashover** test voltage 1.2 x 50 µs (Dry) POSITIVE / NEGATIVE	kV(peak)	-----	-----	1600/1600	1600/1600
e)	Wet Switching impulse withstand voltage (POSITIVE / NEGATIVE)	kV(peak)	-----	-----	1050/1050	1050/1050
f)	Corona extinction voltage level	kV rms	-----	-----	320	320
g)	Max. RIV for string including corona rings at 320kV rms	micro volts	-----	-----	1000	1000
6.0	**Eccentricity of Long Rod**					
a)	Max. axial/radial run out		-----	-----	1.2 % of insulator length	1.2 % of insulator length
b)	Max. angular displacement	deg	-----	-----	15	15
7.0	**Galvanizing**					
a)	Minimum mass of zinc coating	Gm/	-----	-----	600	600
b)	Minimum no. of one minute dips in	Nos.	-----	-----	6 dips	6 dips
c)	Minimum purity of zinc used for	%	-----	-----	99.95	99.95

11.2.0 SPECIFICATION DRAWINGS:

This specification is 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 in line with the specification.

11.3.0 GENERAL TECHNICAL REQUIREMENTS:

11.3.1 PORCELAIN:

The porcelain used in the manufacture of the shell shall be 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 vitrification.

11.3.2 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 lustre 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.

11.3.3 METAL PARTS:

11.3.3.1 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.

11.3.3.2 SECURITY CLIPS:

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

11.3.4 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 contract with it and its thickness shall be as small and as uniform as possible.

11.4.0 MATERIAL DESIGN AND WORKMANSHIP:

11.4.1 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.

11.4.2 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.

11.4.3 METAL PARTS:

i) 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.

ii) 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.

11.4.4 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.

11.4.4.1 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.

11.4.5 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.)

11.4.6 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).

11.4.7-DIMENSIONAL TOLERANCE OF PORCELAIN LONG ROD INSULATORS

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

11.5.0 TESTS (FOR DISC/ LONG ROD PORCELAIN INSULATORS):

11.5.1 The following tests shall be carried out on the insulator string and disc insulators.

11.5.2 TYPE TEST:

This shall mean those tests, which are to be carried out to prove the design, process of manufacture and general conformity of the material and product with the intents of this specification. These tests shall be conducted on a representative number of samples prior to commencement of commercial production. The Bidder shall indicate his schedule for carrying out these tests.

11.5.3 ACCEPTANCE:

This shall mean these tests, which are to be carried out on samples taken from each lot offered for pre-despatch inspection for the purpose of acceptance of the lot.

11.5.4 ROUTINE TESTS:

This shall mean those tests, which are to be carried out on each insulator to check the requirements, which are likely to vary during production.

11.5.5 TESTS DURING MANUFACTURE:

Stage tests during manufacture shall mean those tests, which are to be carried out during the process of manufacture to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.

11.5.6 TEST VALUE:

For all type and acceptance tests the acceptance values shall be the value guaranteed by the bidder in the guaranteed technical particulars of the acceptance value specified in this specification of the relevant standard whichever is more stringent for that particular test.

11.5.7 TEST PROCEDURE AND SAMPLING NORMS:

The norms and procedure of sampling for the above tests shall be as per the relevant Indian Standard or the internationally accepted standards. This will be discussed and mutually agreed to between the supplier and purchaser before placement of order. The standards and normal according to which these tests are to be carried out are listed against each test.

11.5.8 TYPE TESTS:

The following type test shall be conducted on a suitable number of individual unit components, materials or complete strings.

11.5.8.1 On the complete insulator string with hardware fittings.

a) Power frequency voltage withstand test with corona control rings and under wet condition. : IEC: 60383

b) Switching surge voltage withstand test under wet condition (For 400kV and above only) : IEC: 60383

c) Impulse voltage withstand test under dry condition. : IEC: 60383

d) Impulse voltage flashover test under dry condition. : IEC: 60383

e) Voltage distribution test. : Applicable only for Disc insulators only

f) Corona & RIV test under dry condition. : As per this specification

g) Mechanical strength test. : As per this specification

h) Vibration. : As per this specification

11.5.8.2 On Insulators:

a) Verification of dimensions. : IS: 731/ IEC: 60383

b) Thermal mechanical performance test: : IEC:60575

c) Power frequency voltage withstand and flashover : IEC: 60383

(I) dry (ii) wet.

d)	Impulse voltage withstand flashover test (dry)	: IEC: 60383
e)	Visible discharge test (dry)	: IS:731
f)	RIV test (dry)	: IS:8263/ IEC: 60437

11.5.9 ACCEPTANCE TESTS:

11.5.9.1 For insulator:

a) Visual examination : IS:731/IEC:60383

b) Verification of dimensions. : IS:731/IEC:60383

c) Temperature cycle test. : IS:731/IEC:60383

d) Galvanizing test. : IS:731/IEC:60383

e) Mechanical performance test. : IEC:60575

f) Test on locking device for ball and socket coupling. : IEC:60372

g) Eccentricity test. : IEC: 60383

h) Electro-mechanical/Mechanical strength test. : IEC: 60383 (Disc/Long Rod)

i) Puncture test. : IS:731 (Applicable only for Discs)

j) Porosity test. : IS:731/IEC:60383

11.5.10 ROUTINE TESTS:

11.5.10.1

For insulators :

a) Visual inspection. : IS:731/IEC:60383

b) Mechanical routine test. : IS:731/IEC:60383

c) Electrical routine test. : IEC:60383 (Applicable only for Discs)

11.5.11 TEST DURING MANUFACTURE: On all components as applicable.

a) Chemical analysis of zinc used for galvanizing. : As per the Specification

b) Chemical analysis, mechanical and metallographic test & magnetic particle inspection for malleable casting : As per the Specification

c) Chemical analysis , hardness test & magnetic particle inspection of forging. : As per specifications

d) Hydraulic Internal Pressure tests on shell : As per specifications

e) Crack detection test for metal parts. : As per specifications

11.5.12 ADDITIONAL TEST:

The purchaser reserves the right for carrying out any other tests of a reasonable nature at the works of the supplier/ laboratory or at any other recognized laboratory/ research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the purchaser to satisfy that the material complies with the intent of this specification.

11.5.13 CO-ORDINATION FOR TESTING:

For insulator strings, the supplier shall arrange to conduct testing of their Porcelain disc / long rod insulators with the hardware fittings to be supplied to the purchaser by other suppliers. The supplier is also required to guarantee overall satisfactory performance of the disc/ long rod insulator with the hardware fittings.

NOTE:

In respect of electrical tests on a complete string consisting of insulators and hardware guarantee of values of responsibility of testing shall be with hardware manufacturer of RIV, corona and voltage distribution test (Applicable for Disc insulator strings only) and with insulator manufacturer for all other tests.

11.5.14 TEST CHARGES AND TEST SCHEDULE:

11.5.14.1 TYPE TEST:

The insulator offered shall be fully type tested as per this specification. In case the equipment of the type and design offered, has already been type tested in an independent test laboratory. The bidder shall furnish four sets of type test reports alongwith the offer. These tests must not have been conducted earlier than five years. The purchaser reserves

the right to demand repetition of some or all type tests in the presence of purchasers" carrying representative. For this purpose the bidder may quote unit rates for carrying out each type test. These prices shall be taken into consideration for bid evaluation. For any change in the design/type already type tested and the design/type offered against this specification, purchaser reserves the right to demand repetition of tests without any extra cost.

11.5.14.2 ACCEPTANCE AND ROUTINE TEST:

All acceptance and routine tests as stipulated herein shall be carried out by the supplier in the presence of purchaser's representative.

11.5.14.3 Immediately after finalisation of the programme of type/ acceptance/ routine testing, the supplier shall give sufficient advance intimation to the purchaser to enable him to depute his representative for witnessing the tests.

For type tests involving tests on a complete insulator string with hardware fittings, the purchaser will advice the supplier of the hardware fittings to provide the necessary fittings to the place of the test.

11.5.14.4 In case of failure of the complete string in any type tests, the supplier whose product has failed in the tests, shall get the tests repeated at his cost. In case of any dispute, assessment of the purchaser as to the items that has caused the failure in any of the type tests shall be final and binding.

11.6.1 INSPECTION:

i. Purchaser and its representative shall at all times be entitled to have access to the works and to all places of manufacturer where insulators are manufactured and the supplier shall afford all facilities to them for unrestricted inspection of the works, inspection of materials, inspection of manufacturing process of insulators and for conducting necessary tests as specified herein.

ii. The supplier shall keep the purchaser informed in advance of the time of starting and of progress of manufacture of insulators in its various stages so that arrangements could be made for inspection.

iii. No material shall be dispatched from its point of manufacture unless the materials has been satisfactorily inspected and tested.

iv. The acceptance of any quantity of insulators shall in no way relieve the supplier of his responsibility for meeting all the requirement of this specification and shall not prevent subsequent rejection, if such insulators are later found to be defective.

11.6.2 IDENTIFICATION / MARKING:

11.6.2.1 Each unit of insulator shall be legibly and indelibly marked with the trade mark of the supplier, the year of manufacture, the guaranteed combined mechanical and electrical strength in kilo-newtons abbreviated by „KN" to facilitate easy identification and proper use.

11.6.2.2 The marking shall be on porcelain for porcelain insulators. The marking shall be printed and not impressed and the same shall be applied before firing.

11.7. QUALITY ASSURANCE PLAN:

11.7.1 The bidder hereunder shall invariably furnish following information along with his offer, failing which the offer shall be liable for rejection.

i. Statement giving list of important raw materials, names of sub-suppliers for the raw materials, list of standards according to which the raw material are tested, list of tests normally carried out on raw materials in presence of bidder's representative, copies of test certificates.

ii. Information and copies of test certificates as in (i) above in respect of bought out materials.

iii List of manufacturing facilities available.

iv Level of automation achieved and lists of area where manual processing exists.

v List of areas in manufacturing process, where stage inspections are normally carried out in quality control and details of such tests and inspection.

vi Special features provided in the equipment to make it maintenance free.

vii. List of testing equipping available with the bidder for final testing of equipment specified and test plant limitation, if any, vis-à-vis the type, special, acceptance and routine tests specified in the relevant standards. These limitations shall be very clearly brought out in schedule of deviations from specified test requirements.

11.7.2 The supplier shall within 30 days of placement of order submit the following information to the owner.

i) List of raw material and the names of sub-suppliers selected from those furnished along with the offer

Sl No	Description	EMS value	No of Discs	Size of Disc (mm)	CD of Disc (mm)	No of PLRI	Size of PLRI (mm)	CD of PLRI (mm)
1	132kV Single Suspension string	70/90KN – Normal	1 X 9	255 x 145	320	1 X 1	1305	2628
2	132kV Double Suspension string	70/90KN – Normal	2 X 9	255 x 145	320	2 X 1	1305	2628
3	132kV Single Suspension string	70/90KN – Anti Fog	1 X 9	255 x 145	430	1 X 1	1305	3625
4	132kV Double Suspension string	70/90KN – Anti Fog	2 X 9	255 x 145	430	2 X 1	1305	3625
5	132kV Single Suspension string	120KN – Anti Fog	1 X 10	280 x 145	430	1 X 1	1450	3625
6	132kV Double Suspension string	120KN – Anti Fog	2 X10	280 x 145	430	2 X 1	1450	3625
7	132kV Single Tension string	160KN – Anti Fog	1 X 10	305 x 170	475	1 X 1	1700	3625
8	132kV Double Tension string	160KN – Anti Fog	2 X10	305 X 170	475	2 X 1	1700	3625
9	220kV Single Suspension string	90KN – Normal	1 X 14	255 x 145	320	1 X 2	2030	4088
10	220kV Double Suspension string	90KN – Normal	2 X 14	255 x 145	320	2 X 2	2030	4088
11	220kV Single Suspension string	90KN – Anti Fog	1 X 14	255 x 145	430	1 X 2	2030	4380
12	220kV Double Suspension string	90KN – Anti Fog	2 X 14	255 x 145	430	2 X 2	2030	4380
13	220kV Single Suspension string	120KN – Anti Fog	1 X 15	280 x 145	430	1 X 2	2175	5180
14	220kV Double Suspension string	120KN – Anti Fog	2 X15	280 x 145	430	2 X 2	2175	5180
15	220kV Single Tension string	160KN – Anti Fog	1 X 15	305 x 170	475	1 X 2	2550	5550
16	220kV Double Tension string	160KN – Anti Fog	2 X15	305 X 170	475	2 X 2	2550	5550
17	400kV Single Suspension string	120KN – Anti Fog	1 X 25	280 x 145	430	1 X 3	3335	9200

Sl No	**Description**	**EMS value**	**No of Discs**	**Size of Disc (mm)**	**CD of Disc (mm)**	**No of PLRI**	**Size of PLRI (mm)**	**CD of PLRI (mm)**
18	400kV Double Suspension string	120KN – Anti Fog	2 X25	280 x 145	430	2 X 3	3335	9200
19	400kV Single Tension string	160KN – Anti Fog	1 X 25	305 x 170	475	1 X 3	3910	9200
20	400kV Double Tension string	160KN – Anti Fog	2 X25	305 X 170	475	2 X 3	3910	9200

APPENDIX-A

Table A-1

Typical transmission line details (To be filled by the Bidder)

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32º C) and full wind condition – Earthwire) in kg	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53ºC (in mtrs)	UTS – Earthwire (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A1	B1	C1
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

SECTION-12
TECHNICAL SPECIFICATION FOR OPTICAL GROUND WIRE (OPGW)

12.1. FIBRE OPTIC CABLES PARTICULAR SPECIFICATIONS (OPGW AND APPROACH CABLES)

12.1.1 OVERVIEW AND GENERAL REQUIREMENTS

OPGW and approach cables are required to provide:

- Ground/earth shielding of the 132KV/220KV/400 KV new lines under this project and
- Use the OPGW/Approach fibre component to the new 132KV/220KV/400KV grid substations of AEGCL to the existing Fibre Optic Network that can support grid communications with SLDC. The proposed augmentation will enable integration of SAS of the grid substations to SLDC. The new Fibre Optic Network will also enable transmission of Tele-protection and Tele-control Signalling; other Data transfer, Voice/Telephony and an Energy Management (EMS) System as fibre media-based functions of its grid communications network and enhanced operation and maintenance of Assam's transmission system and also non power utility communications.

12.1.2 STANDARDS

The following standards and codes shall be generally applicable to the equipment and Works supplied under this Contract:

(1) American Society for Testing and Materials ASTM-B415, ASTM-D1248, ASTM D3349.

(2) ITU-T/CCITT Recommendations G.650, G.652, G.653, G.655.

(3) Institute of Electrical and Electronics Engineers IEEE-812, 1138-1994, IEEE-524, IEEE-828 & 830 and latest amendment of IEEE 1138.

(4) Electronic Industries Association, EIA-455-3, 455-25A, 455-31B, 455-32, , 455-41, 455-91, 455-78, 455- 59, 455-80, 455-81, 455-169, 455-81, EIA RS 598

(5) International Electro technical Commission standards, IEC -1396 and IEC - 1089.

(6) International Electro technical Commission standards, IEC 61395, IEC 793-1, 793-2, 794-1, 794-2, IEC-529, IEC 60794-1-2, IEC 60794-4-10.

Specifications and codes shall be the latest version, inclusive of revisions, which are in force at the date of the contract award. Where new specifications, codes, and revisions are issued during the period of the contract, the Bidder shall attempt to comply with such, provided that no additional expenses are charged to the Owner without Owner's written consent.

In addition, and particular recognition of this Contract's purpose to deliver a Fibre based power utility grid operation communication network the following reference documents are to be made available to the Employer its Project Manager and there content reflected as appropriate in the Contractor's Facilities detailed engineering design and implementation programme. These additional reference documents are:

i. CIGRE Guide for Planning of Power Utility Digital Communications Networks

ii. CIGRE Optical Fibre Planning Guide for Power Utilities

iii. CIGRE New Opportunities for Optical Fibre Technology in Electricity Utilities

iv CIGRE guide to fittings for Optical Cables on Transmission Lines.

12.1.3 BASIC TECHNICAL DATA

12.1.3.1 Site and Service Conditions

The OPGW and the Communication Equipment covered under this Contract are to run entirely within the State of Assam, India and shall be suitable for the topical climatic conditions prevailing in the Project areas as mentioned in chapter 2 of this bidding document.

12.1.3.2 Fibre optic cabling

The OPGW shall have 96 nos. optical fibres. The OPGW cable, associated hardware and fittings shall meet the requirements of G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life

span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

12.1.3.3 Required optical fibre characteristics

The optical fibre to be provided should have following characteristics.

12.1.3.4 Required Optical Fibre Characteristics

The optical fibre to be provided should have following characteristic.

12.1.3.5 Physical Characteristic

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

12.1.3.6 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 1-1 (a) shall be "guaranteed" fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Maximum attenuation @ 1310nm: 0.35dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors.

Table-1

DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 µm (± 0.6 µm)
Cladding Diameter:	125.0 µm ± 1 µm
Mode field concentricity error	≤ 0.6µm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength lcc	≤ 1260 nm
1550 nm loss performance	As per ITU-T G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/nm^{2}xkm maximum
Polarization mode dispersion coefficient	≤0.2 ps/km$^{\lambda 1/2}$
Temperature Dependence:	Induced attenuation £ 0.05 dB (-60°C - +85°C)
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

12.1.3.7 Fibre Optic Cable Construction

The OPGW (Optical Ground Wire) cable is proposed to be installed on the EHV transmission lines. The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines.

12.1.3.8 Optical Fibre Cable Link Lengths

The estimated optical fibre link lengths are provided in Appendices/Section Project/BoQ as transmission line route length. However, the Contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contractor shall verify the transmission line route length during the survey and the Contract price shall be adjusted accordingly.

For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price Schedules shall take into account all such factors.

12.1.3.9 Optical Fibre Identification

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres is included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

12.1.3.10 Buffer Tube

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

12.1.3.11 Optical Fibre Strain & Sag-Tension chart

The OPGW cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25-year cable creep.

For the purpose of this specification, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- The no fibre strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry
- The Cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition.
- The cable max strain is defined as the maximum strain experienced by the Cable under the worst-case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate /Rated Tensile Strength (UTS/ RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break. While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:
- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.

- The 25-year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

1. 53° C , no wind and no ice
2. 32° C, no wind and no ice
3. 0°C, no wind and no ice
4. 32° C, full wind and no ice
5. 32° C, 75% full wind and no ice
6. 0° C, 2/3rd / 36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to max. span length in the range of 50 m spans. Max. Vertical sag, max. tension and max sag at 0° C & no wind shall be considered in line with the design parameter of transmission line. The typical details are indicated in the Appendix A. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines.

12.1.3.12 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

12.1.3.13 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibiting moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC 60794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

12.1.3.14 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

12.1.3.15 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line & segment no., factory inspection stamp and date.

(b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor and approved by the owner.

12.1.3.16 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and

performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

12.1.3.17 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless-steel tube with aluminium or aluminium–clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless-steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

Transmission Line Voltage and Wind Zone	**OPGW Cable Parameters**						
	UTS (kg)	**Area (sqmm)**	**Wt (Kg/m)**	**Dia (mm)**	**Modulus of Elasticity (Kg/sqmm)**	**Coeff of Linear Expansion (per deg c)**	**Central Fibre Optic Unit Design**
400kV M/C WZ 1-4 400kV D/C WZ 1-5	9350± 150	56.5±2.5	0.45±0.01	12±0.2	14290±110	0.0000138± 0.0000003	Al tube
220kV D/C WZ 1-4 132kV D/C WZ 1-5	7376±50	51±2	0.355±0.01	11.4±0.2	12344±100	0.0000149± 0.0000003	Al Tube
River Crossing Section	20059± 100	118±5	0.884±0.01	14.7±0.2	16355±100	0.0000127± 0.0000003	Stainless Steel Tube

Table: OPGW Parameters to be considered for different line voltage and wind zone

12.1.3.18 Basic Construction

The OPGW cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 1.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices unless otherwise agreed to by the Employer and shall conform to all applicable clauses of IEC 61089 as they pertain to

stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

12.1.3.19 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

12.1.3.20 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earth wire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes of determining the appropriate Max Working Tension limit for the OPGW cable IS 802:1995 and IS 875: 1987 shall be applied. However, the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts, the limits specified in this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 1.2(a)

OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 1.0 ohm/Km
(3)	**Short Circuit Current**	≥ 6.32 kA for 1.0 second

12.1.3.21 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

12.1.3.22 Installation

OPGW installed under live line condition, i.e. with all circuits charged to the rated line voltage as specified in this section shall be generally in accordance with the IEEE Guide to the Installation of Overhead Transmission Line Conductors (IEEE STD. 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling.

A tower structural analysis shall be carried out by the Contractor wherever required, based on the relevant data to be provided by Employer, to ensure that with the replacement of existing earth wire with the OPGW cable, the tower members remain within the statutory safety limits as per Indian Electricity rules and if required the Contractor shall carry out the tower strengthening as necessary at no additional cost to Employer. The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on Employer specific approval, cable may be terminated on Suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the Contractor at no additional cost to Employer.

12.1.3.23 Installation Hardware

The scope of supply includes all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation minimum@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to Employer. The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and

markings as specified in clause 4.0 of EN 61284: 1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts:

(1) A technical particular sheet

(2) An assembly drawing i.e. level 1 drawing and

(3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies: Preformed armour grip suspension clamps and aluminium alloy armour rods/ reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25 KN. The suspension clamps slippage shall occur between 12kN and 17 kN as measured. The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. The total drop of the suspension assembly shall not exceed 150 mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor.

(b) Dead End Clamp Assemblies: All dead-end clamp assemblies shall preferably be of performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

(c) Clamp Assembly Earthing Wire: Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead-end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

(d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such that clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the

recommendations of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions. The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation. The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows

Sl No	Description	Technical Particulars
1	Span Length in meters (i) Ruling design span: (ii) Maximum span: (iii) Minimum Span:	 400 meters 1100 meters 100 meters
2	Configuration:	As per Specifications
3	Tensile load in each:	As per sag tension calculations
4	Armour rods used:	Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain:	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Contractor.

Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.

(2) Placement distances clearly identifying the extremities between which the distances are to be measured.

(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)

(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

12.1.3.24 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply with ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures. Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anticlimb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be

responsible for splicing of fibres and installation of splice enclosures.

12.1.3.25 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

12.1.3.26 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the appendices/BoQ. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

12.1.3.27 Basic Construction

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

12.1.3.28 Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

12.1.3.29 Optical, Electrical and Mechanical Requirements

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

12.1.4.0 Fibre Optic Distribution Panel

Fibre Optic Distribution Panels is required for each location for termination of fibres in a manner consistent with the following:

(a) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

(b) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement

(c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

12.1.5.0 Optical Fibre Connectors

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively, connector with matching patch cord shall also be acceptable. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

12.1.5.1 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.
(a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.
(b) Indoor Cable Service Loops: FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.
(c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.
(d) Pigtail Service Loops : Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least one (1) metre of service loop to the couplings neatly stored behind the FODP coupling panels.
(e) Fibre Service Loops : At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

12.1.6.0 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipment are enumerated in Table 1.3 below and Chapter " Spares and Tools"

In

Table 1.3

Sl No	**Test Equipment**	
A.	**Test Equipment for OPGW cable**	
1	OTDR (Optical Time Domain Reflectometer) for 1310/1550 nm	
2	Optical Attenuators (variable 1310/1550nm).	
3	Optical Power meter (1310/1550nm)	
4	Laser Light Source (1310/1550nm)	
5	Optical Fibre Fusion Splicer incl. Fibre cleaver etc	
6	OFC Tool kit consisting of Fibre stripping tool and tools for cutting and stripping of sheathing, jacket armouring of OFAC/ADSS/OPGW cables including two nos of high resolution hand held Binoculars	
7	Optical test accessory kit including all Necessary connectors, adaptors, cables, terminations and other items required for testing	

case the offered make/model of test equipment has multiple options for the parameters, the option of higher range shall be acceptable. The supplied test equipment shall be suitable for use in the high EMI/EMC environment. The Contractor shall submit performance certificate for offered test equipment from at least one customer.

12.1.7.0 Inspection & Testing Requirement

All materials furnished and all work performed under this Contract shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, and all deficiencies have been corrected to comply with this Specification and approved for shipment by the Employer.
Except where otherwise specified, the Contractor shall provide all manpower and materials for tests, including testing facilities, logistics, power and instrumentation, and replacement of damaged parts. The costs shall be borne by the

Contractor and shall be deemed to be included in the contract price.
The entire cost of testing for factory, production tests and other test during manufacture specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.
Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.
All tests shall be witnessed by the Employer and/or its authorized representative (hereinafter referred to as the Employer) unless the Employer authorizes testing to proceed without witness. The Employer representative shall sign the test form indicating approval of successful tests.
Should any inspections or tests indicate that specific item does not meet Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies at no cost to the Employer. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.
The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

12.1.8.0 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

12.1.9.0 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:
(a) All cable & equipment being supplied shall conform to type tests as per technical specification.
(b)The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.
(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer's representatives. In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.
In case the Type Test is required to be carried out, then following shall be applicable:-
(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.
(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.
(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.
In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected

from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

12.1.9.1 Type Test Sample

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

12.1.9.2 List of Type Tests

The type testing shall be conducted on the following items

(a) Optical fibres
(b) OPGW Cable
(c) OPGW Cable fittings
(d) Vibration Damper
(e) Splice Enclosure (Joint Box)
(f) Approach Cable

12.1.9.3 Type Tests for Optical Fibres

The type tests listed below in table 2-1 shall be conducted on DWSM fibres to be supplied as part of overhead cables. The tests specific to the cable type are listed in subsequent sections.

SL. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	As per Section-01 of TS	IEC 60793-1-40Or EIA/TIA 455-
2	Attenuation Variation with Wavelength		IEC 60793-1-40 Or EIA/TIA 455-78A
3	Attenuation at Water Peak		IEC 60793-1-40
			Or EIA/TIA 455-78A
4	Temp. Cycling (Temp dependence of Attenuation)		IEC 60793-1-52 Or EIA/TIA 455-3A, 2 cycles
5	Attenuation With Bending(Bend Performance)		IEC 60793-1-47 Or EIA/TIA 455-62A
6	Mode Field dia.		IEC 60793-1-45 Or EIA/TIA 455-164A/167A/174
7	Chromatic Dispersion		IEC 60793-1-42 Or EIA/TIA 455-168A/169A/175A
8	Cladding Diameter		IEC 60793-1-20 OrEIA/TIA 455-176
9	Point Discontinuities of		IEC 60793-1-40 Or
	attenuation		EIA/TIA 455-59
10	Core -Clad concentricity error		IEC 60793-1-20 OrEIA/TIA 455-176

11	Fibre Tensile Proof Testing		IEC 60793-1-30 Or EIA/TIA 455-31B

12.1.9.4 Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 2-2 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

S. No.	**Test Name**	**Test Description**	**Test Procedure**
1	**Water Ingress Test**	**IEEE 1138-2009**	**IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B) : Test duration : 24 hours**
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794 4-10 / IEC 60794-1-2, Method E19	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with the tension/suspension clamps

				proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed
S. No.	**Test Name**	**Test Description**	**Test Procedure**	
5	Galloping test	EEE 1138-2009	IEEE 1138-2009	Test shall be conducted with the tension/suspension clamps proposed to be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	Fibre attenuation shall be continuously monitored and recorded through a digital data logging system or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	The crush test shall be carried out on a sample of approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138-	IEEE 1138-2009,	The impact test shall be carried out in

		2009	(IEC 60794-1-2 E4/ EIA/TIA 455-25B)	accordance with IEC 60794-1-2 E4. Five separate impacts of 0.1- 0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.

