BIDDING DOCUMENT
FOR

"Construction of flood affected tower and associated works of transmission line at Loc. 73 of Nalkata Dhemaji line"

(E-Tender)

VOLUME -2

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BID IDENTIFICATION NO:
AEGCL/MD/TECH-1148/Tower Cons/Loc. 73/SOPD 2024-25/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 DIN 127-1970 section spring washers for bolts nuts, screws.
31.	IS 3188-1965	Dimensions for disc IEC 305-1978 insulators.

32.	IS 4091-1967	Code of practice for ASCE/IEEE 691 design and construction of foundation for transmission line towers and poles.	
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 (Shallow Foundation)	
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 (in mm) (b) Double suspension (c) Pilot Insualtor	 Nil 15° 30° 45° 60° Nil 15°	 1530 1530 1370 1220 1070 1530	 2130 1980 1830 1675 - 2130	 3050 3050 1860 - - 3050 3050
2	Tension string Single/ Double	Nil	1530	2130	3050
3	Jumper	Nil 10°	1530 1530	2130 2130	3050 3050

		20° 30°	1070 1070	1675 1675	1860 -
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
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
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		

SL. No	**Description**	**132 KV**	**220 KV**	**400 KV**
I	**II**	**III**	**IV**	**V**
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	
	(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	

Item	**Particulars**	**132 kV Line (Single/double-3phase) with AAAC**
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 (b) Tension	 9 no. 10 no.
	(ii) Electro-mechanical strength (a) Suspension (b) Tension	 90 kN 120 kN
10. Tension Limits	(a) For conductor and ground wire (i) at 32^0 C &no wind (ii) at 32^0 C &full wind (iii) at 0^0 C &36% of full wind	25 % of UTS 70 % of UTS 70 % of UTS

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 d) Minimum	525 M 200 M	525 M 0 M
	(iii) Weight span, one span	Suspension	Tension
	c) Maximum d) Minimum	315 M 100 M	315 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	

Item	Particulars	**220 kV Line (Single/double- 3phase) with AAAC/ACSR**
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 (d) Tension	 14 no. 15 no.
	(iv) Electro-mechanical strength (c) Suspension (d) Tension	 90 kN 120 kN
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

Item	Particulars	**400 kV Line (Single/double- 3phase) with ACSR/AAAC**	
		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	
	(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 mm^2	428.90 mm^2	212.10 mm^2
9	Total sectional area	597.00 mm^2	484.50 mm^2	261.50 mm^2

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. No.	Clearance	220 KV	132 KV	33 KV
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 mm	GI Flat
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	**132**	**33 kV**

		kV	**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
g) Creepage Distance

(Min subjected requirement of clause 7.19.2):25 mm/kV

h) Electro mechanical Strength : 70 KN
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).

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.

7.13.4 T Clamp and Equipment Clamps

a) T Clamps:

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.

b) Equipment Clamps (CVT, CB, ISOLATOR, CT, etc.):

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.

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,	Limiting Glare Index

		'Lux'	
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	19.30×10^{-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	19.35×10^{-6} /°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%			
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 (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. 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 comparison with that before fatigue test	%	+/-40 (Maximum)
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	%	75		

	percentage of the resistance of equivalent length of bare Earthwire		
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	2175	5550	2 X 2	2 X 120kN

		Tension				
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 (I) dry (ii) wet. : IEC: 60383
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

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)
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
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"

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	

In 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	IEEE 1138-	IEEE 1138-2009	Fibre attenuation shall be continuously

	Vibration Test	2009 Or IEC60794 4-10 / IEC 60794-1-2, Method E19		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 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in 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	IEC 60794-1-2 E1 / EIA/TIA	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation	

	Test	455-33B	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 Error		EIA/TIA 455-/176
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 OF POWER LINE CARRIER COMMUNICATION EQUIPMENTS WITH LINE TRAP, 48 V DC PLCC BATTERY, CHARGER

13.1 SCOPE

This specification provides design, manufacture, inspection, testing at manufacturer's works, delivery at site, installation and commissioned of indoor and outdoor Power Line Carrier Communication Equipments as specified herein for. The specification shall be complete for speech communication in dialling mode and/or through 4 wire Express Telephone, data communication and carrier aided protection for 400KV, 220KV & 132KV Transmission Lines. All communication equipment shall be suitable for good quality voice communication among new & existing Sub- Stations, reliable tele-protection and also data communication from RTU and SAS (via GATEWAY) to SLDC, Kahilipara.

13.2. SERVICE CONDITIONS

13.2.1 The materials supplied shall be suitable for operation under the climatic and other conditions mentioned in chapter 2.

13.2.2 Power Line Carrier Communication will have the following minimum components. However, for more efficient performance of the system the bidder can provide additional item at no extra cost.

a) Capacitor Voltage Transformer (CVT)
b) Wave Trap
c) PLCC Terminal
d) Line Matching Unit/ Line Matching and Distribution unit
e) Tele Protection Coupler
f) Battery and Battery charger
g) EPAX System and Telephone System
h) HF Coaxial cable

13.3 STANDARDS :

The equipment shall conform to the following latest Edition of the Indian Standards as amended up to date and as per latest relevant I.E.Cs. :
The details are given below :

1. IEC 353 for line trap
2. IS 8792 for line trap
3. I.E.C. 481 for coupling devices
4. I.E.C. 495 for power line carrier terminals
5. I.S. 8997 for coupling devices
6. I.S. 3156 for CVT
7. I.E.C. 358 for C.C. & CVT
8. I.S. 9348 for coupling capacitor
9. I.S. 11967 for Co-axial Cable
10. I.E.C. for Planning of SSB PLCC system
11. I.E.C. for Surge Arrestors
12. I.E.C. 96 for HF Cable
13. I.E.C834-I Part-I for Performance and Testing of Tele protection equipment
14. I.S. 9428 for Characteristic values of Inputs and outputs of single side band PLC terminals
15. I.S. 9528 for frequency planning of power line carrier equipment

13.4 TECHNICAL SPECIFICATION OF LINE TRAP

This specification provides for design, engineering, manufacture, stage testing, inspection and testing before dispatch, packing and delivery at destination of Line Trap along with all accessories specified herein. The line trap to be inserted into high voltage A.C transmission lines to prevent undue loss of carrier signal power, typical in the range 30KHz to 500KHz, under all power system conditions and to minimize interference from carrier signaling systems on adjacent transmission lines.

13.4.1 STANDARDS:

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the line trap shall conform but not limited to the latest revisions and amendments available at the time of placement of order of all the relevant standards as listed hereunder.

Sl No	Standard No.	Title
1	IEC 60353 Second edition, 1989-90	Line Trap for AC Power System
2	IS : 8792-1978	LINE TRAPS FOR AC POWER SPECIFICATION SYSTEMS -(First Revision)
3	IS : 8793-1978	LINE TRAPS FOR AC POWER SPECIFICATION SYSTEMS METHODS OF TESTS -(First Revision)
4	IS-9859 (PART-I)-1981	CODE OF PRACTICE FOR INSTALLATION AND MAINTENANCE OF OUTDOOR POWER LINE CARRIER EQUIPMENT PART I LINE TRAPS (Incorporating Amendment No. 1)
5	IEC 99	Lightning Arresters
6	IEC 99 - 1(1970)	Part-1 , Non-Linear resistor type arresters for AC systems
7	IEC 60099-4/2006	Metal-oxide surge arresters without gaps for a.c. systems
8	IS : 5561-1970	Terminal Clamp / Connector

13.4.2 PRINCIPAL TECHNICAL PARAMETERS FOR LINE TRAP:

The Line Trap covered in this specification shall meet the technical requirements listed hereunder. Line traps of different voltage rating shall conform to the following technical particulars:-

TABLE- I

Sl No	**Technical Parameters**	**VOLTAGE LEVEL**		
		400KV	**132 kV**	**220 kV**
I	**II**	**III**	**IV**	**V**
2	Type of mounting	Pedestal	Suspension /Pedestal	Pedestal
3	Suitable for system Frequency	50 Hz	50 Hz	50 Hz
4	Nominal System Voltage	400KV	132 KV	220 KV
5	Highest System Voltage	420KV	145 KV	245 KV
6	Rated Continuous Current	3150A	800 A	1250 A
7	Rated Short time current for 3 second	63KA	40 kA	50 KA
8	Asymmetrical peak value of the first half wave of the rated short time current	127.5 KA	51 KAp	102 KAp

	9	Rated inductance	1 mH	0.5 mH	0.5 mH
	10	Type of Tuning	Broad Band	Broad Band	Broad Band
	11	Blocking Band frequency range	90-150Khz 150-500Khz	90-150Khz 150-500Khz	90-150Khz 150-500Khz
	12	Minimum Guaranteed resistive component of impedance in Blocking Frequency range	500 Ohm	570 ohm	570 ohm
13.4.3	13	Protective device	a) Non-linear resistive type Gapped lightning arresters for a.c. system	a) Non-linear resistive type Gapped lightning arresters for a.c. system	a) Non-linear resistive type Gapped lightning arresters for a.c. system
	14	Nominal discharge current of protective device	10KA. However, Coordination shall be done by taking 20KA 8/20 micro-sec discharge in to consideration.	10 KA	10 KA
	15	Rated voltage of protective device	> 15.72 KV rms	4.5 KV	9 KV
	16	Minimum value of power frequency spark over voltage (Dry and wet) of protective device	> 23.58 KV rms	6.75 KV rms	13.5 KV rms
	17	Visual corona extinction voltage	320 KV rms	97 KV rms	156 KV rms
	18	Radio Influence Voltage (RIV)	< 500 micro Volt @ 280KV.	< 500 micro volt	< 500 microvolt
	19	Attenuation in tuned frequency band	> 7.5 dB	>7.5 dB	>7.5 dB
	20	Maximum tapping loss over blocking band I & II stated bove above	2.6 dB	2.6 dB	2.6 dB
	21	Maximum tapping loss based on blocking resistance	2.6 dB	2.6 dB	2.6 dB
	22	Insulation class	Class F Insulation	Class F	Class F
	23	Maximum working stress	Twice the weight of wave trap + 500Kgs.	Twice the weight of wave trap + 500 Kgs	Twice the weight of wave trap + 500 Kgs

GENERAL TECHNICAL REQUIREMENTS:

A line trap, consisting of a main coil in the form of an inductor, a tuning device and a protective device, is intended for insertion in a high voltage power transmission line between the point of connection of carrier frequency signals and adjacent power system elements such as busbar, transformers etc. The tuning device connected across the main coil ensures, with proper adjustment, that the line trap presents relatively high impedance at one or more carrier frequencies or carrier frequency bands, whereas the impedance of the line trap at power frequencies is negligible. A line trap may also be used to

limit the loss of carrier-frequency at a power system tee point.

13.4.3.1 Main Coil:

An inductor carries the power frequency current of the high voltage transmission line. Wave trap shall consist of a main coil designed to carry continuously the rated current at the maximum ambient temperature and at full operating line voltage. It shall be supplemented with a protective device and a tuning device.

13.4.3.1.1 Tuning Device:

Line traps are to be tuned for a carrier frequency band, which will depend upon the operation carrier frequency pair chosen for transmission lines in question. The resistive component of impedance of the wave trap within its band shall not be less than 570 ohms. The wave traps should be provided with suitable barriers to prevent the entry of birds into the same.

13.4.3.2 Protective Device:

The device connected across the main coil and tuning device which prevents the line trap from being damaged by transient over voltages which may occur across it. The protective device shall be so designed and arranged that neither a significant alteration in its protective function nor physical damage shall result either from the temperature rise or magnetic field of the main coil at continuous rated current, rated short-time current or from emergency overload current. It shall neither enter into operation as a result of the power frequency voltage developed across the line trap by rated short time current nor shall it remain in operation after a response to a transient over voltage which is immediately followed by the power frequency voltage developed across the line trap by rated short-time current.

The protective device shall be shunt connected to the main coil and the tuning device.

For proper coordination with the lightning arrester installed in the substations and generating stations, the wave traps shall be provided with protective device with nominal discharge current of 10 KA.

13.4.4 DESIGN REQUIREMETS:

Ability to withstand rated short-time current: The line trap so designed shall be capable to withstand the mechanical forces produce by asymmetrical peak value of the short-time current.