S. No.	Test Name	Test Description	Test Procedure	
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain margin limits shall also be calculated.
11	Fibre Strain Test	IEEE 1138-1994	IEEE 1138-1994	
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009	
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009	
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-2009	
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1	
16	Corrosion (Salt Spray) Test	EIA/TIA 455-16A		
17	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.	
18	Lightning Test	IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.	

19	DC Resistance Test (IEC 60228)	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.

12.1.9.5 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly

Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16o. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre

optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one-minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one-minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

*Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 -17 kN.
- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.
- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.
- The Armour Rods shall not be displaced from their original lay or damaged**.

** Definition of no damage in accordance with convention expressed in IEC 61284:

1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead –End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increase up to 95 % of the UTS and maintained for one minute. After one-minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.

- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage. Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall

be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also, the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

12.1.9.6 Type Test on Vibration Damper

(a) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five dampers shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits: V.D. for OPGW - 0.060 f to 0.357 f kgf/mm* Where f is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25o to 130o within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

(i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and

vibration energy input.
(v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.
(vi) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.
The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.
(c) Fatigue Tests
(i) Test Set Up
The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement.
After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.
(ii) Fatigue Test
The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.
The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ±25/f mm where f is the frequency in Hz.
The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above.
During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.
The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.
After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.
For purposes of acceptance, the following criteria shall be applied:
(1) There shall not be any resonant frequency shift before and after the test by more than ± 20%
(2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20% Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper.

Sl No	Test Name	Test Procedure
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

12.1.9.7 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40□C to +65□C with a dwell time of at least 2 hours on each extreme. Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55□C ±2□C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than ±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the

joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

12.1.9.8 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Sl No	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling	(EIA 455-81A)
	compound	Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles

12.1.9.10 Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

12.1.9.11 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical

specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general, the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc. For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

12.1.9.12 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items. Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

12.1.9.13 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

12.1.9.14 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above-mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 2-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

Sl No	Test Name	Acceptance Criteria	Test Procedure
1	Attenuation Coefficient	T S,Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Point Discontinuities of attenuation	TS ,Table 2-1(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity		EIA/TIA 455-/176

	Error		
6	Cladding diameter		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		EIA/TIA 455-31B

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

12.1.9.15 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 2-5
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

Sl No	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

12.1.9.16 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 2-6
Factory Acceptance Tests On OPGW Fittings

S. No.	**Factory Acceptance Test**
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings

8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
Factory Acceptance Test	
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp fit test
21	Clamp Strength test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings

12.1.9.17 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 2-7

Factory Acceptance Tests On Approach Cable

Sl No	**Factory Acceptance Test**
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

12.1.9.18 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2 8

Table 2-8

Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	**Factory Acceptance Test**
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

12.1.9.19 Factory Acceptance Test on Test Equipment & other items

As per technical specification and approved DRS/Documents.

12.1.9.20 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.
The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.
During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

12.1.9.21 Minimum Site Acceptance Testing Requirement for FO Cabling

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

12.1.9.22 Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links. The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents. Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be documented. Upon completion of a continuous cable path, all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Table 2- 9(a) through 2-9(c) below:

Table 2-9(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3	Fibre Optic Cable length measurement using OTDR

Table 2-9(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1	Per splice bi-directional average attenuation with OTDR
2	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3	Physical inspection of sealing techniques, weatherproofing, etc.

Table 2-9(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.

3	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.

12.1.10 Installation of OPGW Cabling

12.1.10.1 OPGW cable installation requirements

The following shall be under the scope of OPGW Cabling:

- Supply of OPGW Cable & Hardware Fittings needed to tie the OPGW cable to the towers/gantries.
- Supervision of stringing of OPGW Cable at sites as per instruction by Employer. The supervision shall include the inspection as per stringing procedure, proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations
- The Splicing work of OPGW Cable and after that testing of link.

12.1.10.3 Installation Hardware

All required hardware's shall be installed along with OPGW Cable.

12.1.10.4 Installation of Approach Cable

The existing cable trenches/ cable raceways proposed to be used shall be identified in the survey report. The Contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be provided after Employer approval. However, the approach cable shall be laid in the HDPE pipe in all condition. Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable. All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for laying and installation of approach cables shall be supplied and installed by the Contractor.

12.1.10.5 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack /wall mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

12.1.10.6 Fibre Optic Distribution Panel

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

(a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

(b) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

12.1.10.7 Methodology for Installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step

discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

12.1.11.0 Cable Raceways

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

(a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anticorrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to- paint bond.

(c)Mechanical construction drawings of the cable raceways shall be submitted for Employer’s information & review

APPENDIX-A

Table A-1

Typical transmission line details (To be filled by the Bidder)

Line Voltage	S/C or D/C	Nominal Span (E/W & Conductors in mtrs.)	Wind Zone as per IS 802	Design Tension at Every Day Temp (32º C) and full wind condition – Earthwire) in kg	Wind Pressure (kg/Sq-m) considering gust factor	Max Sag – Ground Wire at 53ºC (in mtrs)	UTS – Earthwire (in Kg)	Weight – Earth wire (in Kg/km)	Minimum Clearance in mtrs.		
									A1	B1	C1
400KV	S/C										
	D/C										
220 KV	S/C										
	D/C										
132 KV	S/C										
	D/C										

A1 Minimum clearance between conductor and ground (in meters)

B1 Minimum clearance between two phase conductors (in meters) – vertical in case of D/C towers and horizontal in case of S/C towers.

C1 Minimum clearance between conductor and earth wire (in meters)

SECTION-13
TECHNICAL SPECIFICATION AAAC CONDUCTORS AND ACCESSORIES FOR CONDUCTOR

13.1.0 SCOPE

13.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor and accessories for Power Conductors.

13.2.0 POWER CONDUCTOR

13.2.1 TYPE OF CONDUCTOR

The Power Conductor shall be stranded, 37/4.00 mm size (AAAC Zebra) and 37/3.15mm size (AAAC Panther) all aluminium alloy conductor (AAAC) conforming to IS: 398, Part-IV.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

13.2.2 TECHNICAL PARTICULARS

All Aluminium Alloy Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

13.2.3 MATERIAL

All Aluminium Alloy Conductor shall be stranded consisting of heat treated aluminium magnesium silicon alloy wires (Strands) containing approximately 0.5% magnesium and approximately 0.5% silicon.

13.2.4 JOINTS IN WIRE

In conductors containing more than seven wires, joints in individual wires are permitted in any layer except the outermost layer (in addition to those made in the brass rod or wire before final drawing) but no two such joints shall be less than 15 m apart in the complete stranded conductor, such joint shall be made by resistance or cold pressure butt welding. They are not required to fulfil the mechanical requirement of un-jointed wires. Joints made by resistance butt welding shall, subsequent to welding, be annealed over a distance of at least 200 mm on each side of the joint.

13.2.5 STRANDING

The wires used in construction of a stranded All Aluminium Alloy Conductor (AAAC) shall, before and after stranding, satisfy all requirements as per IS 398 (Part-IV).

The lay ratio of the different layers shall be with in the limits as per the said Standard.

In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded.

In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

13.2.6 ROUTINE/ACCEPTANCE TESTS

The samples of individual wires for the test shall normally be taken before stranding. The manufacture shall carry out test on samples taken out at least from 10 % of the aluminium wire spools. However, when desired by the Employer, the test sample may be taken from the stranded wires. The wires used for alloy conductors shall comply with the following tests as per IS: 398 –Part - IV) (amended up to d):

i) Breaking load test

ii) Elongation test

iii) Resistance test.

13.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

13.2.8 PACKING

13.2.8.1 All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

13.2.8.2 All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

13.2.8.3 All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

13.2.8.4 The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

13.2.8.5 The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

13.2.9 TECHINCAL DATA SHEET FOR CONDUCTOR

AAAC Zebra

Sl. No	DESCRIPTION	PARTICULARS
I	II	III
1	Type of Conductor	All Aliminium Alloy Conductor (AAAC), Stranded
2	No of Strand x size	37 x 4.00 mm
3	Conductor over all diameter	28.00 mm
4	Total sectional area	465 mm^2
5	Approx. weight	1280.5 kg/km
6	Minimum UTS	136.38 Kn
7	Modulus of Elasticity (Final)	0.5814 kg/cm^2
8	Coefficient of linear expansion	23.0 x 10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.0734 ohms/km
10	Particulars of Aluminium Alloy Wires (strands)	
	(a) Wire Diameter (i) Standard: (ii) Maximum: (iii) Minimum:	 4.00 mm 4.04 mm 3.96 mm
	(b) Resistivity of wire	0.0328 ohms.mm^2/m
	(c) Density	2.70 kg/dm^2
	(d) Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	(e) Cross Sectional area of Aluminium wire	12.57 mm^2
	(f) Approximate Total weight of each strand	33.93 kg/km
	(g) Calculated resistance at 20°C (D.C.)	2.663 ohm/km
	(h) Minimum Breaking Load of each strand	4.40 Kn – before stranding 4.18 Kn – after stranding

AAAC PANTHER

Sl. No	**DESCRIPTION**	**PARTICULARS**
		IV
1	Type of Conductor	All Aliminium Alloy Conductor (AAAC), Stranded
2	No of Strand x size	37 x 3.15 mm
3	Conductor over all diameter	22.05 mm
4	Total sectional area	288 mm^2
5	Approx. weight	794.05 kg/km
6	Minimum UTS	84.71 kN
7	Modulus of Elasticity (Final)	0.5814 kg/cm^2
8	Coefficient of linear expansion	23.0 x 10^{-6} /^{0}C

Sl. No	DESCRIPTION	PARTICULARS
		IV
9	Calculated maximum resistance/Km of Conductor at 20°C	0.1182 ohms/km
10	Particulars of Aluminium Alloy Wires (strands)	
	(i) Wire Diameter (iv) Standard: (v) Maximum: (vi) Minimum:	 3.15mm 3.18 mm 3.12 mm
	(j) Resistivity of wire	0.0328 ohms.mm^2/m
	(k) Density	2.70 kg/dm^2
	(l) Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	(m) Cross Sectional area of Aluminium wire	7.793 mm^2
	(n) Approximate Total weight of each strand	21.04 kg/km
	(o) Calculated resistance at 20°C (D.C.)	4.290 ohm/km
	(p) Minimum Breaking Load of each strand	2.41 kN – before stranding 2.29 kN – after stranding

13.3.0 GROUND WIRES

Optical ground wire (OPGW) shall be used as mentioned in Bid.

13.4.0 FITTINGS AND ACCESSORIES FOR CONDUCTORS

13.4.1 The accessories for conductors shall conform to IS: 2121 and 2486 (Latest version) in all respects.

13.4.2 The tension joints and repaired sleeves in the conductors shall be of compression type. The joints shall be such that in electrical resistance of the joints measured between two points just beyond the fittings shall not exceed 75% of that of an equivalent length of the conductor without joint and shall be capable to withstand a load of 95% of the breaking load of the conductor itself.

13.4.3 The non tension joints such as the parallel groove clamps shall conform to IS 2121 and should be able to withstand a load of 10% of the breaking load of conductor without any slip.

13.4.4 Preformed type armoured rods shall be provided for the conductors at all suspension points. Vibration dampers of stock bridge type shall be used for power conductors.

13.5.0 FITTINGS AND ACCESSORIES FOR GROUND WIRES

Fittings and accessories for OPGW shall be used as per Bid.

SECTION-14
TECHNICAL SPECIFICATION OF HTLS CONDUCTOR

TECHNICAL SPECIFICATIONS OF HTLS CONDUCTOR

14.1 GENERAL REQUIREMENTS

14.1.1 The offered HTLS Conductor shall be Panther equivalent HTLS conductor and shall be capable of providing minimum 600 A capacity and shall conform to latest CEA "Guidelines for Rationalized use of high performance conductors" at a continuous operating conductor temperature higher than that of not exceeding the maximum permissible operating temperature for continuous operation of the offered HTLS Conductor and without exceeding the level of maximum permissible sag as prescribe in clause no 14.1.6. and 14.2.

The physical and operating performance requirements of the transmission line with HTLS conductor are mentioned below. The bidder shall offer HTLS conductor complying with the specified requirements. The Bidder shall indicate particulars of the proposed conductor in the relevant GTP schedule of BDS along with calculations to establish compliance with the specified requirements.

14.1.2 The calculations for Ampacity shall be based on IEEE Standard 738. The bidder in his bid shall furnish calculations for the ampacity based on the above Standard for the proposed HTLS conductor.

14.1.3 The design of conductor shall be suitable for operation at a steady state conductor temperature experienced for AC current flow of rated ampacity 600A (132kV) Amperes under the above ambient conditions based on ampacity calculations mentioned above. The bidder shall also indicate the maximum permissible conductor temperature for continuous operation without any deterioration of its electrical, mechanical & metallurgical properties. The bidder shall also furnish the maximum permissible conductor temperature for short-term operations including permissible duration of such short-term operation.

14.1.4 Each conductor / sub conductor in the bundle of HTLS conductor shall be suitable to carry minimum specified 50 Hz alternating current of 600A (132kV) of 50 Hz alternating current under the ambient conditions & maximum conductor sag specified below while satisfying other specified technical requirements/ parameters as mentioned in the Service condition above.

14.1.5 Maximum permissible conductor sag for 320 (132kV ACSR Panther) and 350 m (220kV ASCR Zebra) span conductor at 85 degC operating temperature and nil wind corresponding to 50 Hz and at maximum alternating current 437 (132kV) amp and 900 (220kV) amp per conductor under ambient conditions specified above = 7.224m (132kV) and 8.435m (220kV). In case of HTLS conductor, the maximum sag for permissible conductor temperature and nil wind for continuous operation shall not be considered more than 7.224m (132kV) and 8.435m (220kV). The bidder shall also furnish the maximum permissible conductor temperature for short term operations including permissible duration of such short-term operation (Not required for bus).

Technical Particulars of HTLS Conductor

The HTLS conductor shall meet the following minimum requirements:

Overall diameter of complete conductor	Not exceeding 21.00mm (132kV) & 28.62 mm (220kV)
Approx. mass of complete conductor (kg/km)	Less than or equal to 974kg/kM (132kV) & 1621 kg/km (220kV)
Direction of lay of outer layer	Right Hand

14.1.6 The bidder shall indicate the technical particulars and details of the construction of the conductor in the relevant schedule of GTP. The bidder shall also guarantee the DC resistance of conductor at 20 deg C and AC resistance at the calculated temperature corresponding to 50Hz alternating current flow of 600 amperes at specified ambient conditions (maximum continuous operating temperature).

The bidder shall submit the supporting calculations for the AC resistance at 600 A indicating details & justifications of values of temperature coefficient of resistance & DC to AC resistance conversion factor(s) with due reference to construction / geometry of the conductor.

Note: In case of any discrepancy, CEA guidelines for Rationalised use of High-Performance conductors shall govern.

14.2 Sag-Tension Requirements (Not required for bus)

14.2.1 The HTLS conductor shall meet the following sag tension requirements for ruling span of 325m (132kV) and 350 meters (220kV)

Particulars	Limiting value
Tension at every day condition (32°C, no wind)	Not exceeding 25% of UTS of proposed conductor
Sag at maximum continuous operating temp	≤ 7.24 m (132kV) & 8.435 meters (220kV)
i) Tension at 32 deg C, full wind (52 kg/m2)	not exceeding 70% of UTS of proposed conductor

14.2.2 Survey & profiling of existing line route using Total stations, verification of availability of statutory electrical clearances using PLS-CADD software.

Sag-Tension calculations at various conditions mentioned above using parabolic equations shall be submitted along with the bid. These calculations shall also include calculations for determination of transition/knee point temperature. The bidder must use PLS-CADD software for sag tension calculations.

14.2.3 The bidder shall also furnish sag & tensions under no wind for various temperatures starting from 0 deg C to maximum continuous operating temperature in steps of 5 deg C.

14.2.4 After award of the contract, the Supplier shall submit Sag-Tension calculations corresponding to various conditions given above for all the existing spans and spans ranging from 50 m to 350 m in intervals of 50 m.

Besides above, the Supplier shall also furnish details of creep characteristics in respect of HTLS conductor based on laboratory investigations/ experimentation (creep test as per IEE1138) conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6 month, 1 year & 10 year creep at everyday tension & at maximum continuous operating temperature.

14.3 Ohmic Loss and Liquidated damage for excessive losses: -

Average ohmic losses (kW)= Loss load factor X Line length X no. of sub conductors X (continuous operating current)^2

X AC resistance per km guaranteed by the bidder at temperature corresponding to continuous operating current under normal condition.

On testing, if it is found that actual losses are more than the values, quoted in the bid, undisputed liquidated damages shall be recovered from the supplier at the following rates.

For each KW of excess loss Rs.3, 30,220.00/ KW.

For fractional Kilowatt, penalties shall be applied on pro-rata basis. No bonus shall be payable for loss, which are less than those, stated in the GTP.

14.4 Workmanship:

All the conductor strands shall be smooth, uniform and free from all imperfections, such as spills and splits, cracks, die marks, scratches, abrasions, rust etc.

The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, gritetc.

14.5 Joints in Wires

14.5.1 Aluminum OR Aluminum Alloy Wires

During stranding no Aluminum/ aluminum Alloy welds shall be made for the purpose of achieving the required conductor length.

14.5.2 No joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer(s) of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of Aluminium Alloy wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other Aluminium Alloy wire of the completed conductor. A record of such joints for each individual length of the conductor shall be maintained by The Contractor for Owners review.

14.5.3 Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand guaranteed.

14.5.4 Composite Carbon Core

There shall be no joint of any kind in the finished core entering into the manufacture of the strand. There shall also be no joints or splices in any length of the completed stranded core.

14.5.5 Tolerances

Manufacturing tolerances on the dimensions to the extent of one percent (±1%) shall be permitted for individual strands and the complete conductor.

14.6Materials

The materials used for construction of the conductor shall be such that the conductor meets the specified technical and performance requirements.

14.6.1 Outer layer

The material of outer layer HTLS conductor shall be of fully annealed aluminium (0 tempered) having purity not less than 99.5% and a copper content not exceeding 0.04%. The strands shall be manufactured through appropriate manufacturing process to ensure consistent electrical, mechanical and metallurgical properties under continuous high temperature operation. Bidder shall guarantee the chemical composition in the schedule GTP of

BDS and also furnish description of the manufacturing process in the Bid.

In case of fully annealed type (0 tempered) aluminium strands trapezoidal/Z-shaped wire shall only be accepted.

14.6.2 Non-Metallic Solid Core

Core of offered HTLS conductor shall be as per CEA guidelines for rationalized use of High-performance conductors.

Hybrid carbon and glass fiber composite core which utilizes a high-temperature epoxy resin matrix to bind hundreds of thousands of individual fibers into a unified load-bearing tensile member will be acceptable. The central carbon fiber core shall be surrounded by high-grade boron-free glass fibers to improve flexibility and toughness while preventing galvanic corrosion between the carbon fibers and the aluminum strands. Stranded core design is also acceptable subject to fulfillment to all the type test reports.

Bidder shall furnish properties and composition of the core in the GTP schedule. The composite material for core shall be of such proven quality that its properties are not deteriorated by the normal operating conditions of 132KV transmission line in tropical environment conditions as experienced by the existing lines. The Bidder shall provide adequate details including specifications, Design Validation test reports as per ASTM B987 and performance certificates etc. in support of the suitability of the offered materials. Care to be taken for internal friction due to different material having different thermal co efficient of expansion.

14.7 Standard conductor Length

After survey of the involved section of the line by tower contractor, the supplier shall determine the most appropriate individual conductor lengths to be manufactured and supplied keeping in view tower schedules, section lengths, special crossings etc. and the drum schedules shall be submitted to the owner for review and approval.

The standard length of the conductor shall be indicated by the bidder in the guaranteed technical particulars of offer. A tolerance of +/-5% on the standard length offered by the Bidder shall be permitted. However, during execution cut lengths shall be acceptable matching with Tower Schedule and allowable wastage of 1% added. Standard Length shall not more than 2500 meters. All lengths outside this limit of tolerance shall be treated as random lengths.

Random lengths will be accepted provided no length is less than 70% of the standard length and the total quantity of such random lengths shall not be more than 10% of the total quantity ordered. When one number random length has been manufactured at any time, five (5) more individual lengths each equivalent to the above random length with a tolerance of +/- 5% shall also be manufactured and all the above six random lengths shall be dispatched in the same shipment. At no point, the cumulative quantity supplied of such random lengths shall not be more than 12.5% of the total cumulative quantity supplied including such random lengths. However, the last 20% of the quantity ordered shall be supplied only in standard lengths as specified.

Bidder shall also indicate the maximum single length, above the standard length, he can manufacture in the guaranteed technical particulars of offer. This is required for special stretches like river crossing etc. The Employer reserves the right to place orders for the above lengths on the same terms and conditions applicable for the standard lengths during the pendency of the Contract.

14.8 Supervision in Stringing

14.8.1 The installation & hotline restringing of the offered HTLS conductor for the above transmission line shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier or Qualified Bidder itself. Bidder's responsibility is to provide Sag- Tension chart based on existing site conditions. It may be noted that AEGCL will not consider any modifications (tower extensions etc) on existing tower/span.

14.8.2 The circuit on which the existing ASCR conductor is strung shall be kept under charged condition during the execution. The installation & stringing of the offered HTLS conductor for the above transmission line shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier or Qualified Bidder is self shall string the circuit with the HTLS conductor section by section and restore the line in original conditions as per program finalized in co-ordination with site. The bidder's engineers are to supervise whether appropriate safety measures along with necessary safety tools and equipment's to carry out stringing operations under the above conditions including mechanical/ structural safety of the towers, are maintained or not.

14.8.3 Necessary calculations shall be carried out by the bidder to ensure that by replacing the existing ASCR

conductor with the HTLS conductor, the loadings on the towers due to conductor tens-ions as well as loads on account of the re-conductoring activities shall be within specified limits. These calculations shall be submitted by the bidder along with bid.

14.8.4 The Contractor should deploy hotline stringing/ installation experts during erection of the offered HTLS conductor.

14.9 Tests and Standards

14.9.1 Type Tests

Type Tests on Stranded Conductor/ Stranded wire

The following tests shall be conducted once on sample/samples of conductor from each manufacturing facility:

(i)	**On complete Conductor**	
a)	DC resistance test on stranded conductor	: As per Annexure-A
b)	UTS test on stranded conductor	: As per Annexure-A
c)	Stress- Strain test on stranded conductor and core at room temperature	: IEC 1089
d)	Stress-strain test on stranded conductor and core at elevated temperature	: As per Annexure-A
e)	High temperature endurance & creep test on stranded conductor	: As per Annexure-A & : IEC 1089
f)	Sheaves Test	As per Annexure-A
g)	Axial Impact Test	: As per Annexure-A
h)	Radial Crush Test	: As per Annexure-A
i)	Torsional Ductility Test	: As per Annexure-A
j)	Aeolian Vibration Test`	: As per Annexure-A
k)	Temperature Cycle Test	: As per Annexure-A
l)	Corona Extinction Voltage Test	: As per Annexure-A
m)	Radio Interference Voltage Test	: As per Annexure-A
(ii)	**On Conductor Strand/core**	
a)	Heat resistance test on Aluminium Alloy strands or core	: As per Annexure-A
b)	Bending test on composite core	As per ASTM B987
c)	Compression test on core	: As per Annexure-A
d)	Coefficient of linear expansion on core/core strands	: As per Annexure-A
e)	Strand Brittle fracture test for Carbon fibre composite core only.	: As per Annexure-A

Type tests specified under clause no. 2.9.1 shall not be required to be carried out if a valid test certificate is available for the offered design, i.e., tests conducted earlier (not more than 5 years old at the time of bid opening) should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) of CTU or State Transmission Utility.

Type test of Panther equivalent HTLS conductors of minimum 600A shall only be accepted for this project.

In the case of composite core conductors, the tests specified under clause 2.9.1 shall be carried out before stranding on as manufactured sample.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design/ material/manufacturing process change including substitution of components or due to non- compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Employer/ Employer/ Employer.

14.9.2 Acceptance Tests (Whichever applicable to Annealed Al. HTLS Conductor)

a)	Visual and dimensional check on drum	: As per Annexure-A
b)	Visual check for joints scratches etc. and length measurement of conductor by rewinding	: As per Annexure-A
c)	Dimensional check on core strands and Aluminium Alloy strands	: As per Annexure-A
d)	Check for lay-ratios of various layers	: As per Annexure-A
e)	Thickness of aluminum on aluminium clad wires	: As per Annexure-A
f)	Torsion and Elongation tests on composite core	: As per Annexure-A
g)	Breaking load test on core strands and Aluminium/Aluminium Alloy strands	: As per Annexure-A
h)	Minimum conductivity test on Aluminium/ thermal resistant Aluminium Alloy strands	: As per IEC : 889
i)	Procedure qualification test on welded joint of Aluminium/Aluminium Alloy strands	: As per Annexure-A
j)	Heat resistance test on Aluminium Alloy strands	: As per Annexure-A
k)	Ageing test on filler (if applicable)	: As per Annexure-A
l)	Minimum conductivity test on aluminium clad core wires (if applicable)	: As per Annexure-A
m)	Glass transition temperature test (For Carbon fibre Composite core only) before stranding.	: As per Annexure-A
n)	Flexural Strength test (For Polymer Composites only) before stranding.	: As per Annexure-A
o)	Galvanic Layer thickness test (For Polymer Composites only) before stranding.	: As per ASTM B987
Note:	All the above tests shall be carried out on Aluminium / Aluminium Alloy and core as specified.	

14.9.3 Routine Test

a)	Check to ensure that the joints are as per Specification
b)	Check that there are no cuts, fins etc., on the strands.
c)	Check that drums are as per Specification
d)	All acceptance tests as mentioned above to be carried out on 10 % of drums

14.9.4 Tests during Manufacture

a)	Chemical analysis of zinc used for galvanizing	: As per Annexure-A
b)	Chemical analysis of Aluminium alloy used for making Aluminium Alloy strands	: As per Annexure-A
c)	Chemical analysis of core strands/composite core	: As per Annexure-A

As indicated in Clause no 2.9.1, no type test charges shall be payable to the supplier.
The entire cost of testing for the acceptance and routine tests and Tests during manufacture as well as type tests, if required, specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/Owner's representative.

The Supplier shall intimate the Employer about carrying out of the type tests along with detailed testing program at least 2 weeks in advance of the schedule date of testing during which the Owner will arrange to depute his

representative to be present at the time of carrying out the tests.

14.10 Additional Tests

2.10.1. The Owner reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the Specifications.

2.10.2. The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test centre. In case of evidence of non compliance, it shall be binding on the part of Supplier to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items all without any extra cost to the Owner.

14.11 Test Reports

Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Employer's representative.

Test Certificates of tests during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Employer.

14.12 Inspection

The Employer's representative shall at all times be entitled to have access to the works and all places of manufacture, where conductor shall be manufactured and representative shall have full facilities for unrestricted inspection of the Supplier's works, raw materials and process of manufacture for conducting necessary tests as detailed herein.

The Supplier shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements can be made for inspection.

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Employer in writing. In the latter case also, the conductor shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

The acceptance of any quantity of material shall in no way relieve the Supplier of any of his responsibilities for meeting all requirements of the Specification, and shall not prevent subsequent rejection if such material is later found to be defective.

14.13 Test Facilities

The following additional test facilities shall be available at the Supplier's works:

a) Calibration of various testing and measuring equipment including tensile testing machine, resistance measurement facilities, burette, thermometer, barometer etc.

b) Standard resistance for calibration of resistance bridges.

c) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 meters per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc. with traverse laying facilities.

14.14 Packing

The conductor shall be supplied in non-returnable, strong, wooden/painted steel/hybrid (painted steel cum wood) drums provided with lagging of adequate strength, constructed to protect the conductor against all damage and displacement during transit, storage and subsequent handling and stringing operations in the field. The Supplier shall select suitable drums for supply of conductor and shall be responsible for any loss or damage to conductor and/or drum during transportation handling and storage due to improper selection of drum or packing.

The Bidder should submit their proposed drum drawings along with the Bid.

a. One conductor length only shall be wound on each drum.

b. The conductor ends shall be properly sealed and secured on the side of one of the flanges to avoid loosening of the conductor layers during transit and handling.

14.15 Marking

Each drum shall have the following information stenciled on it in indelible ink along with other essential data:

a. Contract/Award letter number.
b. Name and address of consignee.
c. Manufacturer's name and address.
d. Drum number
e. Size of conductor
f. Length of conductor in meters
g. Arrow marking for unwinding
h. Position of the conductor ends
i. Distance between outer-most Layer of conductor and the inner surface of lagging.
j. Barrel diameter at three locations & an arrow marking at the location of the measurement.
k. Number of turns in the outer most layer.
l. Gross weight of drum after putting lagging.
m. Tear weight of the drum without lagging.
n. Net weight of the conductor in the drum.

The above should be indicated in the packing list also.

14.16 Service centre in India: If any manufacturer is from outside INDIA, they must have their service centre and calibration facilities in India.

14.17 Verification of Conductor Length

The Employer reserves the right to verify the length of conductor after unreeling at least ten (10) percent of the drums in a lot offered for inspection.

14.18 Standards (Whichever applicable to Annealed Al. non-metallic solid core HTLS Conductor)

The conductor shall conform to the following Indian/International Standards, which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

In the event of the supply of conductor conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the standards proposed by the Supplier and those specified in this document will be provided by the Supplier to establish their equivalence.

Sl. No.	Indian Standard	Title	International Standard
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS: 398-1982	Specification for Aluminium Conductors for Overhead Transmission Purposes	IEC:1089-1991 BS:215-1970
3.	IS:398-1990 Part-II	Aluminum Conductor Galvanised Steel Reinforced	BS;215-1970 IEC:1089-1991
4.	IS:398-1992 Part-V	Aluminum Conductor Galvanised Steel-Reinforced for Extra High Voltage (400 KV) and above	IEC:1089-1991 BS:215-1970
5.	IS : 1778-1980	Reels and Drums for Bare Conductors	BS:1559-1949
6.	IS : 1521-1991	Method of Tensile Testing of Steel Wire	ISO 6892-1984
7.	IS : 2629-1990	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
8.	IS : 2633-1992	Method of Testing Uniformity of Coating on Zinc Coated Articles	

9.	IS : 4826-1992	Galvanised Coating on Round Steel Wires	IEC : 888-1987 BS:443-1969
10.	IS : 6745-1990	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433-1969 ISO 1460 - 1973
11.	IS : 8263-1990	Method of Radio Interference Tests on High Voltage Insulators	IEC:437-1973 NEMA:107-1964 CISPR
12.	IS : 9997-1988	Aluminium Alloy Redraw Rods	IEC 104 - 1987
13.		Zinc Coated steel wires for stranded Conductors	IEC : 888-1987
14.		Hard drawn Aluminium wire for overhead line conductors	IEC : 889-1987
15.	IS:398 (Part-IV)	Aluminium Alloy stranded conductor	IEC : 208-1966 BS-3242-1970
16.		Aluminium clad steel wires	IEC:1232
17.		Method of measurement of resistivity of metallic materials	IEC:468
18		Ampacity	IEEE738
19.		Design Validation Tests on Composite Core	ASTM B987

SCHEDULE—1 (A)
Tower Schedule enclosed.
ANNEXURE –A

Tests on Conductors

1) Tests on Conductor (Whichever applicable to Annealed Al. non-metallic solid core HTLS Conductor)

1.1 UTS Test on Stranded Conductor

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample of conductor of minimum 5 m length between fixing arrangement suitably fixed by appropriate fittings on a tensile testing machine. The load shall be increased at a steady rate upto 50% of minimum specified UTS and held for one minute. The circles drawn shall not be distorted due to relative movement of strands. Thereafter the load shall be increased at steady rate to minimum UTS and held for one minute. The Conductor sample shall not fail during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 Corona Extinction Voltage Test

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154
kV rms line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS:731- 1971

1.3 Radio Interference Voltage Test

Under the conditions as specified under (1.2) above, the sample shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 154 kV rms line to ground under dry condition. The test procedure shall be in accordance with IS:8263.

1.4 D.C. Resistance Test on Stranded Conductor

On a conductor sample of minimum 5m length two contact-clamps shall be fixed with a predetermined bolt torque. The resistance shall be measured by a Kelvin double bridge or using micro ohm meter of suitable accuracy by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least five times and

the average value recorded. The value obtained shall be corrected to the value at 20deg C as per IS:398-(Part-IV)/(Part-V). The resistance corrected at 20deg C shall conform to the requirements of this Specification.

1.5 Stress-strain test at elevated temperature

Stress-strain test as per IEC-1089 shall be conducted keeping conductor temperature at designed maximum temperature.

1.6 High Temperature endurance & creep test

Two conductor samples of length equal to at least 100 X d + 2 X a (where, d is the conductor diameter and a is the distance between the end fitting and the gauge length) shall be strung at tension equal to 25 % of conductor UTS. The distance, a, shall be at least 25 % of the gauge length or 2 m whichever is the smaller. The conductor samples shall be subjected to tests as indicated below:

On one of the conductor samples, the conductor temperature shall be maintained at 20 deg C for 1000 hours. The elongation/creep strain of the conductor during this period shall be measured and recorded at end of 1 hour, 10-hour, 100 hour and subsequently every 100-hour upto 1000 hours' time period. (On other conductor sample, the conductor temperature shall be increased to design maximum temperature in steps of 20 deg. C and thermal elongation of the conductor sample shall be measured & recorded at each step. The temperature shall be held at each step for sufficient duration for stabilization of temperature. Further, the temperature of the conductor shall be maintained at maximum continuous operating temperature (+10 Deg. C) for 1000 hours. The elongation/creep strain of the conductor during this period shall be measured and recorded at end of 1 hour, 10-hour, 100 hour and subsequently every 100-hour upto 1000 hours' time period. After completion of the above, the core of the conductor sample shall be subjected to UTS test as mentioned above at clause 1.1 of Annexure-A. The conductor core shall withstand a load equivalent to 95 % of UTS. In case of polymer composite core conductor, the flexural strength & glass transition temperature of the core shall also be evaluated and the same shall not be degraded by more than 10 % over the initial value. The supplier shall plot the thermal elongation with temperature.

The supplier shall furnish details of creep characteristic in respect of the conducted based on laboratory test and other laboratory investigations/ experimental conducted on similar type of conductor and shall indicate creep strain values corresponding to 1 month, 6 month, 1 year, 10 year & 20 year creep at everyday tension & continuous designed temperature as well as room temperature.

1.7 Sheaves Test

The conductor sample of minimum length of 35 meter shall be tensioned at 22 % of the UTS and shall be passed through pulleys having diameter of 32 times that of the conductor with angle of 20 deg. between the pulleys. The conductor shall be passed over the pulleys 36 times a speed of 2 m/sec. After this test UTS test on the conductor shall be carried out. The core shall be inspected for any sign of damage or cracking through dye penetration test as per ASTM D5117.

1.8 Axial Impact Test

The conductor sample shall be suspended vertically and load applied by dropping a 650 Kg from an elevation of 4 meters above the sample. The impact velocity shall be not be less than 8 m/sec. with an initial pre-tension of 200 kg. The curve for load vs time shall be recorded and recorded load of failure for core shall not be less than UTS of core.

1.9 Radial Crush Test

A section of conductor is to be crushed between two six-inch steel platens. Load shall be held at 350 Kg for 1 minute and then released. Core/ core strands shall be subsequently disassembled and tensile tested. Core/ core strands shall exhibit full strength retention.

1.10 Torsional Ductility Test

The conductor sample of 10-15 m shall be loaded to 25% of UTS and then rotated in increasing steps of +/-180 deg. In case of composite core conductors, after 4 rotations or after separation of aluminium strands, the aluminium wires shall be cut and removed from the conductor and the exposed core shall be twisted and shall withstand upto 16 rotations.

1.11 Aeolian Vibration Test

The conductor and supporting hardware shall be loaded to 25% of RTS. A dynamometer, load cell, calibrated beam or other device shall be used to measure the conductor tension. Some means should be provided to maintain constant tension to allow for temperature fluctuations during the testing. The overall span between system terminations shall be a minimum of 30 m. The span shall be supported at a height such that the static sag angle of the cable to horizontal is (1.5 + 0.5) deg in the active span. Means shall be provided for measuring and monitoring the mid-loop (antinode) vibration amplitude at a free loop, not a support loop. An electronically controlled shaker shall be used to excite the conductor in the vertical plane. The shaker armature shall be securely fastened to the conductor so it is perpendicular to the conductor in the vertical plane. The shaker should be located in the span to allow for a minimum of six vibration loops between the suspension assembly and the shaker.

The test shall be carried out at one or more resonance frequencies (more than 10 Hz). The amplitude at the antinode point shall be one third of conductor diameter. The assembly shall be vibrated for not less than 10 million cycles without any failure. After the test, the conductor should not exhibit any damage (broken strands). The conductor shall be tested to demonstrate that it retains at least 95% RTS.

1.12 Temperature Cycle Test

The purpose of this test is verification of degradation characteristics of metallic and non-metallic material when subjected to thermal cycling temperature cycling can create large internal stresses due to thermal expansion mismatch between constituents.

Test Methods: -

- Mechanical tension, 20 % RBS, marks on the conductor at the edge of the conductor.
- 100 cycles from room temperature up to maximum temperature. Hold at design maximum temperature ± 2.5 deg. C for 5 minutes.
- After the above mentioned 100 cycles, the mechanical tension shall be increased up to 70 % RBS at room temperature and kept at this tension for 24 H. Thereafter release to 20 % RBS.
- This cycling test shall be repeated 5 times.
- During the test, temperature of connectors, conductor and resistance are recorded according to ANSI C 119.
- A breaking load test is applied at the end of the test. Conductor strength has to be higher than 95% RBS.

In case of polymer composites, the flexural strength should not degrade by more than 10 % and the Glass Transition temperature shall not degrade by more than 10 % after thermal cycling. Flexural strength shall be obtained on the basis of test procedure indicated at 1.32 below.

1.13 Heat Resistance test on Aluminium Alloy wire

Breaking load test as per clause 1.12 above shall be carried out before and after heating the sample in uniform heat furnace at following temperature for one hour. The breaking strength of the wire after heating shall not be less than the 90% of the breaking strength before heating: -

Maximum continuous operating temperature of the conductor	Test Temperature
Upto 150 deg. C	230 degC (+5/-3 degC)
More than 150 deg. C & upto 210 deg. C	280 degC (+5/-3 degC)
More than 210 deg. C & upto 230 deg. C	400 degC (+5/-3 degC)

1.14 Bending test on aluminium clad core wire (if applicable)

A sample of aluminium clad invar strand measuring 30 cm in length shall be subject to bending with help of a vise. The vised length of wire should be 5 cm and radius of bend 4.8 mm. The bending should be first 90 degrees left and 90-degree right. After this operation the strand should cut at the bending point. There should be no separation of core and aluminium at the bending point after this operation.

1.15 Compression test on aluminium clad wires (if applicable)

A sample of aluminium clad core strand 10 mm in length is to be compressed by a plate with a load of 3600 kgs.

The aluminium and core strand should not break.

1.16 Coefficient of linear expansion for core/ corewires

The temperature and elongation on a sample shall be continuously measured and recorded at interval of approximately 15 degree C from 15 degree C to maximum continuous operating temperature corresponding to rated current 600A (132kV) by changing the temperature by suitable means. Coefficient of linear expansion shall be determined from the measured results.

1.17 Strand Brittle fracture test (for polymer composite core only)

The sample shall be tensioned to approx. 25 % of UTS with simultaneous application of 1NHNO3 acid directly in contact with naked polymer composite core for 96 hrs. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm.The rod shall withstand UTS test after 96 hours.

1.18 Visual and Dimensional Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to the approved drawings.

1.19 Visual Check for Joints, Scratches etc.

Conductor drums shall be rewound in the presence of the Employer. The Employer shall visually check for scratches, joints etc. and that the conductor generally conform to the requirements of this Specification. Ten percent (10%) drums from each lot shall be rewound in the presence of the Employer's representative.

1.20 Dimensional Check on Core Wires and Aluminium/ Aluminium Alloy Wires

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this Specification.

1.21 Check for Lay-ratios of Various Layers

The lay-ratios of various layers shall be checked to ensure that they conform to the guaranteed values furnished by the Contractor.

1.22 Galvanizing Test

The test procedure shall be as specified in IEC: 888. The material shall conform to the requirements of this Specification. The adherence of zinc shall be checked by wrapping around a mandrel four times the diameter of steel wire.

1.23 Aluminum thickness on aluminum clad wires (if applicable)

The thickness of aluminium of the specimen shall be determined by using suitable electrical indicating instruments operating on the direct measurement. Measurements shall be read to three decimal places, and number rounded to two decimal places is considered as measured thickness. For reference purposes, direct measurement shall be used to determine aluminium thickness on specimens taken from the end of the coils.

1.24 Torsion and Elongation Tests on Composite Core

In case of composite core HTLS conductor, the following procedure shall be applicable: -

Elongation Test: - The elongation of the composite core sample at shall be determined using extensometer. The load along the core shall be gradually increased. The elongation achieved on reaching the tensile strength of the core shall not be less than the value guaranteed in the GTP.

Torsion Test: The purpose of the test is to determine the resilience of the composite core to twisting and to show that after the composite core has experienced the prescribed twisting, it will not crack or have a loss in tensile strength due to the twisting. A sample length that is 170 times the diameter of the composite core being tested is mounted in the gripping fixtures. One grip shall then be fixed so that it does not twist and the other end shall be twisted a full 360 degrees and then fixed in this position for 2 minutes. Once the twist time is completed, the core is untwisted an inspected for any crazing or other damage. If no damage is observed, the composite core is then tensile tested to failure and the

final load recorded. For the test to be accepted, the composite core must withstand at least 100% of its rated tensile strength. Two samples need to be completed in order to satisfy the testing requirement.

1.25 Breaking load test on Aluminium/ Aluminium Alloy & Composite core and D.C Resistance test on Aluminium/ Aluminium Alloy wire

The above tests shall be carried out as per IEC: 888/889 and the results shall meet the requirements of the specification.

1.26 Wrap test on Core wires (Applicable for steel/Al clad Steel/invar core only)

The wrap test on core strands shall be meet the requirements of IEC: 888. In case of aluminium clad core wire, the same shall be wraped around a mandel of diameter of five times that of the strand to form a helix of eight turns. The strand shall be unwrapped. No breakage of strand shall occurred.

1.27 Minimum conductivity test on thermal resistant aluminium alloy wire

Resistivity test as per IEC-468/IEC 889 shall be conducted to confirm minimum conductivity as per specification requirement

1.28 Procedure Qualification test on welded Aluminium/ Aluminium Alloy wire.

Two Aluminium/ Aluminium Alloy wire shall be welded as per the approved quality plan and shall be subjected to tensile load. The breaking strength of the welded joint of the wire shall not be less than the guaranteed breaking strength of individual strands.

1.29 Ageing Test on Filler (if applicable)

The test shall be done in accordance with Grease drop point test method. The specimen should be drop as a droplet when kept at a temperature 45 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

1.30 Aluminium conductivity test on aluminium clad wire (if applicable)

Resistivity test as per IEC-468 shall be conducted to confirm minimum conductivity as per specification requirement.

1.31 Glass Transition Temperature Test (for polymer composite core only)

Test method shall be as per ASTM D7028, A Standard Test Method for Glass Transition Temperature of Polymer Matrix Composites by Dynamic Mechanical Analysis. The glass transition temperature shall be greater than the maximum continuous operating temperature of the offered Composite Carbon Core HTLS Conductor+ 35 deg C.

1.32 Flexural Strength Test (for polymer composite coreonly)

Test method shall be as per ASTM D7264, ASTM D4475 or ISO14125.

1.33 Bending Test on Composite Core:

A composite core sample shall be wrapped 180 degree around a cylindrical mandrel, and the specimen brought to 15 % of the rated tensile strength of the composite core and held for 1 min. The mandrel diameter shall be not more than 50 times the dia of composite core. After completion of the test, the core shall withstand UTS test and dye penetration test.

1.34 Chemical Analysis of Aluminium/ Aluminium Alloy and Composite core/ INVAR Core Wires

Samples taken from the Aluminium /Aluminium Alloy and core coils/ strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the particulars guaranteed by the bidder so as to meet the requirements stated in this Specification.

1.35 Chemical Analysis of Zinc

Samples taken from the zinc ingots shall be chemically/ spectrographically analyzed. The same shall be in conformity to the requirements stated in the Specification.

Note: Any other type test required as per relevant IS/IEC/other standards shall be submitted along with the bid for the offered HTLS conductor

15.1.0 SCOPE OF CONTRACT

This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of 132kV, 66kV and 33 kV outdoor Current Transformers.

15.2.0 STANDARDS

15.2.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

15.2.2 In case of any conflict between the Standards and this specification, this specification shall govern.

15.2.3 The current transformer shall comply also with the latest issue of the following Indian standard.

(i)	IS: 2705(Part-I)	Current transformers: General requirement.
(ii)	IS: 2705(Part-II)	Current transformers: Measuring Current transformers
(iii)	IS: 2705(Part-III)	Current transformers: Protective Current transformers
(iv)	IS: 2705(Part-IV)	Current transformers: Protective Current transformers for special purpose application.
(V)	**All relevant IEC**	

15.3.0 GENERAL REQUIREMENTS

15.3.1 The cores of the instrument transformers shall be of high grade, non-aging CRC steel of low hysteresis loss and high permeability.

15.3.2 Current transformers shall be of Live Tank design.

15.3.3 The instrument transformers shall be truly hermetically sealed to completely prevent the oil inside the tank coming into contact with the outside temperature. To take care of oil volume variation the tenderer are requested to quote the current transformers with stainless steel diaphragm (bellow).

15.3.4 The instrument transformers shall be completely filled with oil.

15.3.5 A complete leak proof shrouded secondary terminal arrangement shall be provided with instrument transformers, secondary terminals shall be brought into weather, dust and vermin proof terminal box. Secondary terminal boxes shall be provided with facilities for easy earthing, shorting, insulating and testing of secondary circuits. The terminal boxes shall be suitable for connection of control cable gland. IP rating of terminal box shall be IP 55. Spare terminals shall be provided. **CT secondary shorting links shall be provided along with one terminal earthing arrangement of CT winding. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement**.

15.3.6 All instrument transformers shall be of single phase unit.

15.3.7 The instrument transformers shall be so designed to withstand the effects of temperature, wind load, short circuit conditions and other adverse conditions.

15.3.8 All similar parts, particularly removable ones, shall be interchangeable with one another.

15.3.9 All cable ferrules, lugs, tags, etc. required for identification and cabling shall be supplied complete for speedy erection and commissioning as per approved schematics.

15.3.10 The instrument transformers housing shall be porcelain.

15.3.11 All steel work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint.

15.3.12 Test terminal for tan-delta/capacitance shall be provided for 132kV CT's.

15.3.13 Accuracy specified shall be maintained at 25% of rated burden.

15.3.14 All winding (Primary/Secondary) shall be of copper. Aluminium is not acceptable

15.4.0 INSULATING OIL

The quantity of insulating oil for instrument transformers and complete specification of oil shall be stated in the tender. The insulating oil shall conform to the requirement of latest edition of IS: 335

15.5.0 COMMON MARSHALLING BOXES (shall be supplied by CT manufacturer)

15.5.1 The outdoor type common marshalling boxes shall conform to the latest edition of IS 5039 and other general requirements specified hereunder.

15.5.2 The common marshalling boxes shall be suitable for mounting on the steel mounting structures of the instrument transformers.

15.5.3 One common marshalling box shall be supplied with each set of instrument transformers. The marshalling box shall be made of sheet steel and weather-proof. The thickness of sheet steel used shall be not less than 3.0 mm. It is intended to bring all the secondary terminals to the common marshalling. The marshalling box shall be of hot dipped galvanized steel.

15.5.4 The enclosures of the common marshalling boxes shall provide a degree of protection of not less than IP 55 (As per IS 2147).

15.5.5 The common marshalling boxes shall be provided with double hinged front doors with pad locking arrangement. All doors and removable covers and plates shall be sealed all around with neoprene gaskets or similar arrangement.

15.5.6 Each marshalling box shall be fitted with terminal blocks made out of moulded non-inflammable plastic materials and having adequate number of terminals with binding screws washers etc. Secondary terminals of the instrument transformers shall be connected to the respective common marshalling boxes. All out going terminals of each instrument transformer shall terminate on the terminal blocks of the common marshalling boxes. The terminal blocks shall be arranged to provide maximum accessibility to all conductor terminals.

15.5.7 Each terminal shall be suitably marked with identification numbers. Not more than two wires shall be connected to any one terminal. At least 20 % spare terminals shall be provided over and above the required number. All terminals of control circuits shall be wired up to marshalling box including spare terminals evenly distributed on all TB's.

15.5.8 All terminal strips shall be of isolating type terminals and they will be of minimum 10 A continuous current rating.

15.5.9 All cable entries shall be from bottom. Suitable removable gland plate shall be provided on the box for this purpose. Necessary number of cable glands shall be supplied fitted on to this gland plate. Cable glands shall be screw on type and made of brass.

15.5.10 Each common marshalling box shall be provided with two numbers of earthing terminals of galvanised bolt and nut type.

15.5.11 All steel, inside and outside work shall be degreased, pickled and phosphated and then applied with two coats of Zinc Chromate primer and two coats of finishing synthetic enamel paint. The colour of finishing paint shall be as follows: -

i) Inside: Glossy White

ii) Outside: Light Grey (Shade No. 697 of IS: 5)

15.6.0 BUSHINGS AND INSULATORS

15.6.1 Bushings and Insulators shall be of Porcelain, Solid core type. Porcelain used for the manufacture of bushings and insulators shall be homogeneous, free from defects, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture **and shall conform to IEC 60135, 60168/IS.**

15.6.2 Glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. Bushings shall be designed to have sufficient mechanical strength and rigidity for the conditions under which they will be used. All bushings of identical ratings shall be interchangeable.

15.6.3 Puncture strength of bushings shall be greater than the dry flashover value. When operating at normal voltage, there shall be no electric discharge between the conductors and bushing. No radio interference shall be caused by the bushings when operating at the normal rated voltage

15.6.4 The design of bushing shall be such that the complete bushing is a self-contained unit and no audible discharge shall be detected at a voltage up to a working voltage (Phase Voltage) plus 10%. The minimum creepage distance for severely polluted atmosphere shall be 31 mm/KV.

15.6.5 Sharp contours in conducting parts should be avoided for breakdown of insulation. The insulators shall be capable to withstand the minimum seismic acceleration of 0.5 g in horizontal direction and 0.6g in vertical direction..

15.6.6 Bushings shall satisfactorily withstand the insulation level specified in data sheet.

15.6.7 Rain shed/drain cover/dome shall be present in CT.

15.6.8 Bellow level indicator shall be present in CT.

15.6.9 Nitrite butyl rubber/Neoprene gaskets shall be used.

15.6.10 Critical flashover voltage of insulator and bushing shall be provided.

15.7.0 TESTS

15.7.1 **Routine/Acceptance Tests (all units)**

All routine tests shall be carried out in accordance with relevant Standards. All routine/acceptance tests shall be witnessed by the Employer/his authorised representative.

15.7.2 **Type Tests:** The bidder shall furnish type test certificates and results for the all tests as per relevant Standards along with the bid for current and potential transformers of identical design.

Type test certificates so furnished shall not be older than 5 (five) years as on date of Bid opening.

15.7.3 **QAP:** QAP indicating all brought out materials tests shall be submitted.

15.8.0 NAME PLATES

All equipment shall have non-corrosive name plates fix at a suitable position indelibly mark with full particular there on in accordance with the standard adapted. Thickness (1mm), purchase order, project name, serial no etc. shall be present in the Name plate.

15.9.0 MOUNTING STRUCTURES

15.9.1 All the equipment covered under this specification shall be suitable for mounting on steel structures. Supply of mounting on **galvanised** structures is also in the scope of this tender.

15.9.2 Each equipment shall be furnished complete with base plates, clamps, and washers etc. and other hardware ready for mounting on steel structures.

15.10.0 SAFETY EARTHING

15.10.1 The non-current carrying metallic parts and equipment shall be connected to station earthing grid with two terminals.

TERMINAL CONNECTORS (Shall be under manufacturer scope)

15.11.1 The equipment shall be supplied with required number of terminal connectors of approved type suitable for ACSR. The type of terminal connector, size of connector, material, and type of installation shall be approved by the AEGCL, as per installation requirement while approving the equipment drawings. No part of a clamp shall be less than 12mm. thick. All connectors shall be of Aluminium Alloy and type tested as per IEC/IS including RIV and short circuit.

PRE-COMMISSIONING TESTS

15.12.1 Contractor shall carry out following tests as pre-commissioning tests. Contractor shall also perform any additional test based on specialties of the items as per the field instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) **Current Transformers**

(i) Insulation Resistance Test for primary and secondary.

(ii) Polarity test.

(iii) Ratio identification test - checking of all ratios on all cores by primary injection of current.

(iv) Dielectric test of oil (wherever applicable).

(v) Magnetising characteristics test.

(vi) Tan delta and capacitance measurement

(vii) Secondary winding resistance measurement

(viii) Contact resistance measurement (wherever possible/accessible).

(ix) Knee-point voltage measurement

15.13.0 TECHNICAL DATA SHEET FOR CURRENT

15.13.1 For **145/72.5/**36 kV CTs the instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in the current transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

15.14.0 TYPE AND RATING:

15.14.1All instrument transformer shall be outdoor type, single phase, oil immersed, self-cooled suitable for mounting on steel structure. The instrument transformer shall have the following ratings and particulars.

SL No.	A. Item		Ratings and Particulars	
I	II	III	IV	
A	Nominal system voltage	132 kV	33 kV	66 kV
B	Highest system voltage, kV	145	36	72.5
C	Rated frequency, HZ	50	50	50
D	System earthing	Solidly earthed	Solidly earthed	Solidly earthed
E	Insulation level			
a)	Full Wave Impulse withstand voltage: kVp (1.2/50)	650	170	325
b)	One-minute p.f. Withstand voltage, kV (r.m.s.) (dry and wet)	275	70	140
F	Short time current for 3 seconds, kA	40	31.5	31.5
G	Minimum creepage distance, mm	4495	1116	2247.5
H	Temperature rise	As per IS	As per IS	As per IS
I	**C.T.**			
	(i) No. of Cores	5	2/5	5
	(ii) Transformation ratio	BoQ		As per
	(iii) Rated out put			
	(a) Core-1	20 VA	20 VA	20 VA
	(b) Core-2	20 VA	20 VA	20 VA
	(c) Core-3	(PX CLASS)	PX (for trafo only)	PX
	(d) Core-4	(PX CLASS)	PX (for trafo only)	PX
	(e) Core-5	(PX CLASS)	PX (for trafo only)	PX
	(iv) Accuracy class			
	(a) Core-1	0.2S	0.2S	0.2S
	(b) Core-2	5P20/PX (trafo)	5P20/PX (trafo)	5P20
	(c) Core-3	PX	PX (for trafo only)	PX
	(d) Core-4	PX	PX (for trafo only)	PX
	(e) Core-5	PX	PX (for trafo only)	PX
	(vi) Instrument security factor			
	(a) Core-1	<5	<5	<5
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-

	(vii) Minimum Knee point voltage, Volts			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(d) Core-4	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(e) Core-5	1:1 of CT ratio min	1:1 of CT ratio min	1:1 of CT ratio min
	(viii) Maximum secondary resistance, ohm			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	<3	<3	<3
	(d) Core-4	<3	<3	<3
	(e) Core-5	<3	<3	<3
	(ix) Maximum exciting current, at Vk/4 mA			
	(a) Core-1	-	-	-
	(b) Core-2	-	-	-
	(c) Core-3	-	-	-
	(d) Core-4	-	-	-
	(e) Core-5	-	-	-
	Tandelta at Um/ root 3	< 3	< 3	< 3
	Rated extended primary current	120%	120%	120%

Note:

(iii) It is intended to use different ratios of the same CT at the same time for various protections and metering cores. The CTS should therefore be suitable for the above purpose by secondary tapings only. The ratio change by secondary taps is acceptable as long as the required CT specifications are achieved at all ratios.