13.4.5 Insulation level:

The insulation level for the insulation between the terminals of a line trap is governed by the rated voltage of the protective device. The insulation of the main coil and the tuning device shall be adequately rated for:-

a) The voltage developed across the line trap at the rated power frequency by the rated short-time current. The rated voltage of the protective device shall be higher than this voltage developed across the line trap.

b) the front of wave impulse spark over voltage or the residual voltage caused by the nominal discharge current of the protective device, which ever is higher.

13.4.6 System Voltage insulation:

The system voltage insulation of a line trap is provided by insulator strings or post insulators. The line trap system voltage insulation shall be consistent with the other equipment in the associated high voltage transmission network.

13.4.7 Tensile strength of suspension system:

The suspension system of a line trap shall be designed for a tensile stress of at least twice the mass of the line trap in kilograms, multiplied by 9.81 to convert to newtons, plus 5000 N.

13.5 ACCESSORIES:

i) **Bird barriers**: The bird barrier design shall be such that no entrance to the line trap shall admit a sphere having a diameter of 16 mm.

ii) **Terminal clamp/connectors**: The clamp shall be suitable for AAAC/ACSR Zebra conductor in case of 220 kV system and AAAC/ACSR Panther conductor in case of 132 kV system. The clamp, connectors, nuts, bolts and hardware shall be of nonmagnetic material and shall conform to IS: 5561. The clamp shall be fitted on incoming and outgoing pad of Line Trap. The incoming and outgoing conductor shall be on either side of the clamp fitted with the help of bolts and nuts arrangements. The clamp shall be designed to carry the continuous load of 800 Amp at

132 KV and 1250 Amp at 220 KV and shall withstand a dynamic short circuit current of 31.5 and 40 KA respectively for 1 second. The temperature rise shall not exceed 35°C over 50°C ambient. All the castings shall be free from blowholes, surface blisters, cracks and cavities. All sharp edges shall be blurred, rounded off and buffed. Clamp and connectors shall be designed to avoid corona formation. The visual corona extinction voltage shall not exceed 97 KV (rms.) for 132 kV and 156 kV (rms) for 220 kV. Radio interference voltage for clamp and connectors shall not exceed 500 microvolts at 97 KV (rms.) for 132 kV and 156 kV (rms) for 220 kV. No current carrying parts of the Clamps and connector shall be less than 10 mm of thickness.

iii) **400KV WAVE TRAP**

The clamp shall be suitable for 4" IPS AL TUBE and TWIN/QUAD ACSR Moose Conductor. The clamps shall be chosen as per requirement of the substation. The clamp, connectors, nuts, bolts and hardware shall be of non-magnetic material and shall conform to IS: 5561. The clamp shall be fitted on incoming and outgoing pad of Line Trap with four Nos. of Nuts & Bolts. The incoming and outgoing conductor shall be on other side of the clamp fitted with the help of six bolts and nuts arrangements. The clamps shall be suitable for horizontal and vertical take off with conductor diameter 31.77 mm for Twin/Quad ACSR Moose conductor. The clamp shall be designed to carry the continuous load of 3150 Amp at 400KV and shall withstand a dynamic short circuit current of 50KA for 3 second. The temperature rise shall not exceed 35 °C over 50 °C ambient. All the castings shall be free from blowholes, surface blisters, cracks and cavities. All sharp edges shall be blurred, rounded off and buffed. Clamp and connectors shall be designed so as to avoid corona formation. The visual corona extinction voltage shall not exceed 320 KV (rms.). All nuts and bolts shall be suitably shrouded. Radio interference voltage for clamp and connectors shall not exceed 1000 microvolt at 305 KV (rms.) at 1 MHz. No current carrying parts of the Clamps and connector shall be less than 10mm thickness including drilled Holes.

iv) RATING PLATES:

The main coil, the tuning device and the protective device shall be provided with rating plates of weatherproof material fitted so that they are readily visible. .

v) **Line Trap:**

The Line Trap shall be supplied with fitted Tuning Pot and Lightning Arrester. All the type test reports as per relevant IS/IEC of the Line Trap offered shall be invariably enclosed with the offer. Offers without Type Test Report shall not be considered. The Line Trap shall be fitted with top and bottom clamp with Connector etc. complete in all respect for connecting line trap to line side and equipment side respectively. The clamp, connector, nut, bolts, etc. which is affected by magnetic field of line trap shall be of nonmagnetic material. All iron parts shall be hot dip galvanized. The arrangement of minimum three nos. of tie rod assembly shall be required to avoid shearing from thread of tie rod assembly.

13.6 DRAWINGS:

The following drawings indicating all the dimensions etc. with complete technical details shall be enclosed together with technical bid :

(i) General arrangement for Line Trap indicating dimensions, technical parameters, weight etc
(ii) Suspension / mounting arrangement indicating dimensions
(iv) Tuning pot ckt arrangement
(v) Details of terminal clamp/connectors suitable for AAAC/ACSR conductor and quac/twin ACSR Moose conductor
(viii) Suspension fittings (hardware) for line trap
(ix) Disc Insulator with general technical specification
(x) Lightning Arrestor as protective device for Tuning Pot
(xi) Bird barriers
(xii) Other accessories of Line Trap
(xiii) Any other components/drawings not covered

13.7 TECHNICAL SPECIFICATIONS OF LINE MATCHING UNIT/LINE MATCHING DISTRIBUTION UNIT

(LMU/LMDU):

13.7.1 GENERAL REQUIREMENT:

The indoor PLCC equipments are connected to line through co-axial cable – outdoor coupling device – Coupling Capacitors for transmission & reception of carrier frequency signals. Coupling devices are connected in between HF terminal of Coupling Capacitor and indoor PLCC terminals through co-axial cable.

The coupling device proposed to be procured shall perform following functions as a composite unit:

1. Compensate the reactive component of coupling capacitor(s) impedance in order to efficiently transmit the carrier signals with the help of tuning device.
2. It shall match the impedance between power line and coaxial cable end.
3. Two numbers 'phase to earth' type coupling filters shall be used to achieve 'phase to phase'/ ' Inter-circuit coupling'. Connection between secondaries of the two phase to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.
4. Galvanic isolation of primary & secondary terminals of coupling device.
5. It shall drain the power frequency current derived from coupling capacitor(s) to earth.
6. It shall arrest the voltage surges received from power line at the terminal of coupling device.
7. It shall provide direct & efficient earthing to primary terminals of the coupling device. The equipments shall be of latest components, technology and highly reliable. The equipments offered must have been type tested.

13.7.2 SCOPE OF SUPPLY:

Line Matching Unit / Line matching Distribution Unit shall be supplied fully wired complete in all respect with all interconnections and coaxial cable termination facilities with UHF glands. The equipment shall be of latest design with modular construction.

13.7.3 SPECIFICATION:

(a) STANDARDS :

The coupling device offered shall confirm to following standards:

1. IS 8997: Specification for coupling devices for PLC system
2. IEC 481: Coupling devices for power line carrier system
3. IS 8998: Methods for tests for coupling devices for PLC System

(b) CONSTRUCTION:

The coupling device offered shall be fully programmable.

The Unit shall be modular in design and should accommodate tunable modules for different use. The bidder will furnish the details of tunable modules, which can be used along with the device. The composite unit shall be housed in waterproof Fibre Box modular construction cabinet with proper ventilation & vermin proofing arrangement. Proper arrangement for mounting the same on G. I. supporting structure shall be made. The equipments shall work satisfactorily under hot humid & polluted atmospheric conditions. Suitable arrangements shall be provided for the connection of co-axial cables in the coupling device and supply of cable connectors shall be in the scope of supply. Cable glands of good quality suitable for co-axial cables shall be provided.

13.7.4 FEATURES:

1. The coupling device offered shall be suitable for nominal equipment side impedance of 75 ohms unbalanced and 150 ohm balanced as required.
2. The equipment offered shall work satisfactorily for carrier frequency range of 50-500 KHz.
3. The line side impedance shall be 200 Ohms to 400 Ohms for phase to earth couplings and 400 ohms to 600 ohms for phase to phase coupling.
4. The coupling device shall be suitable for use with coupling capacitor of 2200 to 8800 pf and shall be programmable.
5. Insulation withstand voltage shall be 10 kV RMS for one minute.
6. Impulse withstand voltage for high voltage input side to ground shall be 10 kV and co-axial cable input to ground shall be 3 kV.
7. The nominal peak power of the coupling device shall not be less than 1000W.
8. The coupling device shall have inbuilt three element protective device consisting of drainage coil, Lighting Arrestor

and Earthing Switch confirming to relevant standards. The same shall be generally meet the following requirements:

(a) Drainage Coil: The drainage coil shall effectively ground the 50Hz power frequency current received from coupling capacitor(s) but shall not permit HF signal to ground. The power frequency impedance shall be less than 1.5 ohm and continuous current capacity at power frequency shall be 1.5Amp.

(b) Lightning Arrestor: The lighting arrestor shall effectively ground the high voltage surges coming from power line side at the terminal of coupling device. The lighting arrestor shall stand spark over voltage of 3.3 kV.

(a) The Earth Switch: The earthing switch shall ground the primary terminal of coupling device when required. The rated current for earthing switch shall not be less than 150 Amp.

9. The interconnections in the coupling device shall be made with special high frequency Liz wires.

10. The impedance matching shall be prefect so that the return loss is minimum.

13.7.5 TYPE TESTS:

Valid Type Test reports not more than 5-Year-old performed for following tests along with all test result sheets & reference documents shall be submitted with the offer here under.

- Composite Loss
- Return Loss
- Distortion & Intermodulation
- Lightning Impulse Voltage Withstand
- Power frequency Voltage Withstand
- Drain Coil
- Environmental test
- Degree of protection : IP 55
- Earth switch

13.7.6 TECHNICAL PARTICULARS FOR MODULAR COUPLING DEVICE

TABLE-II

Sl No	Description	COUPLIND DEVICE
1	Carrier Frequency Range	78-500 kHz
2	Maximum temperature limit for satisfactory operation of coupling device mounted outdoor	**50^0 C or better**.
3	Composite loss	≤ 1 dB
4	Return loss	≥ 12 dB
5	Nominal line side impedance	240/320 ohms (Phase to earth)
6	Nominal carrier equipment side impedance	75ohms unbalanced and 150 ohm balanced, 75ohms unbalanced and 150 ohm balanced (switchable)
7	Nominal Peak Envelop power with Distortion and Inter-modulation Products 80 dB Down)	1000 watts for frequency≥100 kHz
8	Power frequency Impedance between primary terminal and Earth Terminals of Coupling Device	Less than 20 ohm
9	Maximum number of PLC terminals that can be connected in parallel	
	(a) 20 W (P.E.P) PLC Terminals	(a) 8 to 12 nos.
	(b)40 W (P.E.P.) PLC Terminals	(b) 6 to 8 nos.
	(c) 100 W (P.E.P.) PLC Terminals	(c) 4 to 6 nos.

10	1 Minute Power Frequency Insulation level between Primary and Secondary Terminals of Coupling Device	10 KV rms
11	Impulse (1.2/50 micro-sec) withstand level between Primary and Secondary Terminals of Coupling Device	10 kV peak
12	Drainage Coil :	
13	(a) Inductance	0.2 to 0.7 mH
	(b) Continuous power frequency current	≤ 1.5 Arms
	(c) Short time rating for 0.2 sec	≤ 50 A
14	Lighting Arrestor :	
15	(a) Type of construction	Non linear resistor type with spark gap
	(b) Rated Voltage	660 V
	(c) Rated discharge current	5 KA_{peak}
	(d) Maximum permissible short time current	30 kA peak
	(e) Impulse spark over voltage (max)	3300 V_{peak}
16	Earthing Switch	
	(a) Rated Current	250 $A_{rms,}$ or better
	(b) Rated Voltage	10kV
	(c) Short time current	16 kA, 1 sec

13.8 Technical Specifications Digital Power Line Carrier Equipment

13.8.1 General

Power Line Carrier (PLC) System will primarily be used for tele-protection, voice & data communication. The new Power Line Carrier (PLC) circuits in conjunction with existing OPTICAL communication network shall connect the new SAS networks (IEC61850) of existing and new 132KV/220 KV/400KV substations of AEGCL via GATEWAY as per IEC60870-5-101 and IEC60870-5-104 to the nearest Wideband nodes connected to SLDC, Kahilipara for data communication. Digital PLCC (twin channel, 8kHz bandwidth) equipment shall be procured under this project. DPLC shall be applied in analog mode via FSK channels or in digital mode via the implemented data pump to transmit SAS information. For 400kV Lines, bidder shall quote two PLCC Panels for each line where one panel will be for transmission of Speech + Data and the other panel will be for dedicated carrier inter tripping scheme.