(iv) The knee point voltage specified above shall be at higher ratio/ taps.

(v) CT and PT sizing calculations shall be submitted. Burden values and knee point voltage, shall be decided as per the calculations during detailed engineering

(vi) For Station service bay equipments rated system voltage shall be 33kV and highest system voltage shall be 72.5kV.

TECHNICAL SPECIFICATIONS OF HARDWARE FITTINGS & OTHER ACCESSORIES

SECTION – 3 (A)

TECHNICAL SPECIFICATIONS OF HARDWARE FITTINGS & OTHER ACCESSORIES FOR 220kV VOLTAGE LEVEL

Technical Description of Hardware Fittings

3.1 General

This section details technical particulars of hardware fittings and suspension clamps & compression type dead end clamps for the HTLS Conductor to be proposed and supplied for replacement of ASCR zebra conductor by the bidder. Each fitting shall be suitable for HTLS conductor and to be supplied for satisfactory performance of complete conductor system for continuous operation at the designed maximum temperature specified by them for the conductor.

3.2. Hardware Fittings

The hardware fittings shall be suitable for use with long rod porcelain /string insulators having ball and socket fittings. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

3.2.1 Suitable arcing horn as specified in clause 3.11 hereinafter.

3.2.2 Suitable yoke assemblies with the arrangement of fixing a set of arching horn and complying with the specifications given hereinafter.

3.2.3 Bolts, Nuts, washers, split pin etc.

3.2.4 Suspension, tension clamps and dead-end assembly to suit conductor size as detailed in clause 3.3, 3.4 and 3.11, hereinafter.

3.2.5 Other necessary fittings viz D-shackles, eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.

3.2.6 2.5% extra fasteners.

3.3 Suspension Clamp

The suspension clamps shall be made of malleable iron or aluminium alloy, hot dip galvanised and shall be suitable to accommodate the conductor together with one set of standard preformed armour rods. Suitable sheet aluminium liners shall be provided. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor. The lips shall be rounded off and the seating and the bell mouths shall be smooth to avoid corona and radio interference noises. The suspension clamps shall be suitable to carry the bottom part of the arcing horn and to receive the fittings of the long rod porcelain insulator/insulator string.

The suspension clamps shall be such that the conductor should not slip at a load of 25% of the breaking load of the conductor. The ultimate strength of the clamp for vertical load shall not be less than the failing load of the Insulators.

3.4 Strain Clamp

The strain clamps shall also be made of malleable iron or aluminium alloy; hot dip galvanised, lined with sheet aluminium liners and shall be suitable to accommodate the conductor with necessary binding tapes etc. The lips shall be rounded off carefully and conductor seating and the ball mouth shall be smooth to avoid corona and radio interference noises. Suitable attachment for receiving both side of arcing horns and for connecting to the porcelain long rod insulator/insulator strings shall be provided.

The strain clamps shall be such that the conductor should not slip at a load of 90% of the breaking load of the conductor. The ultimate strength of the clamp for horizontal load shall not be less than the ultimate strength of the conductor.

3.5 Clamps fittings

The clamp fittings shall be suitable for attachment to suspension and tension porcelain long rod insulator/insulator strings along with hardware fittings for normal stretches as well as river crossing stretches and shall include 2.5 % extra fasteners. The supplier shall be responsible for satisfactory performance of complete conductor system along with fittings offered by them for continuous operation at the designed maximum temperature specified by them for the conductor.

3.6 Dimensions of long rod porcelain /Insulator String Along with Hardware Fitting

The various limiting dimensions of the long rod porcelain insulator/insulator strings shall generally be in conformity with the dimensions of the hardware fittings. The Contractor shall be required to verify the dimensions of the long rod porcelain insulator/insulator strings and shall ensure that the fittings are generally conforming to the dimensions of the hardware fittings.

3.7 Interchangeability

The hardware for long rod porcelain insulator/insulator strings with disc insulators together with ball and socket fittings shall be of standard design, so that this hardware are inter- changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard

3.8 Maintenance

The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method.

3.9 Designation

3.9.1 Ball and Socket Designation

The dimension of the ball and socket shall be 20mm for 120kN and 160KN Disc insulator. The designation should be in accordance with the standard dimensions stated in IS: 2486-(Part-II)/IEC: 60120. The dimensions shall be checked by the appropriate gauge after **galvanising only.**

3.10 Security Clips and Split Pins

3.10.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS: 2486-(Part-III)/ IEC: 60372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow separation of fittings.

3.10.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg)

3.10.3 Split pins shall be used with bolts & nuts.

3.11 Arcing Horn

1.11.1 The arcing horn / shall be either ball ended rod type or tubular type.

1.11.2 The arcing horn shall be provided generally as per existing fitting and shall conform to specification requirements

3.11.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

3.12 Yoke Plates

The strength of yoke plate shall be adequate to withstand the minimum ultimate tensile strength as specified.

The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for long rod porcelain insulator/disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing arcing horn. All the corners and edges should be rounded off with a radius of at least 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the contractor. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No.10.2.4.2 of IS: 800-2007.

3.13 Turn Buckle

3.13.1 The turn buckle is to be provided with single/ double tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

3.13.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150 mm minimum shall be possible with turnbuckle.

3.14 Suspension Assembly

3.14.1 The suspension assembly shall be suitable for the HTLS Conductor, the bidder intends to supply. The technical details of the conductor shall be as proposed by the bidder.

3.14.2 The suspension assembly shall be made of aluminium alloy and shall be suitable to accommodate the conductor together with standard preformed armour rods or armour grip suspension clamp. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor.

3.14.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

3.14.4 The suspension clamp shall be designed for continuous operation at the temperature specified by the bidder for conductor.

3.14.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

3.14.6 The suspension assembly/clamp shall be designed so that it shall minimise the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

3.15 Standard Preformed Armour Rod Set.

The Preformed Armour Rods Set shall be used to minimise the stress developed in the conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localized heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

3.15.1 The preformed armour rods set shall have right hand lay and the inside diameter of the helices shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

3.15.2 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

3.15.3 The length and diameter of each rod shall be furnished by the bidder in the GTP. The tolerance in length of the rods between the longest and shortest rod in complete set should be within the limits specified in relevant Indian/International Standards. The ends of armour rod shall be parrot billed.

3.15.4 The number of armour rods in each set shall be as per supplier's design to suit HTLS Conductor offered Standards. Each rod shall be marked in the middle with paint for easy application on the line.

3.15.5 The armour rod shall not lose their resilience even after five applications.

3.15.6 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

3.16 Dead end Assembly

3.16.1 The dead-end assembly shall be suitable for the offered HTLS Conductor.

3.16.2 The dead-end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I^2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

3.16.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON- COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions of dead-end assembly before & after compression along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

3.16.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

3.16.5 Jumper bolting arrangement between jumper terminal/cone and terminal pad/plate of dead-end assembly of tension hardware fittings shall be designed to suit the specification requirement of 1050A/800A, as the case may be, current and shall conform to the relevant Indian/International standards

3.16.6 For composite core HTLS conductor, dead end assembly shall inter-alia include collets, collet housing, inner sleeve etc., suitable for the offered design of HTLS conductor.

3.17 Fasteners: Bolts, Nuts and Washers

3.17.1 All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanized as per IS 1367 (Part- 13)/IS 2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

3.17.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS 12427. Bolts should be provided with washer face in accordance with IS 1363 (Part-1) to ensure proper bearing.

3.17.3 Nuts should be double chamfered as per the requirement of IS 1363 Part- III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size up-to M16.

3.17.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

3.17.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

3.17.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro- galvanised. The thickness of washers shall conform to IS: 2016.

3.17.7 The Contractor shall furnish bolt schedules giving thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

3.17.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time

its diameter.

3.17.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners withoutfouling.

3.17.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in- house. The manufacturer should also have proper Quality Assurance system which should be in line with the requirement of this specification and IS-.14000 services Quality System standard.

3.17.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

3.18 Accessories for the HTLS Conductor

3.22.1 This portion details the technical particulars of the accessories for Conductor.

3.22.2 2.5% extra fasteners, filler plugs and retaining rods shall be provided.

3.22.3 The supplier shall be responsible for satisfactory performance of complete conductor system along with accessories offered by him for continuous operation at temperature specified for the HTLS Conductor.

3.19 Mid Span Compression Joint

3.19.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistively less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor. It must be able to withstand the continuous design temperature of conductor.

3.19.2 The dimensions of mid span compression joint before & after compression along with tolerances shall be shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. For composite core conductor, suitable sleeve, collets, collet housing shall be used for core jointing.

3.20 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium / aluminium alloy and shall have a smooth surface. It shall be able to withstand the continuous maximum operating temperature of conductor. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions of Repair sleeve along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification.

3.21 Vibration Damper

3.21.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s are installed in the existing line at suspension and tension points on each conductor in each span to damp out aeolian vibration as well as sub- span oscillations. One damper minimum on each side per conductor for suspension points and two dampers minimum on each side per conductor for tension points shall be used for a ruling design span of 320 meters.

3.21.2 The bidder shall offer damping system including Stockbridge type dampers for proposed HTLS Conductor for its protection from wind induced vibrations which could cause conductor fatigue /strand breakage near a hardware attachment, such as suspension clamps. Alternate damping systems with proven design offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents including type test reports to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid. The damper shall be designed to have resonance frequencies to facilitate dissipation of vibration energy through inter-strand friction of the messenger cable and shall be effective in reducing vibration over a wide frequency range (depending upon conductor dia) or wind

velocity range specified above. The vibration damper shall meet the requirement of frequency or wind velocity range and also have mechanical impedance closely matched with the offered HTLS conductor. The vibration dampers shall be installed at suitable positions to ensure damping effectiveness across the frequency range. The power dissipation of the vibration dampers shall exceed the wind power so that the vibration level on the conductor is reduced below its endurance limit i.e 150 micro strain. The bidder shall clearly indicate the method for evaluating performance of dampers including analytical and laboratory test methods. The bidder shall indicate the type tests to evaluate the performance of offered damping system.

3.21.3 The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

3.21.4 The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/sqmm. It shall be of preformed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826 for heavily coated wires.

3.21.5 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.

3.21.6 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

3.21.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

3.21.8 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

3.21.9 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. 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.

3.21.10 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	Description	Technical particulars
1.	Span length in meters Ruling design span	350 meters
2.	Configuration	Double Circuit single Conductor per phase in vertical Configuration.
3.	Tensile load in Conductor at temperature of 0 deg. C and still air	As per Sag – tension calculations
4.	Armour rods used	Standard preformed armour rods/AGS
5.	Maximum permissible dynamic strain i.e. endurance limit.	+/- 150 micro strains

3.21.11 The damper placement chart shall be submitted for spans ranging from 100m to 1100m. Placement charts should be duly supported with relevant technical documents and sample calculations.

3.21.12 The damper placement charts shall include the following

Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.

Placement distances clearly identifying the extremities between which the distances are to be measured.

Placement recommendation depending upon type of suspension clamps (viz Free centre type/Armour grip type etc.)

The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

3.22 PG Clamp, Come Along Clamp, T-Clamp, CVT Clamp, CB Clamp, CT&PT clamp, Pad clamp for substation Bay stringing by HTLS conductor.

a. Standard Specification and tests shall be as per IS:5561.

b. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electrogalvanised.

c. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.

d. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.

e. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.

f. No part of a clamp shall be less than 15 mm thick for fittings suitable for HTLS conductor, All sharp edges and corners shall be blurred and rounded off.

g. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.

h. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

3.23 Corona and RI Performance.

Sharp edges and scratches on all the hardware fittings shall be avoided. All surface must be clean, smooth, without cuts and abrasions or projections. The Supplier shall be responsible for satisfactory corona and radio interference performance of the materials offered by him.

3.24 Materials

The materials of the various components shall be as specified hereunder. The Bidder shall indicate the material proposed to be used for each and every component of hardware fitting stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

The details of materials for different component are listed as in Table No-1 (a).

TABLE-1 (a)
(Details of Materials)

Sr. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks
1	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 302 or 304-L/ IS- 1385	
2	**For Free Centre /Envelope type clamps/PG Clamp/Come along clamp**				
a.	Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Casted or forged & Heat treated	IS:617or ASTM-B429	
b.	Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	As per IS-226 or IS-2062	
c.	U Bolts	Stainless Steel or High Strength Al Alloy 6061/65032	Forged & & Heat treated	AISI 302 or 304-L ASTM B429	
d.	P. A. Rod	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Heat treatment during manufacturing	ASTM-B429	Min. tensile strength of 35 kg/mm^2
3	**For AGS type clamp**				
(a)	Supporting House	High Strength Corrosion resistant Al.Alloy 4600/ LM-6 or 6061/65032	Casted or forged & Heat treated	S:617or ASTM- B429	
(b)	Al insert & Retaining strap	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Casted or forged I & Heat treated	S:617or ASTM- B429	High Strength Al. Alloy 4600/ LM-6 or 6061/65032
(c)	Elastomer	Molded on Al. reinforcement			
4.	**For Dead End Assembly**				
(a)	Outer Sleeve	EC grade Al of purity not less than99.50%			
(b)	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/ IS-2062	
5.	Ball & Socket Fittings,	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
6.	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
7.	Corona Control ring/ t Grading ring	High Strength Al. Alloy tube (6061/6063/ 1100 ype or 65032/ 63400	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be lessthan 20 kN
8.	Supporting than 20 Brackets & Mounting Bolts	High strength Al Alloy 7061/ 6063/ 65032/63400 Type) or Mild Steel	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or S:2062	

Note: *Alternate materials conforming to other national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered viz a viz specified in the bid or else the bids are liable to be rejected*.

3.24 Workmanship

3.24.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 220 kV transmission lines and will give continued good performance.

3.24.2 High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings / accessories under simulated service condition corresponding to operation of conductor at maximum (emergency) operating temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/performance test certificates as per applicable standards/product specifications to confirm suitability of the offered material.

3.24.3 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

3.24.4 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall be done in accordance with IS 2629 / IS 1367 (Part-13) and shall satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips of one-minute duration in the standard Preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 600 gm/sqm., shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard Preece test for galvanizing.

3.24.5 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 dimensions below the design requirements.

3.24.6 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanising shall be grade Zn 99.95 as per IS: 209.

3.24.7 Pin balls shall be checked with the applicable “GO” gauges in at least two directions. one of which shall be across the line of die flashing, and the other 90^{o} to this line. "NO GO" gauges shall not pass in any direction.

3.24.8 Socket ends, before galvanising, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486/IEC: 120.

The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

3.24.9 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

3.24.10 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

3.24.11 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

3.24.12 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of

the holes shall be free from burrs.

3.24.13 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

3.24.14 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed.
There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

3.25 Bid Drawings

3.25.1 The Bidder shall furnish full description and illustrations of materials offered.

3.25.2 Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following arrangements shall be furnished in three copies along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

i) Attachment of the hanger or strain plate.
ii) Suspension or dead-end assembly.
iii) Arcing horn attachment to the string as specified this technical Specification.
iv) Yoke plates
v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.

3.25.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

i) Dimensions and dimensional tolerance.
ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
iii) Catalogue No.
iv) Marking
v) Weight of assembly
vi) Installation instructions
vii) Design installation torque for the bolt or cap screw.
viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
ix) The compression die number with recommended compression pressure.
x) Placement charts for damper.
xi) All other relevant terminal details.

3.25.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Owner for approval. After getting approval from the Owner and successful completion of all the type tests, the Contractor shall submit ten (10) more copies of the same drawings to the Owner for further distribution and field use at Employer's end.

3.26 Compression Markings

Die compression areas shall be clearly marked, on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' 'suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks, showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished equipment shall be distinct and legible.

3.27 Test and Standards

3.27.1 Type Test

3.27.1.1 On the complete Disc Insulator Strings with Hardware Fittings

a)	Power frequency voltage withstand test with arcing horns under wet condition	:	As per IEC:60383
b)	Impulse voltage withstand test under dry condition	:	As per IEC:60383
c)	Mechanical Strength test	:	As per Annex-B 1
d)	Voltage distribution test	:	As per Annex-B 1
e)	Vibration test	:	As per Annex-B 1

Note: 1) All the type test given in Clause No. 3.27.1.1 shall be conducted on complete single suspension & Single Tension insulator unit.

2) All the type tests given under Clause No. 3.27.1.1 (a) to (e) shall also be conducted on Single I Pilot, Double I Suspension & Double Tension insulator unit

3.27.2 On Hardware Fittings

a. Mechanical Strength Test on Tension Hardware fitting : As per Annex-B 1
b. Mechanical Strength Test on Suspension Hardware fitting : As per Annex-B 1

3.27.3 On Suspension Clamp

a. Magnetic power loss test : As per Annexure-B 1
b. Clamp slip strength Vs torque test : As per Annexure-B 1
c. Ozone Test on elastomer : As per Annexure-B 1
d. Vertical damage load & Failure load test : IEC: 61284

3.27.4 On Dead end Tension Assembly

a. Electrical resistance test for dead end Assembly : As per IS:2486-(Part-I)
b. Heating cycle test for dead end Assembly : As per Annexure-B 1
c. Slip strength test for dead end assembly : As per IS:2486-(Part-I)
d. Ageing test on filler (if applicable) : As per Annexure-B 1

3.27.5 Mid Span Compression Joint for Conductor

a. Chemical analysis of materials : As per Annexure-B 1
b. Electrical resistance test :As per IS:2121 (Part-II)
c. Heating cycle test :As per Annexure-B 1
d. Slip strength test : As per Annexure-B 1
e. Corona extinction voltage test (dry) : As per Annexure-B 1
f. Radio interference voltage test (dry) : As per Annexure-B 1

3.27.6 Repair Sleeve for Conductor

a. Chemical analysis of materials : As per Annexure-B 1
b. Corona extinction voltage test (dry) : As per Annexure-B 1
c. Radio interference voltage test (dry) : As per Annexure-B 1

3.27.7 Vibration Damper for Conductor

a. Chemical analysis of materials : As per Annexure-B 1
b. Dynamic characteristics test* : As per Annexure-B 1
c. Vibration analysis : As per Annexure-B 1
d. Clamp slip test : As per Annexure-B 1
e. Fatigue tests : As per Annexure-B 1
f. Magnetic power loss test : As per Annexure-B 1
g. Damper efficiency test : As per IS:9708
h. Corona extinction voltage test (dry) : As per Annexure-B 1
i. Radio interference voltage test (dry) : As per Annexure-B 1

3.27.8 Type tests specified under Clause 3.27.1 to 3.27.7 shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) Central/State Power Utility.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Employer/ Employer/ Employer.

3.28 Acceptance Tests

3.28.1 On Both Suspension clamp and Tension Assembly

Visual Examination	: As per IS:2486-(Part-I)
Verification of dimensions	: As per IS:2486-(Part-I)
Galvanising/Electroplating test	: As per IS:2486-(Part-I) Mechanical
strength test of each component	: As per Annexure-B 1 Mechanical
strength test for arcing horn	: As per BS:3288(Part-I)
Test on locking device for ball and socket coupling	: As per IEC:372 (2) Mechanical
Strength test of welded joint	: As per Annexure-B 1
Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings	: As per Annexure-B 1

3.28.2 On Suspension Clamp only

a.	Clamp Slip strength Vs Torque test for suspension clamp	: As per Annexure-B 1
b.	Shore hardness test of elastomer cushion for AG suspension clamp	: As per Annexure-B 1
c.	Bend test for armour rod set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
d.	Resilience test for armour rod set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
e.	Conductivity test for armour rods set	: As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11

3.28.3 On Tension Hardware Fittings only

a.	Slip strength test for dead end assembly	: As per IS:2486 (Part-I) Clause 5.4
b.	Ageing test on filler (if applicable)	: As per Annexure-C 1

3.28.4 On Mid Span Compression Joint for Conductor

a.	Visual examination and dimensional verification	: As per IS:2121 (Part-II), Clause 6.2, 6.37 6.7
b.	Galvanizing test	: As per Annexure-B 1
c.	Hardness test	: As per Annexure-C 1
d.	Ageing test on filler (if applicable)	: As per Annexure-C 1

3.28.5 Repair Sleeve for Conductor

Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3

3.28.6 Vibration Damper for Conductor

a. Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3 7 6.7

b. Galvanizing test : As per Annexure-B 1

i. On damper masses : As per Annexure-B 1

ii. On messenger cable : As per Annexure-B 1

c. Verification of resonance frequencies : As per Annexure-C 1

d. Clamp slip test : As per Annexure-C 1

e. Clamp bolt torque test : As per Annexure-C 1

f. Strength of the messenger cable : As per Annexure-C 1

g. Mass pull off test : As per Annexure-C 1

h. Dynamic characteristics test* : As per Annexure-C 1

* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 3.27), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 may be proposed/ carried out by the supplier.

3.29 Routine Tests

3.29.1 For Hardware Fittings

a. Visual examination :IS 2486-(Part-I)

b. Proof Load Test : As per Annexure-B 1

3.29.2 For conductor accessories

Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3 7 6.7

3.29.3 Tests During Manufacture on all components as applicable

a. Chemical analysis of Zinc used for galvanizing : IS 2486-(Part-I)

b. Chemical analysis mechanical metallographic test and magnetic particle inspection for malleable castings : As per Annexure-B 1

c. Chemical analysis, hardness tests and magnetic particle inspection for forging : As per Annexure-B 1

3.30 Testing Expenses

3.30.1 As indicated in clause 3.27 no type test charges shall be payable.

3.30.2 In case type testing is required due to non-availability of type test reports, or type test on the complete insulator string, the Contractor has to arrange similar insulators at his own cost.

3.30.3 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

3.30.4 The entire cost of testing for type tests, acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

3.30.5 In case of failure in any type test, repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector/ Owner's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Owner's representative/Inspector does not find material & facilities to be ready for testing the expenses incurred by the Owner's for re- deputation shall be deducted from contract price.

3.30.6 The Contractor shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance of the scheduled date of testing during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests.

3.31 Schedule of Testing and Additional Tests

3.31.1 The Bidder has to indicate the schedule of following activities in their bids

i. Submission of drawing for approval.
ii. Submission of Quality Assurance programme for approval.
iii. Offering of material for sample selection for type tests.
iv. Type testing.

3.31.2 The Owner reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the specifications.

3.31.3 The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other test centre. In case of evidence of noncompliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Owner.

3.32 Test Reports

3.32.1 Copies of type test report shall be furnished in at least six copies along with one original. One copy shall be returned, duly certified by the Owner, only after which the commercial production of the concerned material shall start.

3.32.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Owner, only after which the materials will be despatched.

3.32.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Owner's representative.

3.32.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.

3.33 Inspection

3.33.1 The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub- Contractor's works raw materials. Manufacturer's of all the material and for conducting necessary tests as detailed herein.

3.33.2 The material for final inspection shall be offered by the Contractor only under packed condition. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

3.33.3 The Contractor shall keep the Employer informed in advance of the time of starting and of the progress of manufacture of material in its various stages so that arrangements could be made for inspection.

3.33.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Owner in writing. In the latter case also the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

3.33.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such materials are later found to be defective.

3.34 Packing and Marking

3.34.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

3.34.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

3.34.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

3.34.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

3.34.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture. However, in such type of component/item, which consists of many parts and are being supplied in assembled condition (suspension clamp, vibration damper, etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts.

3.34.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

3.35 Standards

3.35.1 The Hardware fittings; conductor and earth wire accessories shall conform to the following Indian/International Standards which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

3.35.2 In the event of the supply of hardware fittings; conductor accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	**Indian Standard**	**Title**	**International Standard**
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS:398-1992 Part-V	Aluminum Conductor Galvanised Steel-Reinforced For Extra High Voltage	IEC:1089-1991 BS:215-1970
3.	IS 1573	Electroplated Coating of Zinc on iron and Steel	
4.	IS : 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines: Mid-span Joints and Repair Sleeves for Conductors	
5.	IS:2486 (Part-I)	Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	

6.	IS:2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
7.	IS:2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8.		Ozone test on Elastomer	ASTM- D1 171
9.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC:383-1993
10.	IS:4826	Galvanised Coating on Round Steel Wires	ASTM A472-729 BS:443-1969
11.	IS:6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO: 1460 (E)
12.	IS:8263	Method of Radio Interference Tests on High Voltage Insulators	IEC:437, NEMA:107 CISPR
13.	IS:6639	Hexagonal Bolts for Steel Structures	ISO/R-272
14.	IS:9708	Specification for Stock Bridge Vibration Dampers for Overhead Power lines	

SECTION – 3 (B)

TECHNICAL SPECIFICATIONS OF HARDWARE FITTINGS & OTHER ACCESSORIES FOR 132Kv VOLTAGE LEVEL

Technical Description of Hardware Fittings

3.1 General

This section details technical particulars of hardware fittings and suspension clamps & compression type dead end clamps for the HTLS Conductor to be proposed and supplied for replacement of ACSR panther conductor by the bidder. Each fitting shall be suitable for proposed HTLS conductor and to be supplied for satisfactory performance of complete conductor system for continuous operation at the designed maximum temperature specified by them for the conductor.

Note: The hardware fittings, clamps and connectors and other related accessories shall be provided to suit panther equivalent HTLS conductors of minimum 600A capacity.

3.2. Hardware Fittings

The hardware fittings shall be suitable for use with long rod porcelain /string insulators having ball and socket fittings. Each hardware fitting shall be supplied complete in all respects and shall include the following hardware parts:

3.2.1 Suitable arcing horn as specified in clause 3.11 hereinafter.

3.2.2 Suitable yoke assemblies with the arrangement of fixing a set of arching horn and complying with the specifications given hereinafter.

3.2.3 Bolts, Nuts, washers, split pin etc.

3.2.4 Suspension, tension clamps and dead-end assembly to suit conductor size as detailed in clause 3.3, 3.4 and 3.16, hereinafter.

3.2.5 Other necessary fittings viz D-shackles, eye links, extension links, ball clevis, socket clevis, clevis eye, U clevis and chain link etc. to make the hardware fittings complete.

3.2.6 2.5% extra fasteners.

3.3 SUSPENSION CLAMP

The suspension clamps shall be made of malleable iron or aluminium alloy, hot dip galvanised and shall be suitable to accommodate the conductor together with one set of standard preformed armour rods. Suitable sheet aluminium liners shall be provided. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor. The lips shall be rounded off and the seating and the bell mouths shall be smooth to avoid corona and radio interference noises. The suspension clamps shall be suitable to carry the bottom part of the arcing horn and to receive the fittings of the long rod porcelain insulator/insulator string.

The suspension clamps shall be such that the conductor should not slip at a load of 25% of the breaking load of the conductor. The ultimate strength of the clamp for vertical load shall not be less than the failing load of the Insulators.

3.4 STRAIN CLAMP

The strain clamps shall also be made of malleable iron or aluminium alloy; hot dip galvanised, lined with sheet aluminium liners and shall be suitable to accommodate the conductor with necessary binding tapes etc. The lips shall be rounded off carefully and conductor seating and the ball mouth shall be smooth to avoid corona and radio interference noises. Suitable attachment for receiving both side of arcing horns and for connecting to the porcelain long rod insulator/insulator strings shall be provided.

The strain clamps shall be such that the conductor should not slip at a load of 90% of the breaking load of the conductor. The ultimate strength of the clamp for horizontal load shall not be less than the ultimate strength of the conductor.

3.5 Clamps fittings

The clamp fittings shall be suitable for attachment to suspension and tension porcelain long rod insulator/insulator strings along with hardware fittings for normal stretches as well as river crossing stretches and shall include 2.5 % extra fasteners. The supplier shall be responsible for satisfactory performance of complete conductor system along with fittings offered by them for continuous operation at the designed maximum temperature specified by them for the conductor.

3.6 Dimensions of long rod porcelain /Insulator String Along with Hardware Fitting

The various limiting dimensions of the long rod porcelain insulator/insulator strings shall generally be in conformity with the dimensions of the hardware fittings. The Contractor shall be required to verify the dimensions of the long rod porcelain insulator/insulator strings and shall ensure that the fittings are generally conforming to the dimensions of the hardware fittings.

3.7 Interchangeability

The hardware for long rod porcelain insulator/insulator strings with disc insulators together with ball and socket fittings shall be of standard design, so that this hardware are inter- changeable with each other and suitable for use with insulators of any make conforming to relevant Indian/International Standard

3.8 Maintenance

The hardware fittings offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety. The technique adopted for hot line maintenance shall be generally bare hand method & hot stick method.

3.9 Designation

3.9.1 Ball and Socket Designation

The dimension of the ball and socket shall be 16mm designation for 70 and 90KN and 20mm for 120kN Disc insulator. The designation should be in accordance with the standard dimensions stated in IS: 2486- (Part-II)/IEC: 60120. The dimensions shall be checked by the appropriate gauge after **galvanising only.**

3.10 Security Clips and Split Pins

3.10.1 Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS: 2486-(Part-III)/ IEC: 60372. The legs of the security clips shall be spread after assembly in the works to prevent complete withdrawal from the socket. The locking device should be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking devices allow separation of fittings.

3.10.2 The hole for the security clip shall be countersunk and the clip should be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50 N (5 kg) or more than 500 N (50 kg)

3.10.3 Split pins shall be used with bolts & nuts.

3.11 Arcing Horn

3.11.1 The arcing horn / shall be either ball ended rod type or tubular type.

3.11.2 The arcing horn shall be provided generally as per existing fitting and shall conform to specification requirements

3.11.3 The air gap shall be so adjusted to ensure effective operation under actual field conditions.

3.12 Yoke Plates

The strength of yoke plate shall be adequate to withstand the minimum ultimate tensile strength as specified.

The plates shall be either triangular or rectangular in shape as may be necessary. The design of yoke plate shall take into account the most unfavorable loading conditions likely to be experienced as a result of dimensional tolerances for long rod porcelain insulator/disc insulators as well as components of hardware fittings within the specified range. The plates shall have suitable holes for fixing arcing horn. All the corners and edges should be rounded off with a radius of atleast 3 mm. Design calculations i.e. for bearing & tensile strength, for deciding the dimensions of yoke plate shall be furnished by the contractor. The holes provided for bolts in the yoke plate should satisfy shear edge condition as per Clause No.10.2.4.2 of IS: 800-2007.

3.13 Turn Buckle

3.13.1 The turn buckle is to be provided with single/ double tension hardware fitting. The threads shall be of sufficient strength to remain unaffected under the specified tensile load.

3.13.2 The maximum length of the turn buckle from the connecting part of the rest of the hardware fittings shall be 520 mm. The details of the minimum and maximum adjustment possible shall be clearly indicated in the drawing. An adjustment of 150 mm minimum shall be possible with turnbuckle.

3.14 Suspension Assembly

3.14.1 The suspension assembly shall be suitable for the HTLS Conductor, the bidder intends to supply. The technical details of the conductor shall be as proposed by the bidder.

3.14.2 The suspension assembly shall be made of aluminium alloy and shall be suitable to accommodate the conductor together with standard preformed armour rods or armour grip suspension clamp. The suspension clamps shall be designed to avoid any possibility of deforming or damaging the conductor.

3.14.3 The suspension clamp along with standard preformed armour rods set shall be designed to have maximum mobility in any direction and minimum moment of inertia so as to have minimum stress on the conductor in the case of oscillation of the same.

3.14.4 The suspension clamp shall be designed for continuous operation at the temperature specified by the bidder for conductor.

3.14.5 The suspension assembly shall be designed, manufactured and finished to give it a suitable shape, so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth without any cuts, grooves, abrasions, projections, ridges or excrescence which might damage the conductor.

3.14.6 The suspension assembly/clamp shall be designed so that it shall minimise the static & dynamic stress developed in the conductor under various loading conditions as well as during wind induced conductor vibrations. It shall also withstand power arcs & have required level of Corona/RIV performance.

3.15 Standard Preformed Armour Rod Set.

The Preformed Armour Rods Set shall be used to minimise the stress developed in the conductor due to different static and dynamic loads because of vibration due to wind, slipping of conductor from the suspension clamp as a result of unbalanced conductor tension in adjacent spans and broken wire condition. It shall also withstand power arcs, chafing and abrasion from suspension clamp and localized heating effect due to magnetic power losses from suspension clamps as well as resistance losses of the conductor.

3.15.1 The preformed armour rods set shall have right hand lay and the inside diameter of the helices shall be less than the outside diameter of the conductor to have gentle but permanent grip on the conductor. The surface of the armour rod when fitted on the conductor shall be smooth and free from projections, cuts and abrasions etc.

3.15.2 The pitch length of the rods shall be determined by the Bidder but shall be less than that of the outer layer of conductor and the same shall be accurately controlled to maintain uniformity and consistently reproducible characteristic wholly independent of the skill of linemen.

3.15.3 The length and diameter of each rod shall be furnished by the bidder in the GTP. The tolerance in length of the rods between the longest and shortest rod in complete set should be within the limits specified in relevant Indian/International Standards. The ends of armour rod shall be parrot billed.

3.15.4 The number of armour rods in each set shall be as per supplier's design to suit HTLS Conductor offered Standards. Each rod shall be marked in the middle with paint for easy application on the line.

3.15.5 The armour rod shall not lose their resilience even after five applications.

3.15.6 The conductivity of each rod of the set shall not be less than 40% of the conductivity of the International Annealed Copper Standard (IACS).

3.16 Dead end Assembly

3.16.1 The dead-end assembly shall be suitable for the offered HTLS Conductor.

3.16.2 The dead-end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted should be 30° with respect to the vertical line. The area of bearing surface on all the connections shall be sufficient to ensure positive electrical and mechanical contact and avoid local heating due to I^2R losses. The resistance of the clamp when compressed on Conductor shall not be more than 75% of the resistance of equivalent length of Conductor.

3.16.3 Die compression areas shall be clearly marked on each dead-end assembly designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' suitably inscribed near the point on each assembly where the compression begins. If the dead-end assembly is designed for intermittent die compressions it shall bear identification marks 'COMPRESSION ZONE' AND 'NON- COMPRESSION ZONE' distinctly with arrow marks showing the direction of compressions and knurling marks showing the end of the zones. The letters, number and other markings on the finished clamp shall be distinct and legible. The dimensions of dead-end assembly before & after compression alongwith tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. These shall be guaranteed in the relevant schedules of bid.

3.16.4 The assembly shall not permit slipping of, damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.

3.16.5 Jumper bolting arrangement between jumper terminal/cone and terminal pad/plate of dead end assembly of tension hardware fittings shall be designed to suit the specification requirement of 1050A/800A, as the case may be, current and shall conform to the relevant Indian/International standards

3.16.6 For composite core HTLS conductor, dead end assembly shall inter-alia include collets, collet housing, inner sleeve etc., suitable for the offered design of HTLS conductor.

3.17 Fasteners: Bolts, Nuts and Washers

3.17.1 All bolts and nuts shall conform to IS 6639. All bolts and nuts shall be galvanized as per IS 1367 (Part- 13)/IS 2629. All bolts and nuts shall have hexagonal heads, the heads being forged out of solid truly concentric, and square with the shank, which must be perfectly straight.

3.17.2 Bolts up to M16 and having length up to 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolt for 5.6 grade should be 310 MPa minimum as per IS 12427. Bolts should be provided with washer face in accordance with IS 1363 (Part-1) to ensure proper bearing.

3.17.3 Nuts should be double chamfered as per the requirement of IS 1363 Part- III 1984. It should be ensured by the manufacturer that nuts should not be over tapped beyond 0.4 mm oversize on effective diameter for size upto M16.

3.17.4 Fully threaded bolts shall not be used. The length of the bolt shall be such that the threaded portion shall not extend into the place of contact of the component parts.

3.17.5 All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit the firm gripping of the component parts but no further. It shall be ensured that the threaded portion of the bolt protrudes not less than 3 mm and not more than 8 mm when fully tightened. All nuts shall fit and tight to the point where shank of the bolt connects to the head.

3.17.6 Flat washers and spring washers shall be provided wherever necessary and shall be of positive lock type. Spring washers shall be electro- galvanised. The thickness of washers shall conform to IS: 2016.

3.17.7 The Contractor shall furnish bolt schedules giving thickness of components connected, the nut and the washer and the length of shank and the threaded portion of bolts and size of holes and any other special details of this nature.

3.17.8 To obviate bending stress in bolt, it shall not connect aggregate thickness more than three time its diameter.

3.17.9 Bolts at the joints shall be so staggered that nuts may be tightened with spanners withoutfouling.

3.17.10 To ensure effective in-process Quality control it is essential that the manufacturer should have all the testing facilities for tests like weight of zinc coating, shear strength, other testing facilities etc, in- house. The manufacturer should also have proper Quality Assurance system which should be in line with the requirement of this specification and IS-.14000 services Quality System standard.

3.17.11 Fasteners of grade higher than 8.8 are not to be used and minimum grade for bolt shall be 5.6.

3.18 Accessories for the HTLS Conductor

3.22.1 This portion details the technical particulars of the accessories for Conductor.

3.22.2 2.5% extra fasteners, filler plugs and retaining rods shall be provided.

3.22.3 The supplier shall be responsible for satisfactory performance of complete conductor system along with accessories offered by him for continuous operation at temperature specified for the HTLS Conductor.

3.19 Mid Span Compression Joint

3.19.1 Mid Span Compression Joint shall be used for joining two lengths of conductor. The joint shall have a resistively less than 75% of the resistivity of equivalent length of conductor. The joint shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor. It must be able to withstand the continuous design temperature of conductor.

3.19.2 The dimensions of mid span compression joint before & after compression along with tolerances shall be shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification. For composite core conductor, suitable sleeve, collets, collet housing shall be used for core jointing.

3.20 Repair Sleeve

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from 99.5% pure aluminium / aluminium alloy and shall have a smooth surface. It shall be able to withstand the continuous maximum operating temperature of conductor. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation. The dimensions of Repair sleeve along with tolerances shall be guaranteed in the relevant schedules of the bid and shall be decided by the manufacturer so as to suit the conductor size & conform to electrical & mechanical requirement stipulated in the specification.

3.21 Vibration Damper

3.21.1 Vibration dampers of 4R-stockbridge type with four (4) different resonances spread within the specified aeolian frequency band width corresponding to wind speed of 1 m/s to 7 m/s are installed in the existing line at suspension and tension points on each conductor in each span to damp out aeolian vibration as well as sub- span oscillations. One damper minimum on each side per conductor for suspension points and two dampers minimum on each side per conductor for tension points shall be used for a ruling design span of 320 meters.

3.21.2 The bidder shall offer damping system including Stockbridge type dampers for proposed HTLS Conductor for its protection from wind induced vibrations which could cause conductor fatigue /strand breakage near a hardware attachment, such as suspension clamps. Alternate damping systems with proven design offering equivalent or better performance also shall be accepted provided the manufacturer meets the qualifying requirements stipulated in the Specifications. Relevant technical documents including type test reports to establish the technical suitability of alternate systems shall be furnished by the Bidder along with the bid. The damper shall be designed to have resonance frequencies to facilitate dissipation of vibration energy through inter-strand friction of the messenger cable and shall be effective in reducing vibration over a wide frequency range (depending upon conductor dia) or wind velocity range specified above. The vibration damper shall meet the requirement of frequency or wind velocity range and also have mechanical impedance closely matched with the offered HTLS conductor. The

vibration dampers shall be installed at suitable positions to ensure damping effectiveness across the frequency range. The power dissipation of the vibration dampers shall exceed the wind power so that the vibration level on the conductor is reduced below its endurance limit i.e 150 micro strain. The bidder shall clearly indicate the method for evaluating performance of dampers including analytical and laboratory test methods. The bidder shall indicate the type tests to evaluate the performance of offered damping system.

3.21.3 The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chafing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the conductor without damaging the strands or causing premature fatigue failure of the conductor under the clamp. The clamp groove shall be in uniform contact with the conductor over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the conductor when the clamp is installed. Clamping bolts shall be provided with self-locking nuts and designed to prevent corrosion of threads or loosening in service.

3.21.4 The messenger cable shall be made of high strength galvanized steel/stain less steel with a minimum strength of 135 kg/sqmm. It shall be of preformed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The number of strands in the messenger cable shall be 19. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS: 4826 for heavily coated wires.

3.21.5 The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blowholes etc. The surface of the damper masses shall be smooth.

3.21.6 The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

3.21.7 The damper assembly shall be so designed that it shall not introduce radio interference beyond acceptable limits.

3.21.8 The vibration damper shall be capable of being installed and removed from energised line by means of hot line technique. In addition, the clamp shall be capable of being removed and reinstalled on the conductor at the designated torque without shearing or damaging of fasteners.

3.21.9 The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 kN. 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.

3.21.10 The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed under Annexure-A, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

Sl. No.	**Description**	**Technical particulars**
1.	Span length in meters Ruling design span	325 meters

2.	Configuration	Double Circuit single Conductor per phase in vertical Configuration.
3.	Tensile load in Conductor at temperature of 0 deg. C and still air	As per Sag – tension calculations
4.	Armour rods used	Standard preformed armour rods/AGS
5.	Maximum permissible dynamic strain ie endurance limit.	+/- 150 micro strains

3.21.11 The damper placement chart shall be submitted for spans ranging from 100m to 1100m. Placement charts should be duly supported with relevant technical documents and sample calculations.

3.21.12 The damper placement charts shall include the following

Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per conductor per span.

Placement distances clearly identifying the extremities between which the distances are to be measured.

Placement recommendation depending upon type of suspension clamps (viz Free centre type/Armour grip type etc.)

The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

3.22 PG Clamp, Come Along Clamp, T-Clamp, CVT Clamp, CB Clamp, CT&PT clamp, Pad clamp for substation Bay stringing by HTLS conductor.

a. Standard Specification and tests shall be as per IS:5561.

b. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electro-galvanised.

c. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.

d. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.

e. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.

f. No part of a clamp shall be less than 15 mm thick for fittings suitable for offered HTLS conductor, All sharp edges and corners shall be blurred and rounded off.

g. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.

h. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

3.23 Materials

The materials of the various components shall be as specified hereunder. The Bidder shall indicate the material proposed to be used for each and every component of hardware fittings stating clearly the class, grade or alloy designation of the material, manufacturing process & heat treatment details and the reference standards.

3.23.1 The details of materials for different component are listed as in Table No-1 (b).

TABLE-1 (b)

(Details of Materials)

Sr. No.	Name of item	Material treatment	Process of Standard	Reference	Remarks

1	Security Clips	Stainless Steel/ Phospher Bronze	-	AISI 302 or 304-L/ IS- 1385	
2	**For Free Centre /Envelope type clamps/PG Clamp/Come along clamp**				
a.	Clamp Body, Keeper Piece	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Casted or forged & Heat treated	IS:617or ASTM-B429	
b.	Cotter bolts/ Hangers, Shackles, Brackets	Mild Steel	Hot dip galvanised	As per IS-226 or IS-2062	
c.	U Bolts	Stainless Steel or High Strength Al Alloy 6061/65032	Forged & & Heat treated	AISI 302 or 304-L ASTM B429	
d.	P. A. Rod	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Heat treatment during manufacturing	ASTM-B429	Min. tensile strength of 35 kg/mm^2
3	**For AGS type clamp**				
(a)	Supporting House	High Strength Corrosion resistant Al.Alloy 4600/ LM-6 or 6061/65032	Casted or forged & Heat treated	S:617or ASTM-B429	
(b)	Al insert & Retaining strap	High Strength Al. Alloy 4600/ LM-6 or 6061/65032	Casted or forged l & Heat treated	S:617or ASTM-B429	High Strength Al. Alloy 4600/ LM-6 or 6061/65032
(c)	Elastomer	Molded on Al. reinforcement			
4.	**For Dead End Assembly**				
(a)	Outer Sleeve	EC grade Al of purity not less than99.50%			
(b)	Steel Sleeve	Mild Steel	Hot Dip Galvanised	IS:226/ IS-2062	
5.	Ball & Socket Fittings,	Class-IV Steel	Drop forged & normalized Hot dip galvanised	As per IS: 2004	
6.	Yoke Plate	Mild Steel	Hot dip galvanized	As per IS-226 or IS-2062	
7.	Corona Control ring/ t Grading ring	High Strength Al. Alloy tube (6061/6063/ 1100 ype or 65032/ 63400	Heat treated Hot dip galvanized	ASTM-B429 or as per IS	Mechanical strength of welded joint shall not be less than 20 kN
8.	Supporting than 20 Brackets & Mounting Bolts	High strength Al Alloy 7061/ 6063/ 65032/63400	Heat treated Hot dip galvanized	ASTM-B429 or as per IS:226 or S:2062	

		Type) or Mild Steel			

Note: *Alternate materials conforming to other national standards of other countries also may be offered provided the properties and compositions of these are close to the properties and compositions of material specified. Bidder should furnish the details of comparison of material offered viz a viz specified in the bid or else the bids are liable to be rejected*.

3.24 Workmanship

3.24.1 All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field. The Bidder shall offer only such equipment as guaranteed by him to be satisfactory and suitable for 132 kV transmission lines and will give continued goodperformance

3.24.2 High current, heat rise test shall be conducted by the supplier to determine the maximum temperature achieved in different components of fittings / accessories under simulated service condition corresponding to operation of conductor at maximum (emergency) operating temperature. The material of the components should be suitable for continued good performance corresponding to these maximum temperatures. The supplier shall submit relevant type/performance test certificates as per applicable standards/product specifications to confirm suitability of the offeredmaterial.

3.24.3 The design, manufacturing process and quality control of all the materials shall be such as to give the specified mechanical rating, highest mobility, elimination of sharp edges and corners to limit corona and radio-interference, best resistance to corrosion and a good finish.

3.24.4 All ferrous parts including fasteners shall be hot dip galvanised, after all machining has been completed. Nuts may, however, be tapped (threaded) after galvanising and the threads oiled. Spring washers shall be electro galvanized. The bolt threads shall be undercut to take care of the increase in diameter due to galvanizing. Galvanizing shall be done in accordance with IS 2629 / IS 1367 (Part-13) and shall satisfy the tests mentioned in IS 2633. Fasteners shall withstand four dips while spring washers shall withstand three dips of one minute duration in the standard Preece test. Other galvanized materials shall have a minimum average coating of zinc equivalent to 600 gm/sqm., shall be guaranteed to withstand at least six successive dips each lasting one (1) minute under the standard Preece test for galvanizing.

3.24.5 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 dimensions below the design requirements.

3.24.6 The zinc coating shall be perfectly adherent, of uniform thickness, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust, stains, bulky white deposits and blisters. The zinc used for galvanising shall be grade Zn 99.95 as per IS: 209.

3.24.7 Pin balls shall be checked with the applicable “GO” gauges in at least two directions. one of which shall be across the line of die flashing, and the other 90^{o} to this line. "NO GO" gauges shall not pass in any direction.

3.24.8 Socket ends, before galvanising, shall be of uniform contour. The bearing surface of socket ends shall be uniform about the entire circumference without depressions of high spots. The internal contours of socket ends shall be concentric with the axis of the fittings as per IS: 2486/IEC: 120.
The axis of the bearing surfaces of socket ends shall be coaxial with the axis of the fittings. There shall be no noticeable tilting of the bearing surfaces with the axis of the fittings.

3.24.9 In case of casting, the same shall be free from all internal defects like shrinkage, inclusion, blow holes, cracks etc. Pressure die casting shall not be used for casting of components with thickness more than 5 mm.

3.24.10 All current carrying parts shall be so designed and manufactured that contact resistance is reduced to minimum.

3.24.11 No equipment shall have sharp ends or edges, abrasions or projections and cause any damage to the

conductor in any way during erection or during continuous operation which would produce high electrical and mechanical stresses in normal working. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surface and to maintain good electrical contact under service conditions.

3.24.12 All the holes shall be cylindrical, clean cut and perpendicular to the plane of the material. The periphery of the holes shall be free from burrs.

3.24.13 All fasteners shall have suitable corona free locking arrangement to guard against vibration loosening.

3.24.14 Welding of aluminium shall be by inert gas shielded tungsten arc or inert gas shielded metal arc process Welds shall be clean, sound, smooth, uniform without overlaps, properly fused and completely sealed.
There shall be no cracks, voids incomplete penetration, incomplete fusion, under-cutting or inclusions. Porosity shall be minimised so that mechanical properties of the aluminium alloys are not affected. All welds shall be properly finished as per good engineering practices.

3.25 Bid Drawings

3.25.1 The Bidder shall furnish full description and illustrations of materials offered.

3.25.2 Fully dimensioned drawings of the complete insulator string hardware and their component parts showing clearly the following arrangements shall be furnished in three copies along with the bid. Weight, material and fabrication details of all the components should be included in the drawings.

i) Attachment of the hanger or strain plate.
ii) Suspension or dead-end assembly.
iii) Arcing horn attachment to the string as specified this technical Specification.
iv) Yoke plates
v) Hardware fittings of ball and socket type for inter connecting units to the top and bottom Yoke plates.

3.25.3 All drawings shall be identified by a drawing number and contract number. All drawings shall be neatly arranged. All drafting & lettering shall be legible. The minimum size of lettering shall be 3 mm. All dimensions & dimensional tolerances shall be mentioned in mm.

The drawings shall include:

i) Dimensions and dimensional tolerance.
ii) Material, fabrication details including any weld details & any specified finishes & coatings. Regarding material designation & reference of standards are to be indicated.
iii) Catalogue No.
iv) Marking
v) Weight of assembly
vi) Installation instructions
vii) Design installation torque for the bolt or cap screw.
viii) Withstand torque that may be applied to the bolt or cap screw without failure of component parts.
ix) The compression die number with recommended compression pressure.
x) Placement charts for damper.
xi) All other relevant terminal details.

3.25.4 After placement of award, the Contractor shall submit fully dimensioned drawing including all the components in four (4) copies to the Owner for approval. After getting approval from the Owner and successful completion of all the type tests, the Contractor shall submit ten (10) more copies of the same drawings to the Owner for further distribution and field use at Employer's end.

3.26 Compression Markings

Die compression areas shall be clearly marked, on each equipment designed for continuous die compressions and shall bear the words 'COMPRESS FIRST' 'suitably inscribed on each equipment where the compression begins. If the equipment is designed for intermittent die compressions, it shall bear the identification marks 'COMPRESSION ZONE' and 'NON-COMPRESSION ZONE' distinctly with arrow marks, showing the direction of compression and knurling marks showing the end of the zones. The letters, number and other markings on finished

equipment shall be distinct and legible.

3.27 Test and Standards

3.27.1 Type Test

3.27.1.1 On the complete Disc Insulator Strings with Hardware Fittings

a)	Power frequency voltage withstand test with arcing horns under wet condition	:	As per IEC:60383
b)	Impulse voltage withstand test under dry condition	:	As per IEC:60383
c)	Mechanical Strength test	:	As per Annex-B 2
d)	Voltage distribution test	:	As per Annex-B 2
e)	Vibration test	:	As per Annex-B 2

Note: 1) All the type test given in Clause No. 3.27.1.1 shall be conducted on complete single suspension & Single Tension insulator unit.

2) All the type tests given under Clause No. 3.27.1.1 (a) to (e) shall also be conducted on Single I Pilot, Double I Suspension & Double Tension insulator unit

3.27.2 On Hardware Fittings

a. Mechanical Strength Test on Tension Hardware fitting : As per Annex-B 2
b. Mechanical Strength Test on Suspension Hardware fitting : As per Annex-B 2

3.27.3 On Suspension Clamp

a. Magnetic power loss test : As per Annexure-B 2
b. Clamp slip strength Vs torque test : As per Annexure-B 2
c. Ozone Test on elastomer : As per Annexure-B 2
d. Vertical damage load & Failure load test : IEC: 61284

3.27.4 On Dead end Tension Assembly

a. Electrical resistance test for dead end Assembly : As per IS:2486-(Part-I)
b. Heating cycle test for dead end Assembly : As per Annexure-B 2
c. Slip strength test for dead end assembly : As per IS:2486-(Part-I)
d. Ageing test on filler (if applicable) : As per Annexure-B 2

3.27.5 Mid Span Compression Joint for Conductor

a. Chemical analysis of materials : As per Annexure-B 2
b. Electrical resistance test :As per IS:2121 (Part-II)
c. Heating cycle test :As per Annexure-B 2
d. Slip strength test : As per Annexure-B 2
e. Corona extinction voltage test (dry) : As per Annexure-B 2

3.27.6 Repair Sleeve for Conductor

a. Chemical analysis of materials : As per Annexure-B 2

3.27.7 Vibration Damper for Conductor

a. Chemical analysis of materials : As per Annexure-B 2
b. Dynamic characteristics test* : As per Annexure-B 2
c. Vibration analysis : As per Annexure-B 2

d. Clamp slip test : As per Annexure-B 2
e. Fatigue tests : As per Annexure-B 2
f. Magnetic power loss test : As per Annexure-B 2
g. Damper efficiency test : As per IS:9708

3.27.8 Type tests specified under Clause 3.27.1 to 3.27.7 shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) Central/State Power Utility.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Employer/ Employer/ Employer.

3.28 Acceptance Tests

3.28.1 On Both Suspension clamp and Tension Assembly

Visual Examination : As per IS:2486-(Part-I)
Verification of dimensions : As per IS:2486-(Part-I)
Galvanising/Electroplating test : As per IS:2486-(Part-I) Mechanical
strength test of each component : As per Annexure-B 2 Mechanical
strength test for arcing horn : As per BS:3288(Part-I)
Test on locking device for ball and socket coupling : As per IEC:372 (2) Mechanical
Strength test of welded joint : As per Annexure-B 2
Chemical analysis, hardness tests, grain size, inclusion rating & magnetic particle inspection for forgings/castings : As per Annexure-B 2

3.28.2 On Suspension Clamp only

f. Clamp Slip strength Vs Torque test for suspension clamp : As per Annexure-B 2
g. Shore hardness test of elastomer cushion for AG suspension clamp : As per Annexure-B 2
h. Bend test for armour rod set : As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
i. Resilience test for armour rod set : As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11
j. Conductivity test for armour rods set : As per IS:2121(Part-I), Clause 7.5,7,10 & 7.11

3.28.3 On Tension Hardware Fittings only

i. Slip strength test for dead end assembly : As per IS:2486 (Part-I) Clause 5.4
j. Ageing test on filler (if applicable) : As per Annexure-C 2

3.28.4 On Mid Span Compression Joint for Conductor

e. Visual examination and dimensional verification : As per IS:2121 (Part-II), Clause 6.2, 6.37 6.7

f. Galvanizing test : As per Annexure-B 2
g. Hardness test : As per Annexure-C 2
h. Ageing test on filler (if applicable) : As per Annexure-C 2

3.28.5 Repair Sleeve for Conductor

Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3

3.28.6 Vibration Damper for Conductor

b. Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3 7 6.7
b. Galvanizing test : As per Annexure-B 2
i. On damper masses : As per Annexure-B 2
iii. On messenger cable : As per Annexure-B 2
k. Verification of resonance frequencies : As per Annexure-C 2
l. Clamp slip test : As per Annexure-C 2
m. Clamp bolt torque test : As per Annexure-C 2
n. Strength of the messenger cable : As per Annexure-C 2
o. Mass pull off test : As per Annexure-C 2
p. Dynamic characteristics test* : As per Annexure-C 2

* Applicable for 4 R stockbridge dampers. For alternate type of vibration dampers (permitted as per clause 3.27), as an alternative to dynamic characteristic test, damper efficiency test as per IEEE-664 may be proposed/ carried out by the supplier.