13.8.2 The PLC equipment shall comply with the standard IEC 60495, second edition, 1993.

13.8.3 For safety, the equipment shall conform to IEC 60950-1, 2005.

13.8.4 For EMC and EMI, the equipment shall comply with IEC 61000-6-2(Immunity) and IEC610006-6-4 (Emission). In particular, it shall comply with IEC 60255-5, IEC 61000-4-2/-3/-4/-5/-6/-8/-12/-16/-17/-18, IEC 60255-22-1, EN 55022 / CISPR22.

13.8.5 The system shall be of modular design and allow for easy upgrading.

13.7.6 The PLC equipment shall not use fans or similar for artificial cooling under normal operating conditions.

13.7.7 Carrier frequency section

13.7.7.1 The PLC equipment shall support DPLC (Digital PLC) and APLC (Analog PLC) mode of operation in the same platform, software programmable via PC/Notebook.

13.7.7.2 Modulation shall be SSB (Single-Side-Band) for APLC operation MCM(Multi-Carrier- Modulation) with Trellis Coding for DPLC mode operation.

13.7.7.3 Modulation and coding shall be implemented as software functions in DSP (Digital Signal Processor) technology.

13.7.7.4 Transmission mode shall be 2-wire frequency duplex.
13.7.7.5 The nominal carrier frequency shall be programmable from 40 kHz to 500 kHz minimum, preferably however up to 1000 KHz for nominal band widths ≥ 4 kHz.
13.7.7.6 The carrier frequency stability over the stated temperature operating range shall be equal or better than +/- 1 ppm.
13.7.7.7 The nominal bandwidth BN for transmitting or receiving shall be programmable from 4 kHz to 32 kHz in steps of 4 kHz, and to 2 kHz or 2.5 kHz (for single purpose tele protection).
13.7.7.8 Transmit (Tx) and receive (Rx) bands shall be configurable for adjacent or non- adjacent operation.
13.7.7.9 Transmit output power shall be user-programmable through software up to 100 W or more (Peak Envelop Power) to maintain healthy link for line length of at least 250 km. The output power shall be reducible in steps of 1 dB via user interface program (HMI).
13.7.7.10 The nominal output impedance shall be 75 Ohm unbalanced or 150 Ohm balanced as an option.
13.7.7.11 The return loss in the transmit band shall be ≥ 10 dB, according to IEC 60495.
13.7.7.12 The tapping loss shall be ≤ 10 dB, according to IEC 60495.
13.7.7.13 The receiver selectivity shall be > 65 dB at 300 Hz from the band edges.
13.7.7.14 The AGC range of the receiver shall be 40 dB minimum or better to maintain healthy link for line length of at least 250 km.
13.7.7.15 <u>The supplied PLCC Equipment should be in successful operation for at least 3 years for a line length of Minimum 250 km at 400kV or above voltage level. The bidder shall submit the relevant Performance Certificate from STU/CTU at the time of Bidding.</u>

13.7.8.1 System Operation
13.7.8.1 The PLC shall be programmable via PC with HMI/GUI (Graphical User Interface) based on MS-Windows.
13.7.8.2 The PLC system shall facilitate the programming and monitoring of the remote terminal from the local terminal using the standard GUI/HMI (Human-Machine-Interface).
13.7.8.3 An EMS (Element Management Service) shall be incorporated in the HMI for monitoring and programming of the PLC terminals in the network. The EMS shall allow remote cyclic alarm polling of all the PLC terminals in a network.
13.7.8.4 Supervision of a PLC network shall optionally be possible using SNMP (Simple Network Management Protocol), serving communication network management systems with alarm and equipment information.
13.7.8.5 Remote access to the equipment over IP networks shall make use of the SSL/TLS protocol for secure communication. Equipment internal user authentication and logging of security relevant data shall be supported.
13.7.8.6 Command and alarm events as well as special system events (e.g. equipment reset) shall be stored by an internal event-recorder in a non-volatile memory. At least 1000 command events and another 1'000 alarm/system events shall be recordable. The latest 1000 events of each type must always be available, even in case of a memory overflow.
13.7.8.7 A clock synchronizing input shall be provided, to synchronize the internal real time clock with the external Station GPS signal. The DPC Panel should have interface for sync with the station GPS Clock. Furthermore, the Bidder shall ensure that the remote end stations, to be connected via PLCC Link, have the necessary equipment and interfaces for synchronizing the internal real time clock of DPC panel with the station GPS and shall ensure the same by providing any additional equipment (if required) without any cost implication to AEGCL. The Bidder may carry out the necessary survey for the same before the submission of the BID.
13.7.8.8 Back-up batteries for preserving the data (configuration, event recorder, etc.) during loss of supply are not accepted.
13.7.8.9 The Workstation or PC/Notebook shall be connectable via a serial RS-232 port (converter shall be provided for serial to USB) or via Ethernet/IP port(s). The bidder should provide serial to USB converter for each supplied PLCC Panel as a mandatory accessory.
13.7.8.10 With the Ethernet/IP interface option it shall be possible to access the PLC terminal via LAN intranet.
13.7.8.11 The PLCC/ DPC should be integrated with an external counter for display of any executed inter tripping commands.
13.7.8.12 The PLCC Panel supplied should be equipped with redundant power supply and CPU Card.

13.4.9 Speech and Audio Frequency (AF) signal transmission

13.4.9.1 The PLC shall be configurable for providing up to 3 analog AF (audio-frequency) channels with 4 kHz gross bandwidth each.

13.4.9.2 The useful frequency band shall range from 300 Hz to 3720 Hz for each AF channel.

13.4.9.3 For each channel, a speech low-pass filter shall be configurable with a programmable upper cut-off frequency, ranging from 2 kHz to 3.4 kHz in steps of 200 Hz.

13.4.9.4 Speech interfaces shall be configurable as 4-wire E&M, 2-wire FXO and 2-wire FXS.

13.4.9.5 It shall be possible to configure 3 analog speech channels in 8 kHz or in 12 kHz RF-transmission bandwidth.

13.4.9.6 Inter-channel crosstalk shall be compliant with IEC 60495.

13.4.9.7 A compandor according to ITU-T G.162 shall be configurable via HMI for each speech channel. Control inputs shall be provided for compandor switching (on/off) by the PABX.

13.4.9.8 The frequency band above speech shall be available for the transmission of narrowband modem signals from internal or external modems.

13.4.9.9 The level range of the AF-input/output ports shall be in accordance with IEC 60495.

13.4.9.10 Digital transit filters, programmable with respect to bandwidth and center-frequency in steps of 60 Hz, shall be available for each AF channel for the local extraction, insertion and transit-connection of selected teleoperation frequency bands.

13.4.9.11 An equalizer shall be available for each AF channel for equalizing amplitude response distortions of up to +/- 12 dB.

13.4.9.12 The equalizer shall also be configurable for equalizing group delay distortions of up to 2 ms.

13.4.9.13 The frequency response before and after equalization shall be displayed in graphical form by means of the GUI (HMI).

13.4.9.14 Equalization of the channel frequency response in both directions shall be possible from one (either) end.

13.4.9.15 Integrated Digital Compressed Voice shall be available as an option. Up to 16 digital compressed speech channels shall be supported per PLC link.

13.4.9.16 The data rate required for one compressed speech channel shall be less than 7 kbit/s.

13.4.9.17 In a substation, selected compressed voice channels shall be through connectable on a digital basis to other PLC terminals/links.

13.4.10 Narrowband Data Transmission

13.4.10.1 The PLC shall provide - as software options – up to four integrated modems for narrowband data transmission.

13.4.10.2 Transmission speed, channel center-frequencies and the spectral bandwidth shall be programmable in steps for commonly used data rates, ranging from 100 bit/s to 9600 bit/s in bandwidth of 240 Hz to 3400 Hz respectively.

13.4.10.3 The narrowband modems shall be designed for low delay and short recovery times following a link disturbance.

13.4.10.4 Adaptive equalizers, individually configurable for each narrowband modem, shall ensure optimum performance over time, by compensating changing channel characteristics. In a 4 kHz channel, it shall be possible to transmit up to 4 x 2400 bit/s, or 2 x 4800 bit/s, or 1 x 9600 bit/s.

13.4.10.5 Data transmission above 2 kHz band-limited speech shall be possible at 2 x 2'400 bit/s or 1 x 4'800 bit/s.

13.4.11.0 Broadband Data Transmission

13.4.11.1 The PLC shall provide – as software option – an integrated modem for broadband / high speed data transmission. Transmission speed and spectral bandwidth shall be programmable via PC/Notebook.

13.4.11.2 The speed and transmission bandwidth shall be programmable for up to 32 kbit/s in 4 kHz spectral bandwidth, up to 128 kbit/s in 16 kHz bandwidth and up to 256 kbit/s in 32 kHz bandwidth.

13.4.11.3 The data rates shall be selectable in steps, compliant with commonly used standardized data rates.

13.4.11.4 The system shall support automatic transmission speed adaptation in five user-defined steps, self-adapting to the prevailing line condition (noise and interference).

13.4.11.5 The broadband modem shall provide a facility for automatic detection and suppression of narrowband interferers.

13.4.11.6 Special operating modes shall allow transferring analog speech (with an upper cut-off frequency of 2 kHz) and a

broadband modem (operated in the frequency band above 2 kHz) in channels with nominal bandwidth BN of 4 kHz and 8 kHz. The data rate of the broadband modem using the remaining 2 kHz bandwidth shall be at least 9.6 kbit/s, the data rate of the broadband modem using the remaining 6 kHz bandwidth shall be up to 48 kbit/s.

13.4.12.0 Data Multiplexing

13.4.12.1 The PLC equipment shall provide an internal multiplexer for the time-division multiplexing of up to 6 serial data channels and/or Ethernet/IP traffic.

13.4.12.2 Data ports shall be compliant with V.24/V.28, RS-232 and/or V.11/X.21/X.24.

13.4.12.3 The internal multiplexer shall provide data flow control for the asynchronous ports and speed adaptation for the synchronous ports according to the prevailing aggregate data rate and HV power line condition.

13.4.12.4 All data ports shall be electrically isolated from ground and against each other.

13.4.12.5 Point-point and point-multipoint operation with channel-sharing shall be possible, for polling SCADA protocols.

13.4.12.6 Three Ethernet/IP ports - electrical 10/100 Mbit/s, auto sensing - shall be available as an option. Preferably, a fourth port with exchangeable SFP transceivers for optical connection shall be provided.

13.4.12.7 The Ethernet/IP ports can be used for equipment programming & monitoring and/or for Ethernet/IP traffic switching/routing via the PLC link. No external device(s) shall be required for the latter purpose.

13.4.12.8 IP header compression shall be configurable in order to minimize bandwidth.

13.4.12.9 In switching mode, VLAN support shall be configurable (ID & priority). In routing mode, ≥ 10 IP routes and port-based priority shall be configurable.

13.4.12.10 The bandwidth of the Ethernet/IP service via the PLC link shall follow the automatic speed adaptation of the broadband modem.