3.29 Routine Tests

3.29.1 For Hardware Fittings

a. Visual examination :IS 2486-(Part-I)
b. Proof Load Test : As per Annexure-B 2

3.29.2 For conductor accessories

Visual examination and dimensional verification : As per IS: 2121(Part-II) Clause 6.2, 6.3 7 6.7

3.29.3 Tests During Manufacture on all components as applicable

d. Chemical analysis of Zinc used for galvanizing : IS 2486-(Part-I)
e. Chemical analysis mechanical metallographic test and : As per Annexure-B 2 magnetic particle inspection for malleable castings
f. Chemical analysis, hardness tests and magnetic particle : As per Annexure-B 2 inspection for forging

3.30 **Testing Expenses**

3.30.1 As indicated in clause 3.27 no type test charges shall be payable.

3.30.2 In case type testing is required due to non-availability of type test reports, or type test on the complete insulator string, the Contractor has to arrange similar insulators at his own cost.

3.30.3 Bidder shall indicate the laboratories in which they propose to conduct the type tests. They shall ensure that adequate facilities for conducting the tests are available in the laboratory and the tests can be completed in these laboratories within the time schedule guaranteed by them in the appropriate schedule.

3.30.4 The entire cost of testing for type tests, acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/CIF Price.

3.30.5 In case of failure in any type test, repeat type tests are required to be conducted, then, all the expenses for deputation of Inspector/ Owner's representative shall be deducted from the contract price. Also, if on receipt of the Contractor's notice of testing, the Owner's representative/Inspector does not find material & facilities to be ready for testing the expenses incurred by the Owner's for re- deputation shall be deducted from contract price.

3.30.6 The Contractor shall intimate the Owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance of the scheduled date of testing during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests.

3.31 Schedule of Testing and Additional Tests

3.31.1 The Bidder has to indicate the schedule of following activities in their bids

i. Submission of drawing for approval.
ii. Submission of Quality Assurance programme for approval.
iii. Offering of material for sample selection for type tests.
iv. Type testing.

3.31.2 The Owner reserves the right of having at his own expense any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the specifications.

3.31.3 The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Contractor's premises or at any other test centre. In case of evidence of noncompliance, it shall be binding on the part of Contractor to prove the compliance of the items to the technical specifications by repeat tests, or correction of deficiencies, or replacement of defective items, all without any extra cost to the Owner.

3.32 Test Reports

3.32.1 Copies of type test report shall be furnished in at least six copies along with one original. One copy shall be returned, duly certified by the Owner, only after which the commercial production of the concerned material shall start.

3.32.2 Copies of acceptance test report shall be furnished in at least six copies. One copy shall be returned, duly certified by the Owner, only after which the materials will be despatched.

3.32.3 Record of routine test report shall be maintained by the Contractor at his works for periodic inspection by the Owner's representative.

3.32.4 Test certificates of tests during manufacture shall be maintained by the Contractor. These shall be produced for verification as and when desired by the Owner.

3.33 Inspection

3.33.1 The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where the material and/or its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Contractor's, sub- Contractor's works raw materials. manufacturers of all the material and for conducting necessary tests as detailed herein.

3.33.2 The material for final inspection shall be offered by the Contractor only under packed condition. The engineer shall select samples at random from the packed lot for carrying out acceptance tests.

3.33.3 The Contractor shall keep the Employer informed in advance of the time of starting and of the

progress of manufacture of material in its various stages so that arrangements could be made for inspection.

3.33.4 Material shall not be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Owner in writing. In the latter case also, the material shall be dispatched only after all tests specified herein have been satisfactorily completed.

3.33.5 The acceptance of any quantity of material shall in no way relieve the Contractor of his responsibility for meeting all the requirements of the Specification, and shall not prevent subsequent rejection, if such materials are later found to be defective.

3.34 Packing and Marking

3.34.1 All material shall be packed in strong and weather resistant wooden cases/crates. The gross weight of the packing shall not normally exceed 200 Kg to avoid handling problems.

3.34.2 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

3.34.3 Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

3.34.4 Bolts, nuts, washers, cotter pins, security clips and split pins etc. shall be packed duly installed and assembled with the respective parts and suitable measures shall be used to prevent their loss.

3.34.5 Each component part shall be legibly and indelibly marked with trade mark of the manufacturer and year of manufacture. However, in such type of component/item, which consists of many parts and are being supplied in assembled condition (suspension clamp, vibration damper, etc.), the complete assembly shall be legibly and indelibly marked on main body/on one of the parts.

3.34.6 All the packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly despatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stencilled on it in indelible ink.

3.35 Standards

3.35.1 The Hardware fittings; conductor and earthwire accessories shall conform to the following Indian/International Standards which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the Specification.

3.35.2 In the event of the supply of hardware fittings; conductor accessories conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent to those specified. In case of award, salient features of comparison between the Standards proposed by the Contractor and those specified in this document will be provided by the Contractor to establish their equivalence.

Sl. No.	**Indian Standard**	**Title**	**International Standard**
1.	IS: 209-1992	Specification for zinc	BS:3436-1986
2.	IS:398-1992 Part-V	Aluminum Conductor Galvanised Steel-Reinforced for Extra High Voltage	IEC:1089-1991 BS:215-1970
3.	IS 1573	Electroplated Coating of Zinc on iron and Steel	
4.	IS : 2121 (Part-II)	Specification for Conductor and Earthwire Accessories for Overhead Power lines:	

		Mid-span Joints and Repair Sleeves for Conductors	
5.	IS:2486 (Part-I)	Specification for Insulator Fittings for Overhead power Lines with Nominal Voltage greater than 1000 V: General Requirements and Tests	
6.	IS:2629	Recommended Practice for Hot Dip Galvanising of Iron and Steel	
7.	IS:2633	Method of Testing Uniformity of Coating on Zinc Coated Articles	
8.		Ozone test on Elastomer	ASTM- D1 171
9.		Tests on insulators of Ceramic material or glass for overhead lines with a nominal voltage greater than 1000V	IEC:383-1993
10.	IS:4826	Galvanised Coating on Round Steel Wires	ASTM A472-729 BS:443-1969
11.	IS:6745	Methods of Determination of Weight of Zinc Coating of Zinc Coated Iron and Steel Articles	BS:433 ISO: 1460 (E)
12.	IS:8263	Method of Radio Interference Tests on High Voltage Insulators	IEC:437, NEMA:107 CISPR
13.	IS:6639	Hexagonal Bolts for Steel Structures	ISO/R-272
14.	IS:9708	Specification for Stock Bridge Vibration Dampers for Overhead Power lines	

ANNEXURE – B 1

Tests on Complete Insulator with Hardware Fittings

1.1 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 Voltage Distribution test

The voltage across each insulator unit shall be measured by sphere gap method. The result obtain shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings.

1.3 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 metres. In the case of suspension string a load equal to 600kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and four sub-conductors (each tensioned at 43kN shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-

conductors throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string(more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than 1000/f1.8 where f is the frequency of vibration in cycle/sec. The insulator string shall be vibrated for not less than 10million cycles without any failure. After the test the disc insulator shall be examined for looseness of pins and cop or any crack in the cement. The hardware shall be

examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and composite long rod/disc insulators after the vibration test.

The composite long rod insulators shall be subjected to the Mechanical performance test followed by mechanical strength test as per relevant standards.

The Disc insulators shall be subjected to the following tests as per relevant standards.

Sl.no.	**Test**	**Percentage of insulator units to be tested**
1	Temperature cycle test followed by mechanical performance test	60
2	Puncture test/steep wave front test (Only for glass insulators)	40

1.4 Mechanical Strength Test for Suspension/Tension Hardware Fittings

The complete string without insulators excluding arcing horn, corona control rings/grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the string component shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for the one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 **Magnetic Power Loss Test for Suspension Assembly**

Two hollow aluminium tubes of 32 mm diameter for the conductor shall be placed 450 mm apart respectively. An alternating current over the range of 1000 to 1500 amperes shall be passed through each tube. The reading of the wattmeter with and without suspension assemblies along with line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to 875 (132Kv) 1200 amperes shall be read off from the graph and the same shall be limited to the value guaranteed by the supplier.

1.6 Galvanising/Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS: 2486-(Part-1) except that both uniformity of zinc coating and standard preecee test shall be carried out and the results obtained shall satisfy the requirements of this specification.

1.7 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

1.8 Mechanical Strength Test of Welded Joint

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter,

it shall be subjected to die-penetration/ ultrasonic test. There shall not be any crack at the welded portion.

1.9 Clamp Slip Strength Vs Torque Test for Suspension Clamp

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of conductor shall be fixedin the clamp. The clampslip strength at various tightening torques shall be obtained by gradually applying the load at one end of the conductor. The Clamp slip strength vs torque curve shall be drawn. The above procedure is applicable only for free centre type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out. The clamp slip strength at the recommended tightening torque shall be as indicated in GTP.

1.10 Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2486 (Part-I) with following modifications: -

i. Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.
ii. Number of cycles: 100
iii. Slip strength test shall also be carried out after heating cycle test.

1.11 **Ageing Test on Filler (if applicable)**

The test shall be done in accordance with Grease drop point test method. The specimen should be drop as a droplet when kept at a temperature 40 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

1.12 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

1.13 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

1.14 Tests for Forging Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

1.15 Ozone Test for Elastomer

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2 x magnification.

2.0 Tests on Accessories for Conductor

2.1 Mid Span Compression Joint for Conductor

a. Slip Strength Test

The fitting compressed on conductor shall not be less than one meter in length. The test shall be carried out as per IS:2121 (Part-ii)-1981 clause 6-4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fit tings during this one-minute period.

b. Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2121 (Part-II-1981) with following modifications: -

i. Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.
ii. Number of cycles: 100

iii. Slip strength test shall also be carried out after heating cycle test.

2.2 Vibration Damper for Conductor

a. Dynamic Characteristics, Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 5 to 40 Hz for damper for conductor. The damper assembly shall be vibrated vertically with a + 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

i. Force Vs Frequency
ii. Phase angle Vs frequency
iii. Power dissipation Vs. frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor without dampers.

Acceptance criteria for vibration damper.

i. The above dynamic characteristics test on five dampers shall be conducted. The above dynamic characteristics test on five dampers shall be conducted.
ii. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
iii. The above mean reactance response curve should lie within 0.191 f to 0.762f Kgf/mm limits where f is frequency in Hz.
iv. The above mean phase angle response curve shall be between 25^{o} to 130^{o} within the frequency range of interest.
v. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
vi. Visual resonance frequencies of each mass of damper are to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the conductor shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

i) The analysis shall be done for single conductor without armour rods as per the parameters given of this part of the Specification. The tension shall be taken from Sag & Tension calculation (o deg. C & no wind condition and 350 m ruling span) for a span ranging from 50 m to 1100.

ii) The self damping factor and flexural stiffness (EI) for conductor shall be calculated on the basis of experimental results. The details for experimental analysis with these data should be furnished.

iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.

iv) Examine the 66aeolian vibration level of the conductor with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

v) From vibrationanalysis of conductor withoutdamper, anti-nodevibrationamplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

vi) From vibration analysis of conductor with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor shall be determined. In addition to above damper clamp vibration amplitude and anti-node vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Clamp Slip and Fatigue Tests

i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The conductor shall be tensioned at tension corresponding to 0 deg & no wind condition and ruling span 350 from sag –tension calculation and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor has been tensioned, clamps shall be installed to support the conductor at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

ii) Clamp Slip test

The vibration damper shall be installed on the test span. The damper clamp, after lightning with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased till the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the, test if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without re-torquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The conductor under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

a. There shall not be any frequency shift by more than +2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.

b. The force response curve shall generally lie within guar anteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.

c. The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

2.3 Corona Extinction Voltage Test (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 154 kV rms line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS:731- 1971.

2.4 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.8) above, the sample shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 154 kV rms line to ground under dry condition. The test procedure shall be in accordance with IS:8263.

2.5 Tests on All components (As applicable)

2.5.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analysed as per IS-209-1979. The purity of zinc shall not be less than 99.95%.

2.5.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The, sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

2.5.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

ANNEXURE – B 2

Tests on Complete Insulator with Hardware Fittings

1.1 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 Voltage Distribution test

The voltage across each insulator unit shall be measured by sphere gap method. The result obtain shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings.

1.3 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 metres. In the case of suspension string a load equal to 600kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and four sub-conductors (each tensioned at 43kN shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub- conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than 1000/f1.8 where f is the frequency of vibration in cycle/sec. The insulator string shall be vibrated for not less than 10million cycles without any failure. After the test the disc insulator shall be examined for looseness of pins and cop or any crack in the cement. The hardware shall be

examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and composite long rod/disc insulators after the vibration test.

The composite long rod insulators shall be subjected to the Mechanical performance test followed by mechanical strength test as per relevant standards.

The Disc insulators shall be subjected to the following tests as per relevant standards.

Sl.no.	Test	Percentage of insulator units to be tested
1	Temperature cycle test followed by mechanical performance test	60
2	Puncture test/steep wave front test (Only for glass insulators)	40

1.4 Mechanical Strength Test for Suspension/Tension Hardware Fittings

The complete string without insulators excluding arcing horn, corona control rings/grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be held for five minutes and then removed. After removal of the load, the string component shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held for the one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.5 Magnetic Power Loss Test for Suspension Assembly

One hollow aluminium tubes of 29mm diameter for the conductor shall be used for 132KV. An alternating current over the range of 300 amps to 700 shall be passed through the tube. The reading of the wattmeter with and without suspension assemblies alongwith line side yoke plate, clevis eye shall be recorded. Not less than three suspension assemblies shall be tested. The average power loss for suspension assembly shall be plotted for each value of current. The value of the loss corresponding to 300 Amperes shall be read off from the graph and the same shall be limited to the value guaranteed by the supplier.

1.6 Galvanising/Electroplating Test

The test shall be carried out as per Clause no. 5.9 of IS: 2486-(Part-1) except that both uniformity of zinc coating and standard preecee test shall be carried out and the results obtained shall satisfy the requirements of this specification.

1.7 Mechanical Strength Test of Each Component

Each component shall be subjected to a load equal to the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. The component shall then again be loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified UTS and held for one minute. No fracture should occur. The applied load shall then be increased until the failing load is reached and the value recorded.

1.8 Mechanical Strength Test of Welded Joint

The welded portion of the component shall be subjected to a Load of 2000 kgs for one minute. Thereafter, it shall be subjected to die-penetratration/ ultrasonic test. There shall not be any crack at the welded portion.

1.9 Clamp Slip Strength Vs Torque Test for Suspension Clamp

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length of conductor shall be fixedin the clamp. The clampslip strength at various tightening torques shall be obtained by gradually applying the load at one end of the conductor. The Clamp slip strength vs torque curve shall be drawn. The above procedure is applicable only for free centre type suspension clamp. For AG suspension clamp only clamp slip strength after assembly shall be found out. The clamp slip strength at the recommended tightening torque shall be as indicated in GTP.

1.10 Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2486 (Part-I) with following modifications: -

i. Temperature of conductor during each cycle: 40 deg. C above designed maximum operating

temperature of the conductor.

ii. Number of cycles: 100

iii. Slip strength test shall also be carried out after heating cycle test.

1.11 Ageing Test on Filler (if applicable)

The test shall be done in accordance with Grease drop point test method. The specimen should be drop as a droplet when kept at a temperature 40 deg. C above designed maximum operating temperature of the conductor for 30 minutes. The temperature shall then be increase till one droplet drops and the temperature recorded.

1.12 Shore Hardness Test for Elastomer Cushion for AG Suspension Assembly

The shore hardness at various points on the surface of the elastomer cushion shall be measured by a shore hardness meter and the shore hardness number shall be between 65 to 80.

1.13 Proof Load Test

Each component shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength which shall be increased at a steady rate to 67% of the UTS specified. The load shall be held for one minute and then removed. After removal of the load the component shall not show any visual deformation.

1.14 Tests for Forging Casting and Fabricated Hardware

The chemical analysis, hardness test, grain size, inclusion rating and magnetic particle inspection for forging, castings and chemical analysis and proof load test for fabricated hardware shall be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as in the Quality Assurance programme.

1.15 Ozone Test for Elastomer

This test shall be performed in accordance with ASTM D-1171 by the Ozone chamber exposure method (method B). The test duration shall be 500 hours and the ozone concentration 50 PPHM. At the test completion, there shall be no visible crack under a 2 x magnification.

2.0 Tests on Accessories for Conductor

2.1 Mid Span Compression Joint for Conductor

a. Slip Strength Test

The fitting compressed on conductor shall not be less than one meter in length. The test shall be carried out as per IS:2121 (Part-ii)-1981 clause 6-4 except that the load shall be steadily increased to 95% of minimum ultimate tensile strength of conductor and retained for one minute at this load. There shall be no movement of the conductor relative to the fittings and no failure of the fit tings during this one-minute period.

(a) Heating Cycle Test

Heating cycle test shall be performed in accordance with IS 2121 (Part-II-1981) with following modifications: -

i. Temperature of conductor during each cycle: 40 deg. C above designed maximum operating temperature of the conductor.

ii. Number of cycles: 100

iii. Slip strength test shall also be carried out after heating cycle test.

2.2 Vibration Damper for Conductor

a. Dynamic Characteristics, Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for aeolian vibration frequency band ranging from 5 to 40 Hz for damper for conductor. The damper assembly shall be vibrated vertically with a + 1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at ± 0.5mm to determine following characteristics with the help of suitable recording instruments:

i. Force Vs Frequency

ii. Phase angle Vs frequency

iii. Power dissipation Vs. frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs

between the resonance frequencies. The resonance frequencies shall be suitably spread within the aeolian vibration frequency-band between the lower and upper dangerous frequency, limits determined by the vibration analysis of conductor without dampers.

Acceptance criteria for vibration damper.

i. The above dynamic characteristics test on five dampers shall be conducted. The above dynamic characteristics test on five dampers shall be conducted.
ii. The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.
iii. The above mean reactance response curve should lie within 0.191 f to 0.762f Kgf/mm limits where f is frequency in Hz.
iv. The above mean phase angle response curve shall be between 25^{o} to 130^{o} within the frequency range of interest.
v. If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.
vi. Visual resonance frequencies of each mass of damper are to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the conductor shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis:

i) The analysis shall be done for single conductor without armour rods as per the parameters given of this part of the Specification. The tension shall be taken from Sag & Tension calculation (o deg. C & no wind condition and 320 m ruling span) for a span ranging from 50 m to 1100.

ii) The self-damping factor and flexural stiffness (EI) for conductor shall be calculated on the basis of experimental results. The details for experimental analysis with these data should be furnished.

iii) The power dissipation curve obtained from Dynamic Characteristics Test shall be used for analysis with damper.

iv) Examine the vibration level of the conductor with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

v) From vibration analysis of conductor without damper, anti-node vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

vi) From vibration analysis of conductor with damper/dampers installed at the recommended location, the dynamic strain level, at the clamped span extremities, damper attachment point and the antinodes on the conductor shall be determined. In addition to above damper clamp vibration amplitude and anti-node vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment points, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Clamp Slip and Fatigue Tests

i) Test Set Up

The clamp slip and fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30 m. The conductor shall be tensioned at tension corresponding to 0 deg & no wind condition and ruling span 320 from sag –tension calculation and shall not be equipped with protective armour rods at any point. Constant tension shall be maintained within the span by means of lever arm arrangement. After the conductor has been tensioned, clamps shall be installed to support the conductor at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the conductor. There shall be no loose parts, such as suspension clamps, U bolts on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for stepless speed control as well as stepless amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles

and amplitude of vibration at any point along the span.

ii) Clamp Slip test

The vibration damper shall be installed on the test span. The damper clamp, after lightning with the manufacturer's specified tightening torque, when subjected to a longitudinal pull of 2.5 kN parallel to the axis of conductor for a minimum duration of one minute shall not slip i.e. the permanent displacement between conductor and clamp measured after removal of the load shall not exceed 1.0 mm. The load shall be further increased till the clamp starts slipping. The load at which the clamp slips shall not be more than 5 kN.

iii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ± 25/f mm, where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the, test if resonance shift is observed the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned hereinabove shall be repeated after fatigue test without re-torquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from conductor and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristic of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The conductor under clamp shall also be free from any damage.

For the purpose of acceptance, the following criteria shall be applied.

a. There shall not be any frequency shift by more than +2 Hz for frequencies lower than 15 Hz and ± 3 Hz for frequencies higher than 15 Hz.

b. The force response curve shall generally lie within guar anteed % variation in reactance after fatigue test in comparison with that before fatigue test by the Contractor.

c. The power dissipation of the damper shall not be less than guaranteed % variation in power dissipation before fatigue test by the Contractor. However, it shall not be less than minimum power dissipation which shall be governed by lower limits of reactance and phase angle indicated in the envelope.

2.3 Corona Extinction Voltage Test (Dry)

The sample when subjected to power frequency voltage shall have a corona extinction voltage of not less than 105 kV rms line to ground under dry condition. There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IS:731- 1971.

2.4 Radio Interference Voltage Test (Dry)

Under the conditions as specified under (3.8) above, the sample shall have a radio interference voltage level below 1000 microvolts at one MHz when subjected to 50 Hz AC voltage of 154 kV rms line to ground under dry condition. The test procedure shall be in accordance with IS:8263.

2.5 Tests on All components (As applicable)

2.5.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analyzed as per IS-209-1979. The purity of zinc shall not be less than 99.95%.

2.5.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The, sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

2.5.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic particle inspection for castings will be as per the internationally 74ecognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Contractor and Employer in Quality Assurance Programme.

ANNEXURE – C 1

Acceptance Tests

1. **Mid Span Compression Joint for Conductor**

a. Hardness Test

The Brinnel hardness at various points on the steel sleeve of conductor core and tension clamp shall be measured.

2. Vibration Damper for Conductor

a. Verification of Resonance Frequencies

The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/- 0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.

b. Clamp Slip Test

Same as Clause 2.2 I (ii) of Annexure-B.

c. Clamp Bolt Torque Test

The clamp shall be attached to a section of the conductor/earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 2.2 I (i), Annexure-B.

d. Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of messenger cable may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the cable. The load shall be not less than the value guaranteed by the Contractor.

e. Mass Pull off Test

Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the messenger cable. The pull off loads shall not be less than the value guaranteed by the Contractor.

f. Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below :

Vibration Damper of - 1 Sample for 1000 Nos. & below Conductor
- 2 Samples for lot above 1000 & up to 5000 nos
- Additional 1 sample for every additional 1500 technical specifications pieces above 5000.

The acceptance criteria will be as follows

i. The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 5 Hz to 40 Hz.

ii. If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.

iii. If individual results do not fall within the envelope, averaging of characteristics shall be done.

a. Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.

b. Similar averaging shall be done for phase angle.

c. Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequency range.

d. The above curves shall be within the envelope specified.

ANNEXURE – C 2

Acceptance Tests

1. **Mid Span Compression Joint for Conductor**

a. Hardness Test

The Brinnel hardness at various points on the steel sleeve of conductor core and tension clamp shall be measured.

2. Vibration Damper for Conductor

a. Verification of Resonance Frequencies

The damper shall be mounted on a shaker table and vibrate at damper clamp displacement of +/-0.5 mm to determine the resonance frequencies. The resonance shall be visually identified as the frequency at which damper mass vibrates with maximum displacement on itself. The resonance frequency thus identified shall be compared with the guaranteed value. A tolerance of ± 1 Hz at a frequency lower than 15 Hz and ± 2 Hz at a frequency higher than 15 Hz only shall be allowed.

b. Clamp Slip Test

Same as Clause 2.2 I (ii) of Annexure-B.

c. Clamp Bolt Torque Test

The clamp shall be attached to a section of the conductor/earthwire. A torque of 150 percent of the manufacturer's specified torque shall be applied to the bolt. There shall be no failure of component parts. The test set up is as described in Clause 2.2 I (i), Annexure-B.

d. Strength of the Messenger Cable

The messenger cable shall be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. Alternatively, each strand of messenger cable may be fixed in a suitable tensile testing machine and the tensile load shall be gradually applied until yield point is reached. In such a case, the 95% of yield strength of each wire shall be added to get the total strength of the cable. The load shall be not less than the value guaranteed by the Contractor.

e. Mass Pull off Test

Each mass shall be pulled off in turn by fixing the mass in one jaw and the clamp in the other of a suitable tensile testing machine. The longitudinal pull shall be applied gradually until the mass begins to pull out of the messenger cable. The pull off loads shall not be less than the value guaranteed by the Contractor.

f. Dynamic Characteristics Test

The test will be performed as acceptance test with the procedure mentioned for type test with sampling mentioned below:

Vibration Damper of - 1 Sample for 1000 Nos. & below Conductor
- 2 Samples for lot above 1000 & up to 5000 nos
- Additional 1 sample for every additional 1500 technical specifications pieces above 5000.

The acceptance criteria will be as follows

i. The above dynamic characteristics curve for reactance & phase angle will be done for frequency range of 5 Hz to 40 Hz.

ii. If all the individual curve for dampers are within the envelope as already mentioned for type test for reactance & phase angle, the lot passes the test.

iii. If individual results do not fall within the envelope, averaging of characteristics shall be done.

a. Force of each damper corresponding to particular frequency shall be taken & average force of three dampers at the frequency calculated.

b. Similar averaging shall be done for phase angle.

c. Average force Vs frequency and average phase Vs frequency curves shall be plotted on graph paper. Curves of best fit shall be drawn for the entire frequencyrange.

d. The above curves shall be within the envelope specified.

Section-4

Technical Specification of long rod porcelain Insulator Unit

4.1 Scope

4.1.1 This Section of the specification covers design, manufacture, testing, inspection, packing and dispatch of suspension and tension long rod porcelain/string insulator assemblies consists of ball and socket type porcelain disc insulator for a three phase, 50Hz, effectively earthed D/C 132/220 kV transmission lines to be restringing with HTLS conductor. Ball and socket type long rod porcelain/disc insulator and insulator string shall be suitable for HTLS conductor and to be supplied for satisfactory performance of complete conductor system for continuous operation at the designed maximum temperature specified by them for the conductor.

4.2 Long Rod Porcelain Insulator/ Strings Insulator

4.2.1 TYPE OF INSULATORS:

All suspension and tension long rod porcelain/tension strings insulators shall consist of centre ball and socket type porcelain insulators with all the exposed porcelain parts fully glazed.