13.4.12.11 SALIENT FEATURES OF DIGITAL PLCC

The salient features for the Digital PLCC are detailed out as follows

A. HIGH FREQUENCY CHARACTERISTICS

1. Frequency Range	40-500 KHz as per IEC 60495
2. Center Frequency Programmable	In steps of 1 Hz
3. Nominal Impedance	75 ohm unbalanced (150 ohm balanced as an option)
4. Return Loss in the transmitted band	≥10 dB according to IEC 60495
5. Tapping loss	≤ 1.5 dB according to IEC 60495
6. Image rejection	≥75 dB

B. TRANSMITER / RECEIVER

1. Nominal transmit output power (PEP)	upto 100W or better
2. Nominal Bandwidth	4- 32 kHz (each direction)
2. Output Level Adjustment	In steps of 1 dB (via user interface program (HMI))
3. Receiver Sensitivity	-30 dBm
4. Receiver Selectivity	As per IEC-60495
5. AGC Range (Automatic Gain Control)	40 dB dynamic range or better
6. Minimum Signal to Noise Ratio	20dB(QAM16/TCM32)/24dB(QAM64/TCM128)

C.GENERAL CHARACTERISTICS

1. Application	Universally applicable in analog, digital, or mixed operation.
2. Modulation	Single Side Band with Suppressed carrier SSB) Multi-Carrier (OFDM) modulation with Trellis Coding and forward error correction. Single step frequency conversion with Direct Digital Synthesis (DDS).
3. Gross Bit rate	32 kbps in 4 kHz, 128 kbps in 16 kHz up to 256 kbps in 32 kHz bandwidth
4. Test Facilities	Inbuilt accessible via HMI

5. Standards compliance	IEC 60495, IEC 60834-1, IEC 60950-1, IEC 61000-6-2, IEC 61000-6-4

D. USER INTERFACES

1. Data Interfaces and bit rates supported	RS- 232 (up to 19.2 kbps)/V.24 Ethernet, V.11
2. Voice interfaces supported	2W/4W E&M, FXO and FXS, Hotline
3. Speech level adjustment	Transmit level (-20 to + 5 dBm) Receive level (-20 to + 8 dbm)

E. OTHER CHARACTERISTICS

1. Alarms	Supported on panel
2. Operating Temperature and humidity	0 to +45 deg C, 90% humidity
3. Power supply voltage	48 VDC +20/- 15%
4. Maximum power consumption	135 W or better for normal operation @ 75 Ohm

13.5.0 TECHNICAL SPECIFICATION OF TELE-PROTECTION COUPLER

13.5.1 The Digital protection signalling equipment is required to transfer the trip commands from one end of the line to the other end in the shortest possible time with adequate security and dependability. It shall also monitor the healthiness of the link from one end to the other and give alarms in case of any abnormality. The protection signalling equipment shall have a proven operating record in similar application over EHV systems and shall operate on 48V DC (+15%, -10%).

It shall provide suitable interfaces for protective relays, which operate at 220/110V DC. Power supply points shall be immune to electromagnetic interface.

13.5.2 Principle Of Operation

During normal operation, protection signalling equipment shall transmit a guard signal/code. In case Protection signalling equipment is actuated by protective relays for transmission of commands, it shall interrupt the guard signal/code and shall transmit the command code to the remote end. The receiver shall recognize the command code and absence of the guard code and will generate the command to the protective relays.

All signal processing i.e. generation of tripping signal and the evaluation of the signals being received shall be performed completely digital using Digital Signal Processing techniques.

13.5.3 Loop Testing

An automatic loop testing routine shall check the tele protection channel.

It shall also be possible to initiate a loop test manually at any station by pressing a button on the front of the equipment.

Internal test routine shall continuously monitor the availability of the protection signalling equipment.

Proper tripping signal shall always take the priority over the test procedure.

The high-speed digital protection signalling equipment shall be designed and provided with following features.

- Shall work in Digital PLCC Terminal.
- Full Duplex operation
- Auto loop facility shall be provided
- Shall be able to transmit upto 4 commands with trip counter

Bidder shall quote for protection signalling equipment suitable for 4 commands with separate trip counters for transmit and receive. Laptop shall be provided for configuration of PLCC/DPC.

High security and dependability shall be ensured by the manufacturer. Probability of false tripping and failure to trip shall be minimum. Statistical curves/figures indicating above mentioned measures shall be submitted along with the bid.

The DPC shall be housed in offered PLCC panel and should be a standalone type.

Reports of the following tests shall be submitted for approval for protection signalling equipment and relays associated with the protection signalling equipment and interface unit with protective relay units, if any.

i) **General equipment interface tests :**

a. Insulated voltage withstand tests
b. Damped oscillatory waves disturbance test
c. Fast transient bursts disturbance test
d. Electrostatic discharge disturbance test

e. Radiated electromagnetic field test
f. RF disturbance emission test

ii) **Specific power supply tests**
a) Power supply variations
b) Interruptions
c) LF disturbance emission
d) Reverse polarity

iii) **Tele-protection system performance tests**
a) Security
b) Dependability
c) Jitter
d) Recovery time
e) Transmission time
f) Alarm functions
g) Temperature and Humidity tests (As per IEC 68-2)
a. Dry heat test (50°C for 8 hours)
b. Low temperature test (-5°C for 8 hours)
c. Damp heat test (40°C/95%RH for 8 hours)

All the above tests at i, ii & iii (except temperature & humidity tests) shall be as per IEC 60834-1 and the **standards mentioned therein.**

iv) Relays
a) Impulse voltage withstand test as per IEC 60255.
b) High frequency disturbance test as per IEC 60255.

13.5.4 The bidder shall offer voice frequency transmission equipment, which shall work on frequency shift or coded signal principle for transmission/ reception of protection signals.

13.5.5 The teleprotection shall conform to IEC 60834-1, 1999.

13.5.6 Each teleprotection system shall support the transmission of up to four independent and simultaneous commands, programmable individually for blocking, permissive tripping or direct tripping (intertripping).

13.5.7 The transmission of the command signals shall be accomplished within the speech bandwidth or within the spectral bandwidth of the broadband modem, i.e. the teleprotection shall not require the allocation of extra / separate bandwidth.

13.5.8 During transmission of protection commands, other services like speech and data shall be temporarily interrupted in order to transmit the protection signal at increased power (command signal boosting).

13.5.9 The nominal transmission time shall be < 11 ms, < 12 ms and < 13 ms for blocking, permissive tripping and direct tripping respectively.

13.5.10 The equipment for protection shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. The required SNR shall be less or equal than 6 dB for a dependability of < 1E-03 for blocking and permissive tripping, and for a dependability of < 1E-04 for direct tripping, i.e. the probability of missing a command in a maximum actual transmission time Ttr = 15 ms, 17 ms and 22 ms respectively.

13.5.11 The probability of an unwanted command (security) shall for any SNR condition (worst case) be not higher than 1E-03, 1E-06 and 1E-09 for blocking, permissive tripping and direct tripping respectively.

13.5.12 Electrically isolated opto-coupler inputs, solid-state outputs shall be available as I/O interfaces to the protection devices. Voltage range shall be selectable from 24 VDC to 250 VDC nominal.

13.5.13 Commands shall be freely allocatable to the inputs and the outputs, alarms shall be freely allocatable to the outputs (programmable via HMI).

13.5.14 It shall be possible to individually delay and prolongate the input command signals or to prolongate the output command signals and to monitor their duration (all parameters configurable via HMI).

13.5.15 All transmitted and received commands shall be logged with time stamps of 1 ms resolution by the internal event-recorder.

13.5.16 The teleprotection shall provide an integrated cyclic loop test.

13.5.17 The teleprotection shall be software-programmable via PC HMI with GUI.

13.5.18 For single-purpose teleprotection applications, the nominal transmission bandwidth of the PLC terminal shall be configurable for 2 kHz or 2.5 kHz in each direction. A service phone channel shall optionally be available in this operating mode.

13.5.19 The DPC should have E1 interface so that two channels can be created for transmission of commands, out of which one channel will be through PLCC and the other channel through FOTE. The channel arrangement should be such that if the main channel fails, the DPC should automatically switch to the other channel.

13.5.20 The offered DPC shall be equipped with redundant Power Supply Card and redundant 4 command Relay Interfacing card.

13.5.21: The DPC shall be IEC 61850 compliant Digital Tele- Protection Coupler, have 16 commands with redundant power supply card and CPU along with Analog PLCC Interface Card, E1 interface card and optical interface card to support 150 km for 132kV and 220kV and 240km for 400Kv

13.5.22 PRINCIPAL TECHNICAL REQUIREMENTS OF TELE PROTECTION COUPLER

TABLE-III

Application	Transmission of protection commands for line and objects protection via DPLC equipment.		
Number of units	Two No, 8 commands (atleast) module to be fitted in offered DPC (Standalone)		
Number of commands	16 simultaneous commands per system, simultaneously transmitted. Individually configurable for blocking, permissive or direct tripping. Single purpose teleprotection in the 2 kHz APLC chalnnel: 3 independent commands (as above) and 1 prioritised command (for direct tripping).		
Secure against	Noise (continuous or impulsive), speech and sweep tones, DTMF (CCITT 48430 or ITU-T Q.23) in-band signalling		
Bandwidth requirement	Nil; command signal transmission in-band (alternate purpose with signal boosting)		
Processing of received signal	Adaptive (to prevailing channel condition, always ensuring shortest transmission time)		
Guard signal	Pilot signal or own guard signal in speech band		
Number and type of inputs Method of tripping Voltage ranges	16 optocoupler per tele protection interface Contact and battery, or dry contact 24 to 250 V DC, selectable in 4 ranges.		
Number and type of outputs Tripping voltage Tripping current	16 solid state relays contacts per tele protection interface. 5 to 250 V DC ≤ 1 A carry / 2 A peak solid state 5 A carry / 20 A peak mechanical relay		
HMI configurable	Command and alarm assignment to I/O ports, Command pick-up times, hold times, duration monitoring State of command outputs during link alarm Alarm and unblocking level thresholds		
Test facilities	Manual or periodic loop test every 1,3,6,12,24 hours.		
Event recording	Time-stamped command events, command counters, stored in non-volatile memory. GPS Clock synchronizing input should be available		
Teleprotection performance	Blocking	Permissive tripping	Direct tripping

Overall time for PLC, VFT and transmission path	<20 ms	<20 ms	< 30 ms
Operating time lower than the specified maybe preferred provided they fulfil the requirements of security and reliability as mentioned: False Trip Probability (Noise burst of any amplitude) : 10^{-5} or better Fail to trip probability for S/N 6 dB in 3.1kHz Band (white Noise Measurement) : 10^{-2} or better			

13.6.0 TECHNICAL SPECIFICATION 48V PLCC BATTERY BANK

13.6.1. TYPE AND RATING

i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lightning, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC 896, Part 2 / ANSI T1.330.

ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 200 AH.

iii) The nominal voltage of the battery bank shall be 48 Volts D.C.

iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

13.6.2 PLATES

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in ,float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble-free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

13.6.3. CONTAINER AND LID

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable lo deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

13.6.4 VENT PLUGS

Each cell shall be equipped with one-way safety valve with opening pressure of 5±1 psi and closing pressure 4±1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

13.6.5. SEPARATORS

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

13.6.6 CONNECTORS

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heal shrinkable sleeves except at the connecting points.

13.6.7. ELECTROLYTE

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

13.6.8 WATER

Water required for preparation of electrolyte shall conform to IS: I069.

13.6.9. PLATE CONNECTION

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be caste with lead alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

13.6.10 BOLTS AND NUTS

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

13.6.11 TERMINALS

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed.

13.6.12. BATTERY RACKS

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

13.6.13 CAPACITY REQUIREMENTS:

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27°C) shall also not be less that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX hours of discharge: 1.92V/cell

(b) After EIGHT hours of discharge: 1.85V/cell

(c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

13.6.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

a) Best quality metallic stand/frame as per Clause 9.12.

b) Stand insulators +5% extra

c) Inter row connectors :Appropriate quantity

d) Inter tier connectors

e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No

f) Torque wrench/ Spanners : 1 No

g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)

h) Cable clamps with hardware

i) Cell numbering tags with fixing arrangement

j) Two sets of special tools and tackles for connecting terminals of the battery

k) Any other accessories not specified but required for satisfactory operation.

13.6.15 TYPE TEST OF BATTERY:

The Bidder/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the range of at least one capacity per design. The Bidder/ Supplier shall submit necessary evidences enclosed along with tender documents.

Sl No	**DESCRIPTION**
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification

8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge for reliable mains power
14	Recharge behavior
15	Service Life at an operating temperature of 40°C for brief duration exposure time
16	Impact of Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installati

13.6.16 Routine Test:

(i) Physical Examination Test

(ii) Visual Inspection

(iii) Dimensions, Mass & Layout

(iv) Marking & Packing

13.6.17 ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking

(ii) Verification of Dimensions

(iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank

(iv) Test of AH Capacity

13.6.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sr. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

13.7.0 48V BATTERY CHARGER

13.7.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

13.7.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

13.7.3 Power System Configuration: The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

Sl No	Basic SMR Module	Configuration	Permissible Ultimate Capacity
1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp

4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where 'n' is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.

AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement.

13.7.3.1. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

13.7.3.2: The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.

13.7.3.3: The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

13.7.4 Rack Configuration :

Rack is composed of following units accommodated in sub racks

a) Dual Float Rectifier cum Boost Charger (FR-BC) Modules

b) Distribution-Switching-Control-Alarm Arrangement (DSCA)

c) The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser's requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

13.7.5 Parts & Components

13.7.5.1 The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

13.7.5.2 Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

13.7.5.3 Component mounting and fixing methods shall be secured.

13.7.6. Wiring:

13.7.6.1 All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

13.7.6.2 All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

13.7.7 Bus Bars:

13.7.7.1 Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm2 but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

13.7.7.2 Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

13.7.7.3 Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided.

13.7.8 The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0ºC to 55ºC.

13.7.9 Insulation Resistance and Voltage Proof

13.7.9.1 The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

a) AC input and Earth - Greater than 2 Mega Ohm

b) DC Output and Earth - Greater than 1 Mega Ohm

c) AC input and DC output - Greater than 5 Mega Ohm.

13.7.10 Lightning Protection :

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

13.7.11 Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

13.7.12 Name plate :

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain followinginformation.

1. Specification Number
2. Type of Unit
3. Manufacturer's name and identification
4. Model No.
5. Unit Serial No.
6. Input Voltage and phase
7. Output Voltage and current
8. Year of manufacture
9. Suitable for battery capacity

13.7.13 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation,incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

13.7.14 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of ±5V may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

13.7.15 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of ±10% of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

13.7.16 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

13.7.17 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

13.7.18. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

13.7.19 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

13.7.20 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

13.7.21 PARTICULARS FOR 48 VDC

Type FLOAT CUM BOOST CHARGER

Hot swappable rectifier modules 25A/48V, N+1 configuration.

TABLE-IV (a)

SL NO	DESCRIPTION	PARAMETERS
1	RATING	48 V (Capacity shall be as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery).
	AC INPUTS	
2	VOLTAGE	415 V AC+ 10% (230V AC +10%)
3	PHASE	3 phase, 3 wire (single phase)
4	FREQUENCY	50 Hz+5% (50Hz+2Hz)
5	POWER FACTOR	(Better than 0.7 lagging)
	DC OUTPUT	
6	FLOAT VOLTAGE	48 V- 54 V DC
7	BOOST VOLTAGE	48 V-55.2 V DC
8	OUTPUT CURRENT	35A
9	VOLTAGE REGULATION	Better than + 1% of set value
10	RIPPLE	Less than 1% r m s
11	EFFICIENCY	(Better than 90%)
12	SYSTEM OUTPUT VOLTAGE	55.2V DC+1%(at load terminal)

METERS: The microprocessor-based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.

TABLE-IV (b)

PROTECTION			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor fuse	Fast acting semiconductor fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at battery input	:	Protected	Protected
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required
INDICATION			
AC input ON	:	Required	

DC output ON	:	Required
Float ON	:	Required
Boost ON	:	Required

AC under voltage	:	Required
AC over voltage	:	Required
DC over load	:	Required
DC over voltage	:	Required
Short circuit	:	Required
Reverse polarity	:	Required
Mains fail		Required
Charger fuse fail		Required
Battery over voltage		Required

TABLE-IV (c)

CONTROLS AND SWITCHES	
AC input MCCB	ON/OFF switch at input
DC output MCCB	Three-way switch to select auto / manual float / manual boost operation
Auto/manual float/boost mode selector switch	Two-way switch to read charger output current or battery charge / discharge current
Auto /manual voltage regulator selector switch	Single tern potentiometer for float voltage adjust
Float and boost voltage variable potentiometer	Single tern potentiometer for boost voltage adjust
Manual voltage adjust variable potentiometer	Single tern potentiometer for charger total current adjust
Battery current adjust potentiometer	Single tern potentiometer for battery current adjust
Heaters power supply switch	
Socket power supply switch	
ADDTIONAL FEATURES	
Soft start on DC side	Auto float / boost operation

13.8.0. TECHNICAL SPECIFICATION OF PAX SYSTEM

13.8.1. The offered exchange shall be the latest state of-art digital 32-bit microprocessor based suitable for direct connection to PLCC terminals, Optic Fibre, Digital Microwave, VSAT, etc, without the need for any four wire interconnection device. The design shall employ stored program technique and utilizes the principles of Time Division Multiplexing / PCM technology.

13.8.2 The offered EPAX directly interface with the Power Line Carrier Communication terminals with E & M signalling. The EPAX shall also support the CO trunk. The software of the EPAX should support both the E & M and CO trunks and should have the facility to be interconnected to P & T trunks for CO Access.

13.8.3 The EPAX should support single, two- or three-digit numbering scheme. The exchange should support a minimum of 16 out pulsing digits and a maximum of 20 out pulsing digits at time from a normal telephone. The exchange

should be fully Non-blocking.

13.8.4 The duplication of both CPU and PSU is to be provided as in-built features in the offered exchange.

13.8.5 The EPAX should support a maximum configuration of 250 Ports. The EPAX shall have universal ports wherein any type of line card or trunk card of the EPAX can be inserted into any slots. Also, the number of trunks can be either E & M or CO or a combination of both. The offered exchange shall work purely as a PLCC switch or a combination of PLCC & CO or a network switch or a combination of PLCC, CO, Fibre and digital microwave.

13.8.6 The offered switch shall have an integrated E1 type card wherein a direct 2 MB stream can be connected to the switch.

13.8.7 The switch shall have ISDN compatibility for interfacing with PSTN and other public ISDN exchanges. A valid TEC certification for ISDN compatibility to be enclosed without the same the bid is liable for rejection.

13.8.8 The switch shall be equipped with voice guidance feature to navigate the subscriber in using the major features of the exchange. Data transmission through MODEM pooling shall be available in the exchange. The EPAX shall support exclusive Load Despatch Express type communication network with all to one and one to All type of trunk access. This feature shall be in addition to the normal All to All type. The exchange offered needs to be type tested for EMC specifications in line with IEC recommendations 495 for PLCC equipment. A valid certification for EMC compliance from any government laboratory within three years as on date of bid opening needs to be enclosed with the bid. The EPAX must have been EMI / EMC tested for the following as per IEC 495 to suit the stringent conditions in the Sub-station environment.

a. Impulse Voltage withstand test (IEC 255-4).

b. High Frequency disturbance susceptibility test (IEC 255-22-1).

c. Electrical Fast Transient Susceptibility Test (IEC 801-4).

d. Electrostatic discharge susceptibility test (IEC 801-2). Radiated susceptibility (IEC 801-3).

13.8.9. The Bidders shall offer suitable telephone equipment for automatic dialling which must work in full cordination with the already provided telephone equipment in the existing PLC system.

13.8.10 The bidder shall offer the latest state-of-art digital based Microprocessor EPAX suitable for direct connection to the PLCC terminals without the need of any four wire-interconnecting device (EFGS/EMFGS). The EPAX shall employ stored programme technique and utilize Time Division Multiplexing.

13.8.11. The EPAX shall be suitable for internal communication between the local subscribers as well as for selective communication over tie lines.

The special features of the offered EPAX shall be as follows:

i) EPAX is of latest microprocessor-based design, which employs Pulse Code Modulation/Time Division Multiplexing principle.

The following are the advantages over space division/reed relay switching:

a) Fully solid-state circuitry and hence high reliability in operation.
b) Fast response
c) Low operation and maintenance cost
d) High traffic handling capacity - Fully Non-blocking type
e) Compact size
f) Noise free operation

ii) Self checking diagnostics facility as a built-in feature of the EPAX. In view of this, the maintenance of the EPAX is extremely simple.

iii) The design of the software structure should be very flexible. Using any standard telephone instrument, the following programming shall be done at site:

- Modification of local subscriber number
- Modification of subscriber priority
- Modification of subscriber facilities like Access to Tie lines and Follow Me
- Modification of Tie line number
- Modification of Tie line groups
- Modification of Exchange number
- Allocation of Alternate route

- Transit call barring

The above programming facility at site should not require any additional test equipment.

iv) Built-in main distribution frame with Protective Devices such as surge arresters and fuses for all limbs of subscriber lines and tie lines to protect the sophisticated electronic circuitry of the exchange from damage due to external surges/spikes.

v) The EPAX is suitable for easy expansion if required at a later date.

As per your requirement, supply of EPAXs equipped with 16,32,64 subscriber lines and 8,16,32 tie lines (PLCC directions). The ultimate capacity of the EPAX shall be 250 ports for flexible usage of either the subscriber lines or trunk lines.

13.8.13. The line interface circuit module shall serve as an interface between the subscriber line and the exchange whereas the trunk interface circuit module shall serve as an interface between the tie line and the exchange. However, the EPAX shall be possible to expand either the number of subscriber lines or tie lines if required, at a later date, in view of the modular construction adopted. The EPAX shall have a 32-bit microprocessor and programmable at site. The software shall support both E&M signalling and CO trunks. The EPAX shall be provided with universal ports wherein the Subscriber line card and CO trunk card can be inserted into any slots. . If the ultimate capacity of the trunks has been used and on a later date the board intends to increase the trunk capacity the same can be done by decreasing the subscriber lines and thereby increasing the trunks. Vice versa for subscriber lines if the ultimate capacity is reached by reducing the trunks the subscriber lines can be increased.

13.8.14 The duplication of both the CPU and PSU is to be provided as an in-built feature in the offered EPAX. The EPAX shall support the digital telephone with display on a single pair of cable. The offered EPAX shall be provided with a voice guidance card, which helps the subscriber in using, the all the features of the exchange viz. call back etc. The EPAX shall be fully automatic and should function without the help of an operator. The details of site programming facility shall be provided in detail.

13.8.15. The EPAX shall have the following facilities:

a) Follow me

b) Priority interrupt/Conference

c) Automatic alternate route selection

d) Ring when free

e) Line Lock out

f) Either party release

g) Real time clock

h) Audible and visual alarm on all fault conditions.

13.8.16. The EPAX shall be self-contained and provide its own ringing current and tones.

13.8.17. Visual display with LED's shall be available on each line and trunk card to display call status. Visual and audible alarms shall be provided on all fault conditions based on the self-diagnostic routines.

13.8.18. The EPAX is to be housed in dust proof steel cabinet.

13.8.19. The EPAX works on 48V DC +15% -10% supply. The loop resistance for subscriber lines is 1000 ohm maximum and for Tie lines 1500 ohm maximum.

13.8.20. The offered EPAX shall support the system software to work as an exclusive PLCC exchange or a combination of PLCC and CO trunks or as a network exchange on E&M. It is very important to note that these three combinations shall be available on the system software so that the purchaser can switch to the exact application at the time of commissioning. The offered EPAX shall work in conjunction with the existing EPAXs of other makes in the grid.

13.8.21. The offered EPAX shall have ISDN compatibility for the CO trunks. The system software shall be posted on flash memory as per the latest International standards for fast and reliable operations. The EPAX shall also support a minimum dialling of 16 digits at a time and a maximum of 20 digits. The EPAX shall have compatibility with E1 trunks for expansion in later stage. It should have the software in-built for through connectivity from E1 trunk to PLCC trunks.

13.8.22. The EPAX should be provided with universal ports for peripheral cards so that any combination of subscribers and trunks can be selected by the user by inserting suitable interface cards.

13.8.23. The EPAX must have been EMI/ EMC tested for the following as per IEC 495 to suit the stringent conditions in the Sub-station environment.

1.Impulse Voltage withstand test. (IEC 255-4)
2. High Frequency disturbance susceptibility test (IEC 255-22-1)
3.Electrical Fast Transient Susceptibility Test (IEC 801-4)
4.Electrostatic discharge susceptibility test (IEC 801-2)
5.Radiated susceptibility. (IEC 801-3).

13.9.0 TECHNICAL SPECIFICATION OF HIGH FREQUENCY COAXIAL CABLE

13.9.1 The high frequency coaxial cable shall be required to connect the line matching unit / line matching distribution unit installed in the switchyard of the substation to the carrier equipment installed in the carrier rooms.