4.2.2 DIMENSION AND STRENGTH OF THE INSULATORS:

The size of long rod porcelain/disc insulator, minimum creepage distance, number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string along with hardware fittings shall be as follows:

a. For Long rod Insulators (For both Suspension and Tension)

Sl.no.	Type of string	Minimum creepage distance(mm)	Electromechanical strength of insulator disc(kN)	Mechanical strength of insulator string along with hardware fittings(kN)
1	Single Suspension	3625	90	90
2	Double Suspension	3625	90	180
3	Single tension	3625	120	120
4	Double tension	3625	120	240

4.3 General Technical Requirement

4.3.1 Materials used

A. Porcelain

The porcelain used in the manufacture of the insulators shall be of the best quality and shall be manufactured by the wet process. The porcelain used shall be non-porous of high dielectric, mechanical and thermal strength homogeneous, free from stress blisters, laminations, voids, foreign matter, flaws etc. and well finished making it impervious to moisture. The glaze shall be brown colour and shall cover all the porcelain parts of the insulator except these areas necessarily left unglazed for the purpose of assembly. The cement used in the construction of the insulators shall not cause fracture by expansion or loosening and shall not give rise to any chemical reaction with the metal fittings. Porcelain shall remain unaffected by climatic conditions, ozone, acid, alkalies, zinc or dust.

B. Cement

Cement used in the manufacture of the insulator shall not cause fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper care shall be taken to correctly centre and locate individual parts during cementing.

4.3.2 The design of the insulator Long Rods shall be such that all the stresses due to expansion or contraction in any part of the insulator under rapid temperature fluctuation, which may be created due to variation in the loads or fault of any nature, while in service shall not lead to any type of deterioration. Flat surface and

corners shall not be allowed and shall be completely rounded off.

4.3.3 Corona and radio interference voltage (riv) performance

All surfaces shall be even, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The metal parts and porcelain shall not produce any noise generating corona under all operating conditions

4.3.4 Security clip

Security clip shall be made of good quality stainless steel or phosphor bronze as per IEC 60372. 2.5% extra security clip shall be provided.

4.4 Ball and socket designation

The dimensions of the balls and socket shall be of following designation for different insulators in accordance with the standard dimensions stated in IS 2486-(Part-II)/IEC:120: -

Sl. No.	Rating of Insulators	Designation of Ball & socket as per IEC: 120
1	70KN	16 mm, AltB
2	90 KN	16 mm, AltB
3	120 KN	20 mm

4.5 Interchangeability

The Long Rod porcelain/ disc insulators string with ball and socket fittings shall be of standard design, suitable for use with hardware fittings of any make conforming to relevant Indian/International Standard

4.6 Maintenance

a) The Long Rod porcelain/disc insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operations can be carried out with ease, speed and safety.

b) Bidders shall indicate the methods generally used in the routine hot and dead line maintenance of EHV lines for which similar disc insulators have been supplied by them. Bidders shall also indicate the recommended periodicity of such maintenance.

4.7 Bid Drawings

4.7.1 The Bidder shall furnish full description and illustration of the material offered.

4.7.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information:

a) Major Dimensions with manufacturing tolerances
Number of sheds
b) Minimum Creepage distance with positive tolerance
c) Protected creepage distance
d) Unit mechanical and electrical characteristics
e) Size and weight of ball and socket parts
f) Weight of unit insulator disc
h) Materials

4.7.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 4.7.2 above, in four (4) copies to Purchaser for approval. After getting approval from Purchaser, the Supplier shall submit 10 more copies of the same drawing along with a soft copy to the Purchaser for further distribution and field use at Purchaser's end.

4.7.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different

type of insulators.

4.8 TEST AND STANDARDS

Type Tests

The required type tests on individual standard Long Rod porcelain/disc insulators, components, materials or complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

(i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of AEGCL.

(ii) **Tests have been conducted not prior to 5 (five) years from the date of bid opening.**

In case the test have been conducted earlier than the above stipulated period or in the event of any discrepancy in the test report (i.e., any test not applicable due to any design/manufacturing change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

4.8.1 A. **Type test On unit Long Rod Porcelain Insulator (120kN)**

a) Verification of dimensions test — As per IEC:60383

b) Thermal mechanical performance test — As per IEC:60383

c) Power frequency voltage withstand and flashover test under i) Dry — As per IEC:60383

ii) Wet condition

d) Impulse voltage withstand and flashover test — As per IEC:60383 (dry)

e) Visible Discharge test(dry) — As per IS:731, cl. 10.2

f) RIV test(dry) — As per IEC:60437

g) Residual strength test — As per IEC:797

h) Steep wave front test — As per Annexure D

i) Impact test — ANSI-C29.2 clause 8.2.8

B. On the complete Insulator String/ Long Rod Porcelain Insulator with Hardware Fittings:

Sl. No.	Tests	Ref	Strings on which test to be conducted*.
a)	Power frequency / DC voltage withstand test with arcing horns & corona control rings under wet condition	IEC: 60383-1993/ IEC:60-1	All strings
b)	Corona & RIV test under dry condition	IEC: 60383	All strings
c)	Switching surge voltage withstand test under wet condition	IEC:60383-1993	All strings
d)	Impulse voltage withstand test under dry condition	IEC:60383-1993	All strings
e)	Impulse voltage flash over test under dry condition	IEC:60383-1993	All strings
f)	Voltage distribution test	As per Annex-D	
g)	Mechanical Strength test	As per Annex-D	
h)	Vibration test	As per Annex-D	
h)	Salt –Fog pollution withstand test	As per Annex-D	

4.8.2 Acceptance tests

4.8.2 For Long Rod Porcelain Insulator

a) Visual examination :As per IEC 60383
b) Verification of dimension :As per IEC 60383
c) Temperature cycle test :As per IEC 60383
d) Galvanising test :As per IEC 60383
e) Mechanical performance test :As per IEC 60575 cl 4.0
f) Test on locking device for ball and socket coupling :As per IEC 60372
g) Eccentricity test: : As per IEC 60383
h) Residual strength test :As per IEC 797 cl 4.4$ 4.5
i) Electro-mechanical strength test :As per annexure
j) Porosity test :As per IEC 60383
k) Puncture test :As per IEC 60383

4.8.3 Routine tests For Disc Insulators/ Long Rod Porcelain Insulator

a) Visual inspection :As per IS 731
b) Mechanical routine test :As per IS 731
c) Electrical routine test :As per IS 731

4.8.4 Test During Manufacture

1	Chemical analysis of Zinc used for Galvanising	As per relevant IS with latest Amendment
2	Chemical Analysis of Porcelain	-Do-
3	Chemical Analysis of steel used	-Do_

4.8.5 Type tests specified under Clause 4.8.1 to 4.8.3 shall not be required to be carried out if a valid test certificate is available for a similar design, i.e., tests conducted earlier should have been conducted in accredited laboratory (accredited based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation body of the country where laboratory is located) or witnessed by the representative (s) Central/State Power Utility.

In the event of any discrepancy in the test report (i.e., any test report not applicable due to any design / material/manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specification) the tests shall be conducted by the Contractor at no extra cost to the Employer/ Employer/ Employer.

4.9 Additional Tests

The Purchaser reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the Specifications.

The Purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test center. In case of evidence of non-compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Purchaser.

4.10 Guarantee

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators and insulator strings.

4.11 Test Reports

Copies of type test reports shall be furnished in at least six (6) copies along with one original. One copy shall be returned duly certified by the Purchaser only after which the commercial production of the concerned material shall start.

Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Purchaser, only after which the material shall bedispatched.

Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Purchaser's representative.

Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Purchaser.

4.12. Inspection

The Purchaser's representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

The material for final inspection shall be offered by the Supplier only under packed condition as detailed in clause No. 4.12 of the specification. The Purchaser shall select samples at random from the packed lot for carrying out acceptance tests. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

The Supplier shall keep the Purchaser informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Purchaser in writing. In the latter case also the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

The acceptance of any quantity of material shall be no way relieve the Supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such material is later found to be defective.

4.13 Packing and Marking

All insulators shall be packed in suitable PVC/ plastic tubes of at least 3 mm thickness or water-resistant packing material and the packaging shall not break during storage & transportation even in overhang condition during transportation. Further, last 20% quantity of insulators shall be packed in PVC/ plastic tubes only to ensure long storage of about 5 years. The packing shall provide protection against rodent. The Supplier shall furnish detailed design of the packing. For marine transportation, crates shall be palleted.

The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in indelible ink.

The Supplier shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing.

4.14 Standards

The insulator strings and its components shall conform to the following Indian / International Standards which shall mean latest revision, with amendments /changes adopted

and published, unless specifically stated otherwise in the Specification.

a) In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent or better to those specified. In case of award, salient features of comparison between the standards proposed by the Bidder and those specified in this document will be provided by the Supplier to establish equivalence.

Sl.No	**Indian Standard**	Title	**International Standard**
1.	IS:209-1992	Specification for zinc	BS:3436
2.	IS:406-1991	Method of Chemical Analysis of Slab Zinc	BS:3436
3.	IS:731-1991	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	BS:137- (I&II) IEC:60383
4.	IS:2071 Part (I) – 1993 (Part(II)- 1991 Part(III)- 1991	Methods of High Voltage Testing	IEC:60060-1
5.	IS:2486 Part- I- 1993 Part- II- 1989 Part- III-1991	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	BS:3288 IEC:60120 IEC:60372
6.	IS:2629-1990	Recommended Practice for Hot, Dip Galvanization for iron and steel	ISO-1461 (E)
7.	IS:2633-1992	Testing of Uniformity of Coating of zinc coated articles	
8.	IS:6745-1990	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	
9		Characteristics of string insulator units of the long rod type	IEC Publication 433-1969 ISO:1460-1973
10	IS: 2486(partIV)	Mechanical Performance test	IEC: 575

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonvile Road, N - 19-ND, UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva, SWITZERLAND
BIS/IS	Beureau Of Indian Standards. ManakBhavan, 9, Bahadur Shah ZafarMarg, New Delhi - 110001.INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

ANNEXURE - D

Tests on Complete Strings with Hardware Fittings

1.1 Mechanical Strength Test

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/dead end assembly shall be subjected to a load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. The load shall be held for five minutes and then removed. After removal of the load, the string components shall not show any visual deformation and it shall be possible to disassemble them by hand. Hand tools may be used to remove cotter pins and loosen the nuts initially. The string shall then be reassembled and loaded to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded.

1.2 **Electro-mechanical failing load test as per IS:731 on string insulator unit.**

1.3 Voltage Distribution test

The voltage across each insulator unit shall be measured by sphere gap method. The result obtain shall be converted into percentage. The voltage across any disc shall not exceed 9% for suspension insulator strings and 10% for tension insulator strings.

1.4 Vibration Test

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meter. In the case of suspension string a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and specified no. of sub-conductors each tensioned at 25 % of UTS of the conductor shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. Both the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than 1000/f 1.8 where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test the insulators shall be examined for looseness of pins and cap or any crack in the cement. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the following test for a tension of 25 KN (132kV line) as per relevant standards:

1.5 Power-Arc Test

This test shall be performed on the complete string in accordance with IEC Technical Report IEC:61467-1997 with the following test series:

Test Circuit	Short circuit current	Number and duration of test
B	$I_n = I_{sys} = 35KA$	Two of $t_n = 0.2s$ and one of $t_n = 0.5s$

The acceptance criteria after the completion of test series shall be following.

a. Insulation separation not permitted

b. Burning/melting of metal components, breakage of insulator sheds, glaze removal is permitted.

c. The compete insulator string along with its hardware fitting excluding arching horn, corona control ring/grading ring shall withstand 80% of UTS.

1.5 AC Salt-fog pollution withstand test

This test shall be carried out in accordance with IEC: 60507. The salinity level for composite long rod insulators shall be 160Kg/m3 NACL.

1.6 DC pollution withstand test

This test shall be carried out as per IEC-61245 with solid layer method. The D.C. pollution withstand voltage (negative) shall be 500kV for +/-500kV HVDC insulators as applicable at average ESDD of 0.1 mg / sq. cm.

2 On disc Insulator Unit

2.1 Steep wave front Test

Following test shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for selection of sample for type test.

a. Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500kV per microsecond.

b. Each unit shall then be subjected to three dry power frequency voltage flashovers.

Acceptance criteria--

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashovers, the arithmetic mean of the three subsequent dry/power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

a. It has not flashover when the oscillogram or peak voltage indicator shows a marked reduction in voltage.

Or

b. Any one of the subsequent three dry power frequency voltage flashover value is less than 80% of the value specified.

Failure of any one unit either in the steep wave front or subsequent low frequency voltage test shall cause for testing on double number of units.

3 Tests on All components (As applicable)

3.1 **Chemical Analysis of Zinc used for Galvanizing**

Samples taken from the zinc ingot shall be chemically analyzed as per IS: 209-1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Owner in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Owner in Quality Assurance Programme.

3.4 Autoclave Test

For cement used in the assembly of the insulators six samples from different batches shall be tested in accordance with ASTM C-151. The cement shall have an expansion less than 0.12%.

SECTION – 5
TECHNICAL SPECIFICATIONS FOR HOTLINE RESTRINGING ACTIVITIES OF HTLS CONDUCTOR

General

The scope of erection work shall include installation of necessary hardware, hoisting of insulator strings, installing & stringing of HTLS Conductor including fixing of conductor accessories, the cost of all labour, tools and plant and all other incidental expenses in stringing work. The contractor shall have to string with the equivalent HTLS Conductor section wise and restore the line in original conditions as per program finalized in co-ordination with site. Stringing of the line shall be carried out under induced voltage condition i.e. one circuit under charged condition. Adequate safety measures and precautions shall be taken by the Contractor during this erection work.

5.1 Site Inspection

5.1.1 Site Inspection Report

The contractor shall visit the site to inspect the transmission line and collect observations/information which would be useful for stringing activity & bidding. Complete BOQ of each transmission line for reconductoring shall be furnished in the report & is to be got approved.

5.1.2 All observations/ information which the Contractor thinks would be useful to implement the re- conductoring of the existing transmission line mentioned under scope of work are to be reported & timely.

5.1.3 The detailed procedure for carrying out the reconductoring shall be submitted to the site Engineer- in-charge before taking up the work

5.1.4 Suggestions regarding location for setting up stores during line construction in consultation with Employer representative shall also be provided by the contractor.

5.1.5 Working months available during various seasons along the transmission line, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.

5.1.6 Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc.

5.1.7 All the requisite data for processing the case of statutory clearances such as Forest and Railway shall be provided along with the report.

Six copies of survey reports shall be furnished by the contractor to the Employer.

5.2 Environmental Conditions

5.2.1 Forest

The line route passing through forest stretches if any shall be indicated to the successful Bidder.

5.2.2 General Climatic Conditions

Climatic conditions shall be of tropical nature having summer period for 8 months and winter period for 4 months in a year. Working season shall be approximately 9 months/year and balance 3 months shall be monsoon period.

The maximum temperature during summer shall be of the order of 42°C and the minimum temperature in the winter shall be of the order of 0°C. Normal everyday temperature is 32°C.

5.2.3 Statutory Regulations and Standards

5.2.3.1 **Statutory Regulations**

The Contractor is required to follow local statutory regulations stipulated in Electricity (Supply) Act 1948, Indian Electricity Rules, 1956 as amended and other local rules and regulations referred in this Specification.

5.2.3.2 **Reference Standards**

The Codes and/or standards referred to in the specifications shall govern, in all cases wherever such references are made. In case of a conflict between such codes and/or standards and the specifications, latter shall govern.

Such codes and/or standards, referred to shall mean the latest revisions, amendments/changes adopted and published by the relevant agencies.

Other internationally accepted standards which ensure equal or better performance than those specified shall also be accepted, subject to prior approval by the Employer.

5.3 Span and clearances

4.3.1 Normal Span

The normal ruling span of the line on panther conductor is 350 m.

4.3.2 Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

4.3.3 Weight span

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

5.4 Electrical Clearances

5.5.1. Ground Clearance

The minimum ground clearance from the bottom conductor is not to be less than 6100mm for 132kV and 7000 mm for 220KV line, at the maximum sag conditions corresponding to maximum continuous operating temperature and still air.

5.5 Maximum Tension

5.5.1 Maximum tension shall be based on either

a. at 0^0 C with 36% of full wind pressure, or

b. at 32^0 C with full wind pressure whichever is more stringent.

5.5.2 Limiting Tensions of conductor

The ultimate tension of conductor shall not exceed 70% of the ultimate tensile strength

5.6 Stringing of Conductor and Installation of Line Materials

5.6.1 The Contractor shall be responsible for transportation to site of all the materials to be provided by the Contractor as well as proper storage and preservation of the same at his own cost, till such time the erected line is taken over by the Employer. Similarly, the Contractor shall be responsible for proper storage, safe custody, and loss or damage of all Employer's supplied items, if any, as well as its transportation to site for incorporation in the lines and shall maintain and render proper account of all such materials at all times.

5.6.2 The Contractor shall reimburse the cost of any of the materials lost or damaged during storage and erection beyond the limits permitted under this specification.

5.6.3 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Employer.

5.6.4 Payment for stringing shall be done on the basis of per kilometer and irrespective of number of tension/suspension towers.

5.6.5 The complete work including installation of line materials (insulator strings, hardware and accessories for conductor) shall be supervised by a team of supplier/Contractor's engineers / supervisory staff/ workmen already experienced in stringing work associated with the type of HTLS Conductor being supplied. The contractor shall furnish experience details of the engineers /supervisory staff proposed to be deployed along with the bid document.

5.7 Handling of Conductor

5.7.1 Running Out of the Conductors

The conductors shall be run out of the drums form the top in order to avoid damage. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing.

5.7.2 A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors. Care shall be taken that the conductors do not touch and rub against the ground or objects which

could scratch or damage the strands.

5.7.3 The sequence of running out shall be from the top down. Unbalanced loads on towers shall be avoided as far as possible. Inner phase of line conductors shall be strung before the stringing of the outer phases is taken up.

5.7.4 As tower is not designed for one sided stringing, tower shall be well guyed and step taken by contractor to avoid damage. Guying proposal along with necessary calculation shall be submitted by the contractor to Employer for approval. All expenditure related to this work is deemed to be included in the bid price and no extra payment shall be made for the same.

5.7.5 The Contractor shall take adequate safety precautions to protect personnel; from the potentially dangerous voltage build up due to electromagnetic and electrostatic coupling in the pulling wire, conductors during stringing operations. These precautions include measures taking into account the other circuit on the line under live conditions.

5.7.6 The Contractor shall also take adequate safety precautions to protect personnel from potentially dangerous voltage build up due to distant electrical storms/energized lines.

5.8 Running Blocks

5.8.1 The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor and it does not slip over or rub against the slides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

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

5.9 Repairs to Conductors

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

5.9.2 Repairs to conductor where no more than two strands in the outermost layer are broken shall be carried out with repair sleeve with approval of Engineer-Incharge.

5.9.3 Repairing of the conductor surface shall be carried out only in case of minor damage, scuff marks, etc. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.

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

5.10 Crossings

Derricks or other equivalent methods ensuring that normal services need not be interrupted nor damage caused to property shall be used during stringing operations where roads, channels, telecommunication lines, power lines and railway lines have to be crossed. In case of railway crossings, shutdown might not be available and therefore, contractor shall be required to carry out re-conductoring under such condition i.e. without any shutdown of railways. However, shut down shall be obtained when working at crossings of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor and accessories in the field.

5.11 Stringing of HTLS Conductor

The stringing of the equivalent HTLS conductor shall be done by the standard stringing method suitable for the type of HTLS Conductor offered.

5.12 Supervision in Stringing

5.12.1 The installation & hotline restringing of the offered HTLS conductor for the above 132 & 220 kV transmission line shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier or Qualified Bidder itself. Bidder's responsibility is to provide Sag- Tension chart based on existing site conditions. It may be noted that AEGCL will not consider any modifications (tower extensions etc) on existing tower/span.

5.12.2 The circuit on which the existing ASCR conductor is strung shall be kept under charged condition during the execution. The installation & stringing of the offered HTLS conductor for the above transmission line shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier or Qualified Bidder is self shall string the circuit with the HTLS conductor section by section and restore the line in original conditions as per program finalized in co-ordination with site. The bidder's engineers are to supervise whether appropriate safety measures along with necessary safety tools and equipment's to carry out stringing operations under the above conditions including mechanical/ structural safety of the towers, are maintained or not.

5.12.3 The Contractor shall deploy appropriate tools/ equipments/ machinery to ensure that the stringing operation is carried out without causing damage too conductor and the conductor is installed at the prescribed sag tension as per the approved stringing chart. Prior to taking up stringing work the contractor shall submit for approval of Site-In charge the complete details of stringing methods he proposes to follow.

5.12.4 If any special tools and tackles other than those generally used for stringing of ASCR conductors are deployed for stringing of HTLS Conductor by the contractor, a set of those tools & tackles shall be supplied by the contractor to the Employer, on completion of the project, at no extra cost. The quantity of such tools & tackles shall be sufficient to carry out stringing operations of the longest section (from angle tower to angle tower) of the existing transmission line.

5.12.5 The contractor shall submit, for approval of site in-charge, the complete details of the stringing methods he proposes to follow. Prior to stringing the Contractor shall submit the stringing charts for the conductor showing the initial and final sags and tension for various temperatures and spans along with equivalent spans in the lines for the approval of the Employer.

5.12.6 Conductor creep is to be compensated by over tensioning the conductor at an appropriate temperature lower than the ambient temperature based on creep calculations to be furnished by the Contractor.

5.13 Jointing

5.13.1 When approaching the end of a drum length at least three coils shall be left in place when the stringing operations are stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the approved drawing and procedures recommended by the manufacturer of joints.

5.13.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment/methods during conductor stringing which ensures complete compliance in this regard.

5.13.3 All the joints on the conductor shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies etc., shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc., and be properly greased with anti- corrosive compound. If required and as recommended by the manufacturer, before the final compression is carried out with the compressors. For HTLS Conductor suitable sleeve, collets, collet housing shall

be used for jointing of core as per the offered design and methodology applicable for similar type of design/application.

5.13.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads, railways and small river tension spans. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self-centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation; the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

5.13.5 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints, in case they are to be passed over pulley blocks/aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

5.14 Tensioning and Sagging Operations

5.14.1 The tensioning the sagging shall be done in accordance with the approved stringing charts or sag tables. The "initial" stringing chart shall be used for the conductor. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps.

5.14.2 Dynamometer shall be employed for measuring tension in the conductor. Dynamometers employed shall be periodically checked and calibrated with the standard Dynamometer.

5.14.3 The sag will be checked in the first and the last section span for sections up to eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

5.14.4 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.

5.14.5 At sharp vertical angles, conductor and earth wire sags and tensions shall be checked for equality on both sides of the angle and running block. The suspension insulator assemblies will normally assume verticality when the conductor is clamped.

5.14.6 Tensioning and sagging operations shall be carried out in calm whether when rapid changes in temperature are not likely to occur.

5.15 Clipping In

5.15.1 Clipping of the conductors into position shall be done in accordance with the manufacturer's recommendations.

5.15.2 Jumpers at section and angle towers shall be formed to parabolic shape as per existing tower line diagrams to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, if found necessary, to restrict jumper swing to design values.

5.15.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

5.16 Fixing of Conductors Accessories

Conductor accessories including vibration dampers shall be installed by the Contractor as per the design requirements and manufacturer's instruction within 24 hours of the conductor clamping. While installing the conductor accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage

occurs to any part of the accessories or of the conductors. Torque wrench shall be used for fixing the Vibration Dampers, Suspension Clamps etc. and torque recommended by the manufacturer of the same shall be applied.

5.17 Final checking, Testing and Commissioning

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

5.17.1 The stringing of the conductors has been done as per the approved sag and tension charts and desired clearances are clearly available;

5.17.2 All conductor accessories are properly installed;

5.17.3 The original tracings of profile are submitted to the Employer for reference and record.

5.17.4 The insulation of the line as a whole is tested by the Supplier through provision of his own equipment, labour etc., to the satisfaction of the Employer.

5.18.5 The line is tested satisfactorily for commissioning purpose.

5.18.6 Any defect found as a result of testing shall be rectified by the contractor forthwith to the satisfaction of the Employer without any extra charges.

The contractor should also fulfill the requirements of pre commissioning.

5.18.8 In addition to the above, the contractor shall arrange for testing of the total and relative sags of the conductors and shall be responsible to maintain the values within specified tolerances.

5.18.9 The contractor shall make all arrangements for such tests and the contractor shall provide necessary labour, transport and equipment.

5.18.10 After satisfactory tests on the line and on approval by the Employer the line shall be energised at full operating voltage before handing over.

SECTION – 6

TECHNICAL SPECIFICATIONS FOR RESTRINGING ACTIVITIES OF HTLS CONDUCTOR

6.1 General

The scope of erection work shall include installation of necessary hardware, hoisting of insulator strings, installing & stringing of HTLS Conductor including fixing of conductor accessories, the cost of all labour, tools and plant and all other incidental expenses in stringing work. The contractor shall have to string with the equivalent HTLS Conductor section wise and restore the line in original conditions as per program finalized in co-ordination with site. Stringing of the line shall be carried out under induced voltage condition i.e. one circuit under charged condition. Adequate safety measures and precautions shall be taken by the Contractor during this erection work.

6.2 Site Inspection

6.2.1 Site Inspection Report

The contractor shall visit the site to inspect the transmission line and collect observations/information which would be useful for stringing activity & bidding. Complete BOQ of each transmission line for reconductoring shall be furnished in the report & is to be got approved.

6.2.2 All observations/ information which the Contractor thinks would be useful to implement the reconductoring of the existing transmission line mentioned under scope of work are to be reported & timely.

6.2.3 The detailed procedure for carrying out the reconductoring shall be submitted to the site Engineer- in-charge before taking up the work

6.2.4 Suggestions regarding location for setting up stores during line construction in consultation with Employer representative shall also be provided by the contractor.

6.2.5 Working months available during various seasons along the transmission line, with period, time of sowing & harvesting of different type of crops and the importance attached to the crops particularly in the context of way leave problems and compensation payable shall be stated by the Contractor.

6.2.6 Some portions of the line may require clearance from various authorities. The Contractor shall indicate the portion of the line so affected, the nature of clearance required and the name of concerned organizations such as local bodies, municipalities, P&T (name of circle), Inland navigation, Irrigation Department, Electricity Boards and Zonal railways, Divisional Forest Authorities etc.

6.2.7 All the requisite data for processing the case of statutory clearances such as Forest and Railway shall be provided along with the report.

Six copies of survey reports shall be furnished by the contractor to the Employer.

6.3 Environmental Conditions

6.3.1 Forest

The line route passing through forest stretches if any shall be indicated to the successful Bidder.

6.3.2 General Climatic Conditions

Climatic conditions shall be of tropical nature having summer period for 8 months and winter period for 4 months in a year. Working season shall be approximately 9 months/year and balance 3 months shall be monsoon period.

The maximum temperature during summer shall be of the order of 45°C and the minimum temperature in the winter shall be of the order of 0°C. Normal everyday temperature is 32°C.

6.3.3 Statutory Regulations and Standards

6.3.3.1 **Statutory Regulations**

The Contractor is required to follow local statutory regulations stipulated in Electricity (Supply) Act 1948, Indian Electricity Rules, 1956 as amended and other local rules and regulations referred in this Specification.

6.3.3.2 **Reference Standards**

The Codes and/or standards referred to in the specifications shall govern, in all cases wherever such references are made. In case of a conflict between such codes and/or standards and the specifications, latter shall govern. Such codes and/or standards, referred to shall mean the latest revisions, amendments/changes adopted and published by the relevant agencies.

Other internationally accepted standards which ensure equal or better performance than those specified shall also be accepted, subject to prior approval by the Employer.

6.4 Span and clearances

6.4.1 Normal Span

The normal ruling span of the line on panther conductor is 320 m.