13.9.2. The high frequency cable to be offered by the bidders shall be suitable for being laid directly to the ground or in trench or ducts.

13.9.3. The cable shall be PVC sheathed and steel armoured. The capacitance of the cable shall be low so as to minimise attenuation of the signal within carrier frequency range. The impedance of the cable shall be so as to match the output impedance of the PLC terminals and secondary impedance of the coupling units. The cable shall be installed to withstand a test voltage of 4 KV.

13.9.4 Bidders shall specify attenuation per Km. of high frequency coaxial cable at various frequencies in the range of 80 to 450 KHz.

13.9.5. High frequency cable shall be supplied on drums containing lengths of minimum 500 metres.

TABLE-V

Sl No	Description	Particulars
1	COAXIAL CABLE	1/1.22mm HF Coaxial Cable having annealed plain tinned copper wire centre conductor, Semi-Air spaced dielectric of composite helical thread of polythene in a polythene tube and annealed plain tinned copper wire braided, Melinex tapped, extruded, special PVC sheathed, black steel wire Braid armoured and characteristic impedance of 75 ohms.
2	Centre Conductor	Tinned copper wire of 1.22 mm dia.
3	Cable Core and Air	Centre Conductor wrapped with Spaced Centre Conductor wrapped with Spaced Radial thickness:1.00 mm. Diameter over Pe tube: 5.20 mm.
4	Outer conductor	Braid of tinned copper (Electrolytic grade/wire of 0.20mm dia with 90% coverage.
5	Barrier	PVC/MYLAR Tape.
6	Inner Jacket	Special cable grade PVC Radial thickness 0.70 mm.
7	Bedding	PVC Tape.
8	Armouring	0.4mm GI wire, 70% coverage.
9	Overall jacket	PVC.
10	Electrical data:	
11	Max Conductor resistance @ 20%	15.7 Ohms/KM
12	Dielectric strength(Core to shield)	4KV RMS for 1 minute
13	Nominal impedance	75 ohm
14	Nominal capacitance at 1Khz	53 pf/meter
15	Mx. Attenuator frequency (KHZ)	(KHZ) db/km 10 0.80 60 1.40 300 3.30 500 4.70
16	Min.Bending radius	15 Cm

SECTION-14
SPECIFICATIONS FOR COMMUNICATION EQUIPMENT FOR ESTABLISHMENT OF FIBRE OPTIC COMMUNICATION SYSTEM

14.0 Introduction, General Information and General Requirement

This Chapter describes the technical specifications for Communication Equipment for Establishment of Fibre Optic Communication System under the contract. This specification describes the functional and performance requirements of the system.

14.1 Scope and General Requirements

The broad scope of the procurement of this part include the survey, planning, co-ordination with other suppliers' equipment, design, engineering, supply, transportation, insurance, delivery at site, unloading, handling, storage, installation, termination, testing, training, and demonstration for acceptance, commissioning and documentation for

(i) SDH Equipment along with suitable optical line interfaces & tributary cards.
(ii) Integration with existing NMS at SLDC.
(iii) All cabling, wiring, Digital Distribution Frame patch facilities and interconnections to the supplied equipment at the defined interfaces.
(iv) System integration of the supplied subsystems and also integration with existing communication equipment such as SDH
(v) Integration of supplied system with the User equipment such as RTUs, SCADA system SAS etc.
(vi) Maintenance of the supplied system
(vii) Integration/Interfacing with PLCC/DPC

All other associated works/items described in the technical specifications for a viable and fully functional communication network.

The network shall comprise multi input and multi output fibre optic equipment complete for speech communication in dialling mode and or through express telephone, data communication, fibre optic based power system protection, suitable for multi point to multi point fibre optic network. The terminal optical communication equipment shall be installed in the Sub Stations to be constructed under this Package (only for 400kV Voltage Level.

The responsibility of connecting the optical terminal equipments with the FODP of the respective substation shall rest with this contract. Also, the connection of OLTE with FODP is within the scope of this contract..

14.2General Requirements

14.2.1 It should be noted that preliminary design information and bill of quantity (BOQ) specified in this specifications are indicative only. The Contractor shall verify the design data during the site surveys & detail engineering and finalise the BOQ as required for ultimate design & system performance.

14.2.2 The Tenderer's proposal shall address all functional and performance requirements within this specification and shall include sufficient information and supporting documentation in order to determine compliance with this specification without further necessity for inquiries.

14.2.3 An analysis of the functional and performance requirements of this specification and/or site surveys, design, and engineering may lead the Contractor to conclude that additional items are required that are not specifically mentioned in this specification. The Contractor shall be responsible for providing at no added cost to the Employer, all such additional items and services such that a viable and fully functional communication equipment system is implemented that meets or exceeds the capacity, and performance requirements

specified. Such materials and services shall be considered to be within the scope of the contract. To the extent possible, the Tenderers shall identify and include all such additional items and services in their proposal.

14.2.4 All telecom equipment provided shall be designed to interface with existing telecom equipment and shall be capable of supporting all present requirements and spare capacity requirement identified in this specification.

14.2.5 The communication equipment shall be designed and provisioned for expansions and reconfigurations without impairing normal operation, including adding and removing circuits. The offered items shall be designed to operate in varying environments. Adequate measures shall be taken to provide protection against rodents, contaminants, pollutants, water & moisture, lightning & short circuit, vibration and electro-magnetic interference etc.

14.2.6 The Tenderer is supposed to make necessary survey for integration of the SDH Equipment with the existing NMS at SLDC, Kahilipara. For this if any traffic routing to SLDC is required through other Utilities; AEGCL will arrange the same. However, during interfacing with the existing telecom equipment if any hardware/software is required (at SLDC or Remote end), the Bidder has to offer the same with no cost implication to AEGCL.

14.2.7 The Tenderers are advised to visit sites (at their own expense), prior to the submission of a proposal, and make surveys and assessments as deemed necessary for proposal submission. The successful tenderer (Contractor) is required to visit all sites. The site visits after contract award shall include all necessary surveys to allow the contractor to perform the design and implementation functions. The Contractor shall inform their site survey schedule to the Employer well in advance. The site survey schedule shall be finalised in consultation with the Employer. The Employer may be associated with the Contractor during their site survey activities. After the site survey, the Contractor shall submit to the Employer a survey report on each link and site. This report shall include at least the following items:

(a) Proposed layout of Equipment in the existing rooms and buildings.
(b) Proposed routing of power, earthing, signal cables and patch cords etc.
(c) Confirmation of adequacy of Space and AC/DC Power supply requirements
(d) Proposals for new rooms/buildings if required
(e) Identification of facility modifications if required
(f) Identify all additional items required for integration for each site/location.

14.2.8 Synchronization of the Communication Network

The Contractor shall be responsible for synchronization of new communication equipment with existing network utilizing the existing GPS clock. The Contractor shall make an assessment of additional clock requirement for synchronization of the communication equipment.

14.3 General Responsibilities and Obligations

This section describes the general responsibilities and obligations of the Contractor and the Employer.

14.3.1 Responsibilities for the Implementation Plan

The Tenderer's technical proposal shall include a project implementation plan and schedule that is consistent with the implementation plan detailed in this specification. The implementation plan shall be modelled such that it provides fibre optic cabling system support for the activation of this Project. The Implementation plan shall include the activities of both the Contractor and the Employer, showing all key milestones and clearly identifying the nature of all information and project support expected from the Employer. The Employer and Contractor

shall finalise the detailed Implementation plan following award of the contract.

14.3.2 Contractor's Responsibilities and Obligations

The Contractor shall be responsible for all cables and wiring associated with the equipment provided, both inside and outside buildings in accordance with technical specifications. The Contractor shall also be responsible for determining the adequacy of the local power source for the equipment and for wiring to it, with adequate circuit protective breakers. In addition, the Contractor shall be responsible for shielding equipment and cabling to eliminate potential interference to or from the equipment, and for earthing all cabinets and shields.

Contractor's obligations include, but are not limited to, the following:

(1) Site visits, and surveys, necessary to identify and provide all equipment needed to implementation the network.
(2) Equipment Engineering and design specific to each location including review of, and conformance with local environmental and earthing considerations.
(3) Overall integration of communication equipments/subsystem procured in present with existing User equipments such as SDH, RTUs, SCADA, SAS system with SLDC, Kahilipara etc.
(4) All cabling, wiring including supply, laying and termination etc of the cables, and distribution frame at wideband nodes required for full interconnectivity and proper operation of the telecommunications network including equipment supplied under this package and the connectivity and interfacing of user equipment.
(5) Installation and integration of network management software, hardware and firmware.
(6) Project management, project scheduling, including periodic project reports documenting progress, review meeting during the contract period.
(7) Engineering and technical assistance during the contract and warranty period.
(8) Implement all minor civil works and identify any major civil works i.e. expansion or construction of rooms, trenches necessary for installation of proposed equipment and provide the details of such work to the Employer.
(9) Factory and site testing of all hardware, software, and firmware provided.
(10) Provide documented evidence of satisfactory Type Test performance to the Employer and if required by The Employer, conduct type test.
(11) Provide a Quality Assurance Plan, ensuring the Employer access to the manufacturing process.
(12) Training of the Employer personnel.
(13) Hardware, software, and firmware maintenance, debugging, and support of the equipment through final acceptance, and maintenance on all new equipment through out the warranty period.
(14) Availability of service, spare and expansion parts for the supplied items for the designed life of the equipment or seven (7) years after the declaration of withdrawal of equipment from production, whichever is earlier. However, the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

Detailed descriptions of the Contractor's obligations, in relation to individual items and services offered, are delineated in other sections of this specification.

14.3.3 The Employer Responsibilities and Obligations

The Employer will provide the following items and services as part of this Project:

(1) Overall project management of the project
(2) Review and approval of the Contractor's designs, drawings, and recommendations.
(3) Communication network configuration data, including:
    (a) Channel assignments for voice and data
    (b) Interconnection drawings for existing equipment
(4) Review and approval of test procedures.
(5) Participation in and approval of "Type", factory and site acceptance tests where testing is required.
(6) Review and approval of training plans.
(7) Providing support and access to facilities at the sites.
(8) Implement the major civil works such as expansions or construction of rooms, trenches etc. as required for the equipment to be provided by the Contractor.
(9) Coordination of the Contractor's activities with the Employer's and constituents' concerned departments.
(10) Provide to the extent possible drawings for existing sites and facilities for which equipment installations are planned.
(11) Approval of the key personnel for the project

14.4.0 Applicable Standards

The applicable standards are mentioned in the respective technical section. The offered equipment shall conform to the standards mentioned in the specification except to the extent modified by this specification. In case of any discrepancy between the description given in the specification and the standards, the provisions of the technical specification shall be followed. The parameters not specifically mentioned in this specification shall conform to the standard mentioned in this specification.

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 Contractor shall attempt to comply with such, provided that no additional expenses are charged to the Employer without Employer's written consent.

In the event the Contractor offers to supply material and/or equipment in compliance to any standard other than Standards listed herein, the Contractor shall include with their proposal, full salient characteristics of the new standard for comparison.

In case values indicated for certain parameters in the specifications are more stringent than those specified by the standards, the specification shall override the standards.

14.5.0 Network Configuration and Equipment Characteristics

14.5.1 Introduction

This section describes the Fibre Optic Communication network configuration and the equipment characteristics for communication system to be installed under the project. The sub-systems addressed within this section are:

(1) Fibre Optic Transmission System (FOTS)
(2) Craft Terminal based Network Management System (NMS)
(3) DDF and Cabling

The requirements described herein are applicable to and in support of network requirements.

14.5.2 The security related requirements of the equipment shall be as per DOT (Department of Telecommunication)/ MEITY (Ministry of Electronics and Information Technology) guidelines and all similar security requirements as amended by DoT on time to time basis shall be followed/complied by the vendor at no additional cost to employer till the implementation of the project..

14.5.3 The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security /threat check any time during the supplies of equipment.

14.5.4 The contractor shall ensure that the supplied equipment have been tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27000 series Standards, Telecom and Telecom related elements against 3GPP security standards, 3GPP2 security standards etc. from any international agency/ labs of the standards e.g. Common Criteria Labs in case of ISO/IEC 15408 standards until 31st March 2013. From 1st April, 2013, the certification shall be done from authorized and certified agency/lab in India.

14.5.5 The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. Supplied and implemented in the project shall be given for use by the Employer.

14.5.6 The contractor shall get the Employer's equipment audited from security point of view once a year from a network audit and certification agency as identified by DoT. The audit of the equipment shall be carried once in a financial year till the maintenance service contract in the tender.

14.5.7 In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability and criminal proceedings can be initiated against the Contractor as per guidelines of DoT and any other Government department.

14.6.0 General Network Characteristics

14.6.1 Description

The fibre optic network shall be based on the Synchronous Digital Hierarchy (SDH). The network shall consist of overhead fibre optic links with a minimum bit rate of Synchronous Transport Module-STM-16 (STM-16). The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in appendices. The fibre optic network shall also be able to integrate with existing STM-1 network.

14.6.2 Functional Requirement

The primary function of the communication network is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS/RTUs/SAS. The communications support requirement for SCADA/EMS/RTUs/SAS system is for low & high speed data, express voice circuits and administrative voice circuits as defined in appendices. A brief summary of the communication system requirements is as follows:

(a) High speed E1 channel support
(b) 64kbps & nx64kbps data channel support
(c) Low speed (300-1200 bps) data channel support
(d) Voice (2 wire, 4 wire) channel support
(e) Network Management channels either through (Data Communication Channel(DCC) or through

data channel as may be suitable as per site requirement.

(f) The connectivity envisaged for RTUs and SAS with Control Centre (SLDC, Kahilipara) over TCP-IP is Wide Area Network on TCP-IP using IEC 60870-5-104 and IEC 60870-5-101 protocol.

(g) Tele-protection interface for simultaneous transmission and reception of trip (tele-protection) signal from/to one station to/from another two three or more stations. Tele-protections unit should be capable of communicating with remote end tele-protections directly or through fibre with 64kbps or E1 as back up path through fibre optic equipment.

14.6.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

14.6.3.1 System Synchronization

The Contractor shall synchronize the existing equipment and all the new equipment under the contract using existing Master clock. The Contractor shall provide the additional clocks as required under the set of clock indicated in BOQ. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. The contractor shall submit the synchronisation plan as per standard ITU-T G.811. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803. The synchronization plan shall clearly indicate the requirement of additional clocks with full justification.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interface(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

14.6.3.2 System Maintainability

To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control with graphical user interface. Such testing shall not affect the functional operation of the system.

14.6.3.3 System Upgradeability and Expandability

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and NMS shall be sized for maximum equipped system capacity.

14.6.3.4 Equipment Availability

The calculated availability of each fibre optic link (E1 to E1) shall be at least 99.999%. The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between SAS/RTU to reporting Control Centres and between control centres.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the meantime- to-repair (MTTR) of the components and

subsystems comprising the FOTS. The down time of the fibre optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment and configuration proposed by the Tenderers shall capable of demonstrating the specified availability figures it is required that the Tenderer shall include in their proposal a calculated availability analysis for the proposed equipment/sub system. The calculated failure rates of the units and the calculated availabilities of the equipment being offered shall be provided by the Contractor during detailed engineering. The analysis shall be based on an availability block diagram and shall include the mean-time-between-failure (MTBF) and mean-time-to-repair (MTTR) of all the components on the link. The Tenderer shall indicate in the analysis the MTBF and MTTR and the resulting availability of each poini-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

The Tenderer shall carry out the survey at respective Sub-Stations and other linking Sub-Stations to assess the requirements. The required wiring and cabling for the integration with new & existing OPGW systems, new & existing Fibre Optic System, new and existing EPAXs, space requirements, power supply
requirements. Placing of proposed FOTS equipment with FODP shall also be assessed by the Tenderer during the Site Survey.

14.6.3.5 Revision Levels and Modifications

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most of current revision level. All modifications and changes necessary to meet this requirement
shall be completed prior to the start of the factory tests or under special circumstances, on written approval by Employer, prior to the completion of SAT.

14.6.3.6 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BOQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion. Data communications channelization required to support the NMS subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the NMS function.

14.6.3.7 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 2-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 2-1

Equipment Redundancy Requirements Summary

Fiber Optic transmission Equipment : **SDH equipment**	
Power Supply & Converters ----------	1:1 APS
Common Control* Cards ----------	1:1 APS
Common control cards which are essentially required for operation of the equipment.	1:1 APS
DACS(Cross Connect)----------	1:1 APS
Power Supply----------	1:1 redundant
Multiplexer power supply----------	1:1 APS

The offered equipment shall support at least SNCP **as per standard ITU-T G.841**. In case the equipment offered by the Tenderer does not support the above mentioned minimum protection methods, the tenderer shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to Employer. The tenderers shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

14.6.3.8 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

14.6.3.9 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer.

14.6.3.10 General Site Considerations

In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wave length translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored by centralized NMS.

14.6.3.11 Proposed Optical Fibre Characteristics

The link budget calculations and equipment design shall be based on the specified fibre parameters. The optical cables shall have Dual Window Single Mode (DWSM) fibres conforming to ITU-T Recommendations G.652D and the major parameters of these optical fibre(s) are defined in Table-2-2:

Table-2-2
Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode (DWSM)
Mode Field Diameter:	8.6 to 9.5 µm (±0.6 µm)
Cladding Diameter:	125.0 µm + 1µm
Mode field Concentricity Error:	≤ 0.6µm
Core-Clad concentricity error:	≤ 1.0µm
Cladding non-circularity	≤1%
Cable Cut off Wavelength:	≤1260 nm
1550 loss performance	As per G.652D
Proof Test Level	0.69 Gpa
Attenuation coefficient	@1310nm ≤ 0.35 dB/Km @1550nm ≤0.21 dB/Km

Attenuation variation with wavelength **1285 nm - 1330 nm** **1525 nm – 1575 nm**	 Attenuation coefficient @1310 ± 0.05 dB Attenuation coefficient @1550 ± 0.05 dB
Point discontinuities	≤ 0.1dB
Chromatic Dispersion; Max.: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18.0 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/(nm2xkm) maximum
Polarization mode dispersion coefficient	< 0.2 ps/km^1/2
Temperature Dependence:	Induced attenuation < 0.05 dB (-60 deg C - +85 deg C)
Bend performance:	@1310nm (75+2 mm dia Mandrel), 100 turns; Attenuation rise 0.05 dB @1550nm (30+1 mm dia Mandrel), 100 turns; Attenuation rise 0.10 dB @1550nm (32+0.5 mm dia Mandrel), 1 turn; Attenuation rise 0.50 dB

14.7.0 Fibre Optic Link Lengths

The fiber optic route lengths are as specified in appendices/Section Project/BoQ. The lengths specified in appendices are the transmission line route lengths; however the actual fiber cable length shall exceed the route lengths on account of extra cable requirement due to sag, jointing & splicing, approach cabling etc. For bidding purposes the Contractor may assume an additional cable length of 5% of given route length **+** 1Km towards approach cable for calculating the link length. The exact cable lengths shall be determined by the Contractor during the survey. The same shall be used by the Contractor for final link design during the detailed engineering of the project.

14.7.1 Fibre Optic Transmission System

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-16 and equipped with 2 nos. Of minimum 63 port E1 interface (G.703) card, two no. of minimum 8 port Ethernet i nterface (IEEE 802.3/IEEE 802.3u) card supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE802.1P/Q), spanning tree (IEEE 802.1D) quality of service. Protection scheme fo r Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032..

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection. Two number spare jumpers shall be provided for each equipment connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

14.8.0 SDH Equipment

14.8.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The Price schedule shall be referred for BOQ. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary Cards (Electrical tributaries such as E1 & Ethernet 10/100 Mbps) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If tenderer is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, control card shall not be equipped with more than one optical interface/SFP and optical base card shall not be equipped with more than two optical interface/SFPs.

The equipment shall be configurable either as Terminal Multiplexer (TM) as well as ADM with software settings only.

14.8.2 SDH ADM

The aggregate interfaces shall be STM-16 towards at least 5 (five) protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with a 2 nos., min. 63 E1 port electrical tributary cards & one no., min. 8 port Ethernet interface card as tributaries. The equipment shall provide access to full STM16 payload. The equipment shall provide non blocking cross connect capability of 64 STM-1 (bi-directional) at high order VC-4 level and as well as low order VC-12 level. Cross connection (VC4) capability of offered SDH equipment shall be provided according to STM-16 equipment.

14.8.3 Redundancy and Protection

Two fibre rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibres shall be implemented.

14.8.4 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: 8 voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and 4 data channel with opto coupler interface for V.24/V.28 interface. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis.

14.8.5 Supervision and Alarms

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the NMS.

14.8.6 Synchronisation

The equipment shall provide synchronisation as per Table 2-2. One 2MHz synchronisation output from each

equipment shall be provided.

14.8.7 Electrical and Optical I/O Characteristics and General Parameters

Table 2-3 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 2-3
Electrical and Optical I/O Characteristics and General Parameters

Optical Wavelength NOTE (1)	1310/1550nm
Optical Source NOTE (2)	Laser
Optical Source Lifespan	Better than 5 $X10^5$ hours
Optical Fibre Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.813
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

NOTE (2) **Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

NOTE (3) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

14.9.0 Optical Link Performance Requirements

The optical fibre link performance requirements are specified as follows:

14.9.1 Link Budget Calculations

The fibre optic link budget calculations shall be calculated based upon the following criteria:

(1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.21 dB/Km @1550nm and 0.35 dB/km @1310nm.

(2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 3 kms.

(3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.

(4) Equipment Parameters: The equipment parameters to be considered for link budget calculations shall be the guaranteed "End of Life (EOL)" parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB shall be considered and a similar margin shall be considered for optical amplifiers.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 2.5 dB/100Km shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10}.
The tenderers shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fibre optic link during detailed engineering.

For finalising the FOTS system design & BOQ, above methodology shall be adopted taking into account fibre attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

14.9.2 Link Performance

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826.

FOTS equipments shall be provided with in-built loopback capabilities : Each FOTS transceiver pair shall be able to provide local(manual) and remote on demand loopbacks of the composite baseband and each E-1 port.

14.10.0 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP(to be provided under separate contract) and the SDH equipment. The Contractor shall provide FC PC coupled patch cords of suitable length as per requirement. The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

14.11.0 DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities to the wideband telecommunications system. Equipment and material components for DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

14.12.0 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

(i) "Normally thru" circuit routing

(ii) Circuit rerouting via patch cord assemblies

(iii)Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

14.12.1 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. The Patch cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

14.13.0 Telecommunication Management Network / Network Management System

The Contractor shall provide Craft Terminal based Telecommunications Management Network System (NMS) for operational support to the FOTS subsystems (if required). This NMS shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network with the help of a portable personal computer to be known as craft terminal. The Contractor shall submit for Employer's approval the NMS architecture describing in detail the following subsystems/features:

(a) Database used in NMS

(b) Peripherals and hardware

(c) Software and operating system

(d) Craft Terminals

14.14.0 Management Functions

The NMS shall support following Management functions:

14.14.1 Configuration Management

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.

b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.

c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.

d. Provide verification testing to support new equipment installation.

14.15.0 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, and links. Minimum specific requirements that shall be satisfied include the following:

a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.

b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.

c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours.

d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.

e. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.

f. Track network equipment failure history.

14.16.0 Performance Management

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link, together with other data measured at each node, shall be available on operator request.

b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:

1. Select/deselect network equipments, events, and threshold parameters to monitor
2. Set monitoring start time and duration or end time
3. Set monitoring sampling frequency
4. Set/change threshold values on selected performance parameters
5. Generate alarm events when thresholds are exceeded.
6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs. Performance data provided is limited to what is available from the equipment Contractors.
8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

14.17.1. Security Management

The NMS shall be provided with security features to limit access to monitoring and control capabilities to only

authorized personnel. One access level of System Administrator and at least two levels of operator access shall be provided - read (view) only, and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the NMS system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network. It shall be possible to define multiple domains for purposes of monitoring and control. Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

14.17.2. Communication Channel Requirement and Integration

Communication requirements for NMS system have not been considered in Appendices and the Contractor shall provide these as a part of NMS system. The Contractor shall provide all required interface cards / devices etc. The NMS data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible.