6.4.2 Wind Span

The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal ruling span.

6.4.3 Weight span

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

6.5 Electrical Clearances

6.5.1. Ground Clearance

The minimum ground clearance from the bottom conductor is not to be less than 6100 mm for 132KV line, at the maximum sag conditions corresponding to maximum continuous operating temperature and still air.

6.6 Maximum Tension

6.6.1 Maximum tension shall be based on either

a. at 0^0 C with 36% of full wind pressure, or

b. at 32^0 C with full wind pressure whichever is more stringent.

6.6.2 Limiting Tensions of conductor

Conductor tension at everyday temperature and without external load, should not exceed the following percentage of the ultimate tensile strength of the conductor:

Initial unloaded tension: 35% Final

unloaded tension: 25%

Provided that the ultimate tension under everyday temperature and 100% design wind pressure or minimum temperature and 36% design wind pressure does not exceed 70% of the ultimate tensile strength of conductor.

The ultimate tension of conductor shall not exceed 70% of the ultimate tensile strength

6.7 Stringing of Conductor and Installation of Line Materials

6.7.1 The stringing of the HTLS conductors shall be done in a most standard method used for such lines, which shall be indicated in the tender. The Contractor shall give complete details of the stringing method they propose to follow and indicate its adaptability and advantages. They shall also indicate the tools and equipment required for stringing by the method proposed by them. The contractor shall use his own stringing and erection tools and other equipment.

6.7.2 The contractor shall be entirely responsible for any damage to the towers or the conductors during stringing.

6.7.3 The Contractor shall be responsible for transportation to site of all the materials to be provided by the Contractor as well as proper storage and preservation of the same at his own cost, till such time the erected line is taken over by the Employer. Similarly, the Contractor shall be responsible for proper storage, safe custody, and loss or damage of all Employer's supplied items, if any, as well as its transportation to site for incorporation in the lines and shall maintain and render proper account of all such materials at all times.

6.7.4 The Contractor shall reimburse the cost of any of the materials lost or damaged during storage and erection beyond the limits permitted under this specification.

6.7.5 Contractor shall set up required number of stores along the line and the exact location of such stores shall be discussed and agreed upon with the Employer.

6.7.6 Payment for stringing shall be done on the basis of per kilometer and irrespective of number of

tension/suspension towers.

6.7.7 The complete work including installation of line materials (insulator strings, hardware and accessories for conductor) shall be supervised by a team of supplier/Contractor's engineers / supervisory staff/ workmen already experienced in stringing work associated with the type of HTLS Conductor being supplied. The contractor shall furnish experience details of the engineers /supervisory staff proposed to be deployed along with the bid document.

6.8 Handling of Conductor

6.8.1 Running Out of the Conductors

The conductors shall be run out of the drums form the top in order to avoid damage. The Contractor shall be entirely responsible for any damage to tower or conductors during stringing.

6.8.2 A suitable braking device shall be provided to avoid damaging, loose running out and kinking of the conductors. Care shall be taken that the conductors do not touch and rub against the ground or objects which could scratch or damage the strands.

6.8.3 The sequence of running out shall be from the top down. Unbalanced loads on towers shall be avoided as far as possible. Inner phase of line conductors shall be strung before the stringing of the outer phases is taken up.

6.8.4 As tower is not designed for one sided stringing, tower shall be well guyed and step taken by contractor to avoid damage. Guying proposal along with necessary calculation shall be submitted by the contractor to Employer for approval. All expenditure related to this work is deemed to be included in the bid price and no extra payment shall be made for the same.

6.8.6 The Contractor shall take adequate safety precautions to protect personnel from potentially dangerous voltage build up due to distant electrical storms/energized lines.

6.9 Running Blocks

6.9.1 The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor and it does not slip over or rub against the slides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

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

6.10 Repairs to Conductors

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

6.10.2 Repairs to conductor where no more than two strands in the outermost layer are broken shall be carried out with repair sleeve with approval of Engineer-Incharge.

6.10.3 Repairing of the conductor surface shall be carried out only in case of minor damage, scuff marks, etc. The final conductor surface shall be clean, smooth and free from projections, sharp points, cuts, abrasions, etc.

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

6.11 Crossings

Derricks or other equivalent methods ensuring that normal services need not be interrupted nor damage caused to property shall be used during stringing operations where roads, channels, telecommunication lines, power lines and

railway lines have to be crossed. In case of railway crossings, shutdown might

not be available and therefore, contractor shall be required to carry out reconductoring under such condition i.e. without any shutdown of railways. However, shut down shall be obtained when working at crossings of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor and accessories in the field.

6.12 Stringing of HTLS Conductor

The stringing of the equivalent HTLS conductor shall be done by the standard stringing method suitable for the type of HTLS Conductor offered.

6.13 Supervision in Stringing

6.13.1 The installation and restringing of the offered HTLS conductor for the above 132kV transmission line shall be carried out by the transmission line contractor under supervision of the HTLS conductor supplier or Qualified Bidder itself. The bidder's engineers are to supervise whether appropriate safety measures along with necessary safety tools and equipment's to carry out stringing operations under the above conditions including mechanical/ structural safety of the towers, are maintained or not. Bidder's responsibility is to provide Sag-Tension chart based on existing site conditions. It may be noted that AEGCL will not consider any modifications (tower extensions etc) on existing tower/span.

6.13.2 The Contractor shall deploy appropriate tools/ equipment/ machinery to ensure that the stringing operation is carried out without causing damage to conductor and the conductor is installed at the prescribed sag tension as per the approved stringing chart. Prior to taking up stringing work the contractor shall submit for approval of Site-In charge the complete details of stringing methods he proposes to follow.

6.13.3 If any special tools and tackles other than those generally used for stringing of ACSR conductors are deployed for stringing of HTLS Conductor by the contractor, a set of those tools & tackles shall be supplied by the contractor to the Employer, on completion of the project, at no extra cost. The quantity of such tools & tackles shall be sufficient to carry out stringing operations of the longest section (from angle tower to angle tower) of the existing transmission line.

6.13.5 The contractor shall submit, for approval of site in-charge, the complete details of the stringing methods he proposes to follow. Prior to stringing the Contractor shall submit the stringing charts for the conductor showing the initial and final sags and tension for various temperatures and spans along with equivalent spans in the lines for the approval of the Employer.

6.13.6 Conductor creep is to be compensated by over tensioning the conductor at an appropriate temperature lower than the ambient temperature based on creep calculations to be furnished by the Contractor.

6.14 Jointing

6.14.1 When approaching the end of a drum length at least three coils shall be left in place when the stringing operations are stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the approved drawing and procedures recommended by the manufacturer of joints.

6.14.2 Conductor splices shall not crack or otherwise be susceptible to damage in the stringing operation. The Contractor shall use only such equipment/methods during conductor stringing which ensures complete compliance in this regard.

6.14.3 All the joints on the conductor shall be of the compression type, in accordance with the recommendations of the manufacturer, for which all necessary tools and equipment like compressors, dies etc., shall be obtained by the Contractor. Each part of the joint shall be cleaned by wire brush till it is free of dust or dirt etc., and be properly

greased with anti- corrosive compound. If required and as recommended by the manufacturer, before the final compression is carried out with the compressors. For HTLS Conductor suitable sleeve, collets, collet housing shall be used for jointing of core as per the offered design and methodology applicable for similar type of design/application.

6.14.4 All the joints of splices shall be made at least 30 meters away from the tower structures. No joints or splices shall be made in spans crossing over main roads, railways and small river tension spans. Not more than one joint per sub conductor per span shall be allowed. The compression type fittings shall be of the self-centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation; the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After compressing the joint the aluminium sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

6.14.5 During stringing of conductor to avoid any damage to the joint, the Contractor shall use a suitable protector for mid span compression joints, in case they are to be passed over pulley blocks/aerial rollers. The pulley groove size shall be such that the joint along with protection can be passed over it smoothly.

6.15 Tensioning and Sagging Operations

6.15.1 The tensioning the sagging shall be done in accordance with the approved stringing charts or sag tables. The "initial" stringing chart shall be used for the conductor. The conductors shall be pulled up to the desired sag and left in running blocks for at least one hour after which the sag shall be rechecked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps.

6.15.2 Dynamometer shall be employed for measuring tension in the conductor. Dynamometers employed shall be periodically checked and calibrated with the standard Dynamometer.

6.15.3 The sag will be checked in the first and the last section span for sections up to eight spans, and in one additional intermediate span for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

6.15.4 The running blocks, when suspended from the transmission structure for sagging, shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.

6.15.5 At sharp vertical angles, conductor and earth wire sags and tensions shall be checked for equality on both sides of the angle and running block. The suspension insulator assemblies will normally assume verticality when the conductor is clamped.

6.15.6 Tensioning and sagging operations shall be carried out in calm whether when rapid changes in temperature are not likely to occur.

6.16 Clipping In

6.16.1 Clipping of the conductors into position shall be done in accordance with the manufacturer's recommendations.

6.16.2 Jumpers at section and angle towers shall be formed to parabolic shape as per existing tower line diagrams to ensure maximum clearance requirements. Pilot suspension insulator strings shall be used, if found necessary, to restrict jumper swing to design values.

6.16.3 Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

6.17 Fixing of Conductors Accessories

Conductor accessories including vibration dampers shall be installed by the Contractor as per the design requirements and manufacturer's instruction within 24 hours of the conductor clamping. While installing the conductor accessories, proper care shall be taken to ensure that the surfaces are clean and smooth and that no damage occurs to any part of the accessories or of the conductors. Torque wrench shall be used for fixing the Vibration Dampers, Suspension Clamps etc. and torque recommended by the manufacturer of the same shall be applied.

6.18 Final checking, Testing and Commissioning

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

6.18.1 The stringing of the conductors has been done as per the approved sag and tension charts and desired clearances are clearly available;

6.18.2 All conductor accessories are properly installed;

6.18.3 The original tracings of profile are submitted to the Employer for reference and record.

6.18.4 The insulation of the line as a whole is tested by the Supplier through provision of his own equipment, labour etc., to the satisfaction of the Employer.

6.18.5 The line is tested satisfactorily for commissioning purpose.

6.18.6 Any defect found as a result of testing shall be rectified by the contractor forthwith to the satisfaction of the Employer without any extra charges.

6.18.7 The contractor should also fulfill the requirements of pre commissioning.

6.18.8 In addition to the above, the contractor shall arrange for testing of the total and relative sags of the conductors and shall be responsible to maintain the values within specified tolerances.

6.18.9 The contractor shall make all arrangements for such tests and the contractor shall provide necessary labour, transport and equipment.

6.18.10 After satisfactory tests on the line and on approval by the Employer the line shall be energised at full operating voltage before handing over.

Technical Data Sheets
(To be filled up by each Manufacturer)

Contents

SCHEDULE -1

GUARANTEED TECHNICAL PARTICULARS OF HTLS CONDUCTOR

(Technical Data Sheet needs to be furnished separately by the Bidder for each of the projects)

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**
1.	Name & address of Manufacturer		
2.	Construction of conductor/ Designation of conductor as per IEC:1089		
3.1	**PARTICULARS OF RAW MATERIALS**		
3.1	Outer Layers a) Applicable Standard (if any) b) Type of Aluminum alloy c) Minimum purity of aluminum d) Maximum Copper content e) Zirconium content i) Maximum ii) Minimum e) Other elements---------- i) ----- ------ ii) ----- ------	 % % % % % %	
3.2	Inner core a) Applicable Standard(if any) b) Material of core c) Chemical composition of core i) ----- ------ ii) ----- ------	 % %	
4.	OUTER STRANDS AFTER STRANDING		
4.1	Number of outer layers	Nos.	
4.2	Number of strands a) 1st Layer from core b) 2nd Layer from core c) 3rd Layer from core …… ……..	 Nos. Nos. Nos. ……. ……..	
4.2	Diameter of strands a) Nominal b) Maximum c) Minimum	 mm mm mm	
4.3	Minimum Breaking load of strand a) Before stranding b) After stranding	 kN kN	

4.4	Resistance of 1m length of strand at 20 deg. C	Ohm		
4.5	Final Modulus of elasticity	Kg/sq. mm		
4.6	Final Coefficient of linear expansion	Per °C		
5	INNER CORE			
5.1	Diameter a) Nominal b) Maximum c) Minimum	 mm mm mm		
5.2	Minimum Breaking load of strand/Core a) Before stranding b) After stranding	 kN kN		
5.3	Resistance of 1m length of strand at 20 deg. C	Ohm		
5.4	Final Modulus of elasticity	Kg/sq. mm		
5.5	Final coefficient of linear expansion	Per ^{0} C		
5.6	Carbon-fibre composite core			
5.7	Minimum elongation of core which the core will achieve during elongation test	%		
6	FILLER (if applicable)			
6.1	Type & Designation of Filler			
6.2	Chemical composition of Filler			
6.3	Mass of Filler	Kg/km		
7	**COMPLETE HTLS CONDUCTOR**			
7.1	Cross section drawing of the offered conductor enclosed	Yes/No		
7.2	Diameter of conductor a) Nominal b) Maximum c) Minimum	 mm mm mm		
7.3	UTS (minimum) of Conductor	kN		
7.4	Lay ratio of conductor a) 1st layer from center (excluding central wire) b) 2nd Layer c) 3rd Layer d)4th Layer		Maximum 	Minimum
7.5	Minimum Corona Extinction Voltage (line to ground) under Dry condition	kV(rms)		
7.6	RIV at 1MHz and 154 kV (rms) under dry conditions	Micro- volts		
7.7	DC resistance of conductor at 20ºC	Ohm/km		
7.8	Final Modulus of elasticity			
	a) Upto transition temperature	Kg/sq. mm		

	b) Above transition temperature	Kg/sq. mm	
7.9	Coefficient of linear expansion		
	a) Upto transition temperature	Per deg C	
	b) Above transition temperature	Per deg C	
7.10	Calculation for transition temperature enclosed	Yes/No	
7.11	Transition temperature (corresponding to 350m ruling span and tension at ruling condition)	Deg C	
7.12	Maximum permissible conductor temperature for continuous operation	Deg C	
7.13	Maximum permissible conductor temperature for short term operation	Deg C	
7.14	Permissible duration of above short term operation	Minutes	
7.15	Steady state conductor temperature at conductor current of 1200A and under Ambient conditions detailed in Section-1		
7.16	AC resistance at maximum continuous operating temperature corresponding to specified maximum operating current (1200 A under ambient condition enclosed as per relevant clause under Section-1)	Ohm/km	
7.17	AC resistance at continuous operating temperature corresponding to specified operating current of [**Value of Normal Current in the conductor**] (under ambient condition enclosed as per relevant Clause of Section-1 of Bid document)	Ohm/km	
7.18	Details of Creep characteristic for HTLS conductor enclosed (as per Clause 1.5.5 of Section-3 of the bid document)	Yes/No	
7.19	Sag Tension Calculation		
7.19.1	Sag Tension Calculation enclosed (as per Clause 1.5.5 of Section-1 of the bid document)	Yes/No	
7.19.2	Tension at 32 deg. C & no wind	Kg	
7.19.3	Sag & tension at maximum continuous operating temperature (corresponding to current of 1200 A and Ambient conditions detailed in Clause 1.5.5 of Section-3 of the bid document.	Meters & Kgs	

i)	Tension at 32 deg. C & full wind for following wind pressure:		
a.	Wind Pressure: 50 kg/m2	kg	
ii)	Tension at 0 deg. C ,2/3 wind pressure: 34.7 kg/m2	kg	
7.17.4	Tension at transition temperature	kg	
7.18	Direction of lay for outside layer		
7.19	Linear mass of the Conductor a) Standard b) Minimum c) Maximum	 Kg/km Kg/km Kg/km	
7.20	Standard length of conductor	M	
7.21	Maximum length of conductor that can be offered as single length	M	
7.22	Tolerance on standard length of conductor	%	
7.23	Drum is as per specification	Yes/No	
7.24	No. of cold pressure butt welding equipment available at works	Nos.	

Date: (Signature)……

Place: (Printed Name) ……..

(Designation)…….

(Common Seal) …….

SCHEDULE -2

Page 1 of 2

Bidder's Name……..

GUARANTEED TECHNICAL PARTICULARS OF SUSPENSION HARDWARE FITTINGS

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl.	Description	Unit	Value guaranteed by the Bidder
1.	Name & address of Manufacturer		……
2.	Address of Manufacturer		……
3.	Drawing enclosed	Yes/No	
4.	Maximum magnetic power loss of suspension clamp at conductor current of 1200 amperes	Watt	…… ..
5.	Slipping strength of suspension assembly (c!amp torque Vs slip curve shall be enclosed)	kN	…… ..
6.	**Particulars of standard/AGS Standard / AGS preformed armour rod set for suspension Assembly**		
	a) No. of rods per set	No.	……
	b) Direction of lay		……
	c) Overall length after fitting on conductor	mm	……
	d) Actual length of each rod along its helix	mm	……
	e) Diameter of each rod	mm	……
	f) Tolerance in		
	i) Diameter of each rod	±mm	……
	ii) Length of each rod	±mm	……
	iii) Difference of length between the longest and shortest rod in a set	±mm	……
	g) Type of Aluminium alloy used for manufacture of PA rod set		……
	h) UTS of each rod	Kg/mm^2	……
7.	**Particulars of Elastomer**		
	(For AGS Clamp only)		
	a) Supplier of elastomer		……
	b) Type of elastomer		……
	c) Shore hardness of elastomer		……
	d) Temperature range for which elastomer is designed		……
	e) Moulded on insert		Yes/No
8.	UTS of suspension clamp		Yes/No

9.	Purity of Zinc used for galvanising	%	……
10.	Maximum permissible continuous operating		
	temperature of		
	i) Clamp body		
	ii) Standard/AGS preformed rods		
11.	Minimum corona extinction voltage under dry condition	kV (rms)	
12.	Radio interference voltage at 1 Mhz for phase to earth voltage of 154 kV (dry condition)	Micro- volts	

Date: (Signature)……

Place: (Printed Name) ……..

(Designation)……..

(Common Seal) ……..

SCHEDULE -3

Page 1 of 2

Bidder's Name……..

Specification No……

GUARANTEED TECHNICAL PARTICULARS OF DEAD-END ASSEMBLY /TENSION HARDWARE FITTINGS

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**	
1.	Name of Manufacturer		……	
2.	Address of Manufacturer		……..	
3.	Drawing enclosed		Yes/ No	
4.	Purity of aluminum used for aluminum Sleeve	%	……	
5.	**Material for steel sleeve**			
	(i) Type of material with chemical composition		……	
	(ii) Range of Hardness of material (Brinnel Hardness)	BHN	From …….to ……..	
	(iii) Weight of zinc coating	gm/m^2	……	
			Aluminium/ Alloy	Steel
6.	**Outside** diameter of sleeve **before** compression	mm	……..	……..
7.	**Inside** diameter of sleeve **before** compression	mm	……..	……..
8.	Length of sleeve before compression		……..	……..
9.	Dimensions of sleeve **after** compression			
	(a) Corner to Corner		……	……..
	(b) Surface to Surface		……..	…….
10.	Length of sleeve **after** compression		……	……..
11.	**Weight of sleeve**			
	(a) Aluminium/ aluminum Alloy	kg	……	

	(b) Steel	kg	……
	(c) Total	kg	……

Sl.	Description	Unit	Value guaranteed by the Bidder
12.	Electrical resistance of dead end assembly as a percentage of equivalent length of Conductor	%	… …..
13.	Slip strength of dead end assembly	kN	… …..
14.	UTS of dead end assembly	kN	… …..
15.	Purity of Zinc used for galvanizing	%	… …..
16.	Minimum corona extinction voltage under dry condition	kV (rms)	
17.	Radio interference voltage at 1 Mhz for phase to earth voltage of 154 kV (dry condition)	Micro- volts	

Date:

Place:

(Signature)……
……
(Printed Name)
…….
(Designation)……
…….
(Common Seal)
…….

SCHEDULE -4

Page 1 of 2

Bidder's Name……..

Specification No……

GUARANTEED TECHNICAL PARTICULARS OF MID SPAN COMPRESSION JOINT FOR **HTLS CONDUCTOR (Non-Metallic Core)**

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**	
1.	Name of Manufacturer		……	
2.	Address of Manufacturer			
3.	Drawing enclosed		Yes/No	
4.	Suitable for conductor size	Mm	……	
5.	Purity of aluminium used for aluminium Sleeve	%	……	
6.	**Material for steel sleeve**			
	(i) Type of material with chemical composition		……	
	(ii) Range of Hardness of material (Brinnel Hardness)	BHN	From …….to ……..	
	(iii) Weight of zinc coating	gm/m^2	……	
			Aluminium/ alloy	Steel
7.	**Outside** diameter of sleeve **before** compression	Mm	……..	……..
8.	**Inside** diameter of sleeve **before** compression	Mm	……..	……..
9.	Length of sleeve before compression		……..	……..
10.	Dimensions of sleeve **after** compression			
	(a) Corner to Corner		……	……..
	(b) Surface to Surface		……..	…….
11.	Length of sleeve **after** compression		……	……..

SCHEDULE -4 (CONTD.)

Page 2 of 2
Bidder's Name……..
Specification No……

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**
12.	**Weight of sleeve**		
	(a) Aluminium	Kg	……
	(b) Steel	Kg	……
	(c) Total	Kg	……
13.	Slip strength	kN	……
14	Minimum Corona extinction voltage under dry condition	kV (rms)	
15	Radio interference voltage at 1 MHz for phase to earth voltage of 154 kV under dry condition	Microvolt	
16.	Resistance of the compressed unit expressed, as percentage of the resistivity of equivalent length of bare conductor.	%	……
17.	Maximum permissible continuous operating temperature of mid span compression joint	Deg. °C	……

(Signature)……
Date: …
Place: (Printed Name)
……
……..
(Designation)……
….
(Common Seal)…….

SCHEDULE -5

Page 1 of 1

Bidder's Name……..
Specification No……

GUARANTEED TECHNICAL PARTICULARS OF REPAIR SLEEVE FOR HTLS CONDUCTOR

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**
1.	Name of Manufacturer		……
2.	Address of Manufacturer		
3.	Drawing enclosed		Y es/No
4.	Suitable for conductor size	Mm	……
5.	Purity of Aluminium / Al Alloy type	%	……
6.	Dimension of sleeve before compression		
	i) Inside diameter of sleeve	Mm	……
	ii) Outside dimensions of sleeve	Mm	……
	iii) Length of sleeve	Mm	……
7.	Dimension of sleeve after compression		
	i) Corner to Corner	Mm	……
	ii) Surface to Surface	Mm	…….. ……..
	iii) Length of sleeve	Mm	
8.	Weight of sleeve	Kg	……
9.	Minimum Corona extinction voltage under dry condition	kV (rms)	
10	Radio interference voltage at 1 MHz for phase to earth voltage of 154 kV dry condition)	µV	
11.	Maximum permissible continuous operating temperature of Repair Sleeve	Deg. C	

Date: (Signature)……..

Place: (Printed Name)……..
(Designation)……..

(Common Seal)……..

SCHEDULE -6

Bidder's Name……..

Specification No……

GUARANTEED TECHNICAL PARTICULARS OF VIBRATION DAMPER FOR HTLS CONDUCTOR (IF APPLICABLE)

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**	
1.	Name of Manufacturer		……	
2.	Address of Manufacturer			
3	**Drawing enclosed**			
	(a) Design Drawing		YES / NO	
	(b) Placement Chart		YES / NO	
4.	Suitable for conductor size	Mm	……	
5.	Total weight of one damper	Kg		
			Right	Left
6.	Diameter of each damper mass	Mm	……	…….
7.	Length of each damper mass	Mm	…….	……
8.	Weight of each damper mass	Kg	…….	……
9.	Material of damper masses		……	
10.	Material of clamp		……	
11.	Material of the stranded messenger cable			
12.	Number of strands in stranded messenger cable		…… ……	
13.	Lay ratio of stranded messenger cable		……	
14.	Minimum ultimate tensile strength of stranded messenger cable	Kg/mm^2	……	
15.	Slip strength of stranded messenger cable (mass pull off)	kN	……	

SCHEDULE -6 (CONTD.)

Bidder's Name……..
Specification No……

Sl.	**Description**	**Unit**	**Value guaranteed by the Bidder**	
			Right	Left
16.	Resonance frequencies			
	(a) First frequency	Hz	……	…….
	(b) Second frequency	Hz	……	…….
17	Designed clamping torque	Kg-m	……	
18.	Slipping strength of damper clamp			
	(a) Before fatigue test	kN	……	
	(b) After fatigue test	kN	……	
19.	Magnetic power loss per vibration damper watts for [Value of Normal Current in thr conductor] amps, 50 Hz Alternating Current	Watts	……	
20.	Minimum corona Extinction voltage kV (rms) under dry condition	kV		
21.	Radio Interference Voltage at 1 MHz for phase to earth voltage of 154 kV (rms) Microvolts under dry condition	µV		
21.	Maximum permissible continuous operating temperature of Vibration Damper	Deg. C		
22.	Percentage variation in reactance after fatigue test in comparison with that before fatigue test	%	……	
23.	Percentage variation in power dissipation after fatigue test in comparison with that before fatigue test	%	……	

SCHEDULE-7

Bidder's Name……..
Specification No……

GUARANTEED TECHNICAL PARTICULARS OF DISC INSULATOR FOR HTLS CONDUCTOR (IF APPLICABLE)

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

Sl. No	Details	90/120KN
1	Type	Ball & Socket
2	Height – mm	
3	Diameter – mm	
4	Creepage – mm (Minimum) c) Total d) Protected	
5	Ball Diameter – mm	
6	Colour	
7	Surface	
8	Materials a) Socket Cap b) Ball Pin c) Security Clip d) Zinc Sleeve e) Insulator	
9	Shape and material of Security Clip	
10	Minimum Failing Load	
11	Minimum Electro Mechanical strength – KN	
12	Visible Discharge Test Voltage – KV (Min.)	
13	Dry Impulse Flash Over Voltage – KV (Min. +ve	
14	Power Frequency Flash Over Voltage – KV (RMS – Min.) a) Dry b) Wet	
15	Power Frequency Withstand Voltage – KV (RMS – Min.) c) Dry d) Wet	
16	Power Frequency Puncture Voltage – KV (RMS – Min.)	
17	Net weight(approx)	
18	Minimum corona extinction voltage of each disc insulator KV(rms)	
19	Maximum RIV with 10 KV(RMS) of each disc insulator (microvolts)	

SCHEDULE-8

GUARANTEED TECHNICAL PARTICULARS OF LONG ROD PORCELAIN INSULATOR FOR HTLS CONDUCTOR (IF APPLICABLE)

(Guaranteed Technical particulars needs to be furnished separately by the Bidder for each of the projects)

A. GENERAL		
1	Voltage level kV	
2	Type (Ball & Socket)	
3	Material of Disc	
4	Colour	
5	Surface	
6	Type of Locking device and its material (Clip of ss/phos. Bronze or better)	
7	Size	
8	Ball/Socket dia (in mm)	
9	No. of units per single string	
10	Length of insulator string (in mm)	
11	Total length with hardware (in mm)	
12	Guaranteed mechanical failing load (in KN)	
B. ELECTRICAL		
1	Total Min. creep age distance (in mm)	
2	Power frequency withstand voltage- dry KV (peak)	
3	Power frequency withstand voltage – wet KV (peak)	
4	Impulse withstand voltage (+/-) 1.2x50 micro-second KV (peak)	
5	Visible discharge Voltage KV	
6	Standard Applicable	
7	Minimum corona extinction voltage of each disc insulator KV(rms)	
8	Maximum RIV for string including corona rings at 154 kV rms.	

Date:

(Signature)…… (Printed Name)……..

(Designation)……

……

Place:

(Common Seal)……