14.18 Craft Terminal

Each equipment on the fibre optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. Through the use of this PC and local displays/controls, the operator shall be able to:

a. Change the configuration of the station & the connected NEs.
b. Perform tests
c. Get detailed fault information

The craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ given in the appendices

14.19 Hardware Requirements

14.19.1 Craft Terminal

The craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied. The Craft Terminal shall be a laptop. The craft terminal shall have the following minimum configuration:

Parameter	Specification
Compliance	MIL-STD 461F, MIL-STD 810 G
Display	14.0” FHD (1920 x1080)
	1000 nits DynaVue® sunlight readable display with capacitive multi-touch screen
	User selectable touch mode for Finger/Water, Glove, or Stylus programmable function
Operating System	Windows® 10 Pro 64-bit

Processors	Intel® Core™ i7-1185G7 vPro™ (11th Gen) 3.0GHz processor with Turbo Boost Technology up to 4.8GHz, 12MB cache
Memory	2 slots 8GB (3200MHz DDR4)
Storage	Main: 1TB NVME PCIE SSD
Graphics	Intel® Iris® Xe Graphics
Camera	Integrated 2.0 MP web-cam with shutter design
	Optional IR camera for Windows Hello1
Audio	Integrated microphone
	Intel® High Definition Audio Compliant
	Integrated speaker x 2
	Keyboard volume and mute controls
Media Bay (One Option Only)	Optional DVD super Multi Optional 2nd battery Optional SATA SSD
Expansion Box	Optional PCI-Express 3.0 (2 slots)1,6
	Optional discrete VGA1,6
	Optional storage extension with RAID 0/1/5/101,6
	Optional military-grade connectors1
I/O Ports	Thunderbolt 4 (type C) x 1
	USB 3.2 Gen2 (type C) x 1 (support DP)
	USB 3.2 Gen2 (type A) x 1
	USB 3.2 Gen1 (type A) x 1
	USB 2.0 (type A) x 1
	Audio in/out (combo jack) x 1
	microSD card (microSDXC) x 1
	10/100/1000 Ethernet (RJ45) x 2
	VGA port (D-sub,15-pin) x 1
	HDMI port (type A) x 1
	Serial port (RS232 : D-sub,9-pin) x 25
	Docking connector (41-pin Pogo) x 1
	SIM card x 1
	Smart card reader x 1
	DC-In jack x 1
	ExpressCard 54 x 1 (default) or PCMCIA Type II x 1
	Optional RF antenna pass-through for GPS, WWAN, and WLAN
Keyboard & Pointing Device	2 user-definable keys (P1/P2)
	RF signal slide-switch
	Standard membrane keyboard with LED backlight
Communications	Integrated 10/100/1000 Ethernet
	Intel® Wi-Fi 6 AX201 (802.11 ax)
	Bluetooth® V5.2
	Optional dedicated GPS module (UBLOX-NEO-M8N)
	Optional 4G LTE multi-carrier mobile broadband
	Optional RF antenna pass-through for GPS, WWAN, and WLAN

Security	Intel® vPro™ Technology (per CPU options)
	TPM 2.0
	NIST BIOS compliant
	Easy removable SSD
	Smart card reader
	Stealth mode
	Night vision mode
	Kensington lock
	Optional Windows Hello1
	Optional fingerprint scanner
	Optional HF/LF RFID reader1
Power	AC adapter : 100-240V, 50Hz-60Hz, 90W
	Optional AC adapter (100-240V, 50Hz-60Hz, 120W), with NVIDIA® VGA
	Main battery Li-Ion, 10.8V, 7800mAh, 16 hours2
	Optional 2nd battery Li-Ion 10.8V, 4700mAh, 9 hours2
	Optional bridge battery : 5 minutes swap time3
Dimension & Weight	356 mm (L) x 280 mm (W) x 50 mm (H)4
	3.6 kg
Warranty	3-year limited warranty standard

14.19.2 Power Supplies

The NMS system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

14.20 General Software/Firmware Requirements

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

14.20.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, management devices, to allocate system resources, and manage communications among the system processors. The contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

14.20.2 Applications Software

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The contractor shall make no modifications to the applications program except as provided as USER development tools.

14.20.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

14.20.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

All software shall be easily user expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

Software provided shall be compliant with national and international industry standards.

20.5 Database(s)

The contractor shall develop all the databases for final wideband network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of NMS system.

NMS operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

14.20.6 Help

All applications shall be supported by USER accessible HELP commands that shall assist the user in the performance of its tasks. HELP commands for an application shall be available to the user from within the active application and shall not interfere with the activities of the application.

14.21 Environment, EMI, Power Supply, Cabling and Earthing

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

14.21.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

14.21.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 4-1.

Table 4-1

Environmental Operating Limits

Temperature Range: **Specification** **Operation without damage** **Shipping/storage**	(Un Controlled Environment) 0 to 45°C -10 to 55°C -40 to 60°C
Relative Humidity, non-condensing	Upto 90%
Elevation: **Operating** **Non-operating**	 to 3,000 m to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be

installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

14.21.2 EMI and Electrostatic Interference

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location. Specifications provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

14.21.3 Vibration and Shock Resistance

As per testing requirements indicated in this specification.

14.21.4 Tropicalization

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

14.21.5 Contaminants

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

14.22.0 Primary Source AC/DC Power Requirements

Facilities will be required to support both AC and DC power load requirements of telecommunications equipment as specified below:

14.22.1 Primary Source AC Power

It will be the Employer's responsibility to provide required Primary AC source Power for communications equipment installed under this specification. The Primary AC Power supplied will be 240 VAC ± 10%, 50Hz with a frequency variance between 46 and 55 Hz. Harmonic distortion will not exceed five (5) percent. All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 240 VAC supply. The Contractor shall provide in their Bid as well as in the survey report to the Employer the projected 240 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification. The Contractor shall provide suitable UPS for communication equipment/module etc. requiring AC power supply at locations other than control centre.

14.22.2 -48V DC Power

Power supplies/converters for communications equipment (except computer system supplied as part of NMS which shall use 240 VAC) provided under this specification, shall use -48Vdc uninterrupted primary source power. **The 48V SMPS battery charger and 48V battery bank for all the 220KV and 132KV substations that fall under this network shall be supplied by the contractor.** The power supply may vary normally within the voltage range -42 to -58 Vdc and the supplied equipment shall operate satisfactorily within this range.

14.22.3 TECHNICAL SPECIFICATION 48V BATTERY BANK FOR FOTE (If Required)

14.22.3.1 TYPE AND RATING

i) Stationary type, sealed, valve regulated lead acid battery tank suitable for operation on 48 Volts D.C. system to meet loads like emergency lightning, control and signaling circuits, relays, breaker operations, indicating circuits, etc. shall be required. The stationary battery shall comply with the provisions of IEC

896, Part 2 / ANSI T1.330.

ii) The Ampere-hour capacity of the battery bank at 27°C at 10 hours discharge rate shall be 100/200 AH.

iii) The nominal voltage of the battery bank shall be 48 Volts D.C.

iv) The number of cells in a complete battery bank set shall be 24 plus 2 spares.

14.22.3.2 PLATES

Positive plates shall be made of flat pasted type using lead-cadmium antimony alloy for durability, high corrosion resistant, maintenance free, long life both in cyclic as well as in ,float applications. Negative plates shall be heavy duty, durable flat plate using lead calcium alloy pasted box grid. Negative plates shall be designed to match the life of positive plates and combination of negative and positive plates shall ensure long life, durability and trouble free operation of battery. PLC operated equipment should be deployed for preparation of paste to ensure consistency in paste quality. Conventional / manual type of paste preparation is not allowed.

14.22.3.3 CONTAINER AND LID

The containers and lids shall be made of a special grade polypropylene copolymer plastic material. They shall be sufficiently robust and not liable lo deformation under internal operating pressures and within the temperature range naturally encountered, leak proof, non-absorbent and resistant to the acid with low water vapour permeability.

14.22.3.4 VENT PLUGS

Each cell shall be equipped with one-way safety valve with opening pressure of 5±1 psi and closing pressure 4±1 psi. The vent plug shall be made with suitable grade of fire retardant plastic material. Each valve opening shall be covered with flame barrier capable in preventing the ingress of flame into the cell interior when the valve opens and hydrogen / oxygen gas mixture is released.

14.22.3.5 SEPARATORS

Separator shall be made of spun glass, micro porous matrix and shall be resistant to Sulphuric Acid. It shall be capable of keeping the entire electrolyte and shall be electrically insulated. Sufficient separator overlap and PVC shield protection to top and bottom edges of the plates is to be provided to prevent short circuit formation between the edges of adjacent plates.

14.22.3.6 CONNECTORS

The connectors shall be lead coated copper of suitable size to join the cells. The connectors shall be suitably designed and coated to withstand corrosion due to sulphuric acid. The coating should be adequate and tenacious. All the copper inter cell connectors shall be provided with heal shrinkable sleeves except at the connecting points.

14.22.3.7 ELECTROLYTE

The electrolyte shall be prepared from the battery grade Sulphuric Acid confirming to ISS: 266. The batteries shall be supplied in factory filled and charged condition.

14.22.3.8 WATER

Water required for preparation of electrolyte shall conform to IS: I069.

14.22.3.9. PLATE CONNECTION

Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be caste with lead alloy. The

positive and negative terminal posts shall be clearly marked for unmistakable identification.

14.22.3.10 BOLTS AND NUTS

Nuts and Bolts for connecting the cells shall be of superior grade passivated Stainless steel.

14.22.3.11 TERMINALS

Terminals shall be of integral lead terminal with solid copper core with M6 threading for fastening. The junction between terminal posts and cover and between the cover and container shall be hermetically sealed

14.22.3.12 BATTERY RACKS ...

Batteries shall be installed on MS racks to be supplied by the Contractor to fit in the battery room. Racks/Trays shall be powder coated with anti-corrosive paint. Rack shall accommodate 55 cells plus 2 spares. Racks/Tray shall be suitably treated before painting for protection against fungus growth and other harmful effects due to tropical environment. The colour of the supporting racks shall conform to RAL 7032 shade.

14.22.3.13 CAPACITY REQUIREMENTS:

When the battery is discharged at 10 hour rate, it shall deliver 80% of Rated Capacity (corrected at 27°C) before any of the cells in the battery bank reaches 1.85 V/cell. The battery shall be capable of being recharged from the fully exhausted condition (1.75 V/cell) within 10hrs upto 90% state of charge. All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life.

The capacity (corrected at 27°C) shall also not be less that Rated capacity & not more that 120% of Rated capacity before any cell in the battery bank reaches 1.75 V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at a rate of 1/10th of the Rated Capacity:

(a) After SIX hours of discharge: 1.92V/cell
(b) After EIGHT hours of discharge: 1.85V/cell
(c) After TEN hours of discharge: 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35°C for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%. However, the battery to be manufactured and to be delivered at site in such a way that load can be connected with the battery within 15 days from the date of installation. Date of initial charging is to be mentioned on the battery.

14.22.3.14 ASSOCIATED EQUIPMENTS & ACCESSORIES (For each set of battery) :

a) Best quality metallic stand/frame as per Clause 9.12.
b) Stand insulators +5% extra
c) Inter row connectors :Appropriate quantity
d) Inter tier connectors
e) Centre-zero (3-0-3) volts DC Voltmeter : 1 No
f) Torque wrench/ Spanners : 1 No
g) Connection hardwares, such as strips, bolts, nuts(with 5% extra)
h) Cable clamps with hardware
i) Cell numbering tags with fixing arrangement
j) Two sets of special tools and tackles for connecting terminals of the battery
k) Any other accessories not specified but required for satisfactory operation.

14.22.3.15 TYPE TEST OF BATTERY:

The Tenderer/ Supplier shall supply type tested battery as per IS 15549:2004/ IEC 60896-21 & 22 over the

range of at least one capacity per design. The Tenderer/ Supplier shall submit necessary evidences enclosed along with tender documents.

Sl No	DESCRIPTION
1	Gas Emission
2	High Current Tolerance
3	Short Circuit Current & DC Internal resistance
4	Protection against Internal Ignition from External Spark source
5	Protection against Ground Short Propensity
6	Content & Durability of required marking
7	Material Identification
8	Valve Operation
9	Flammability Rating of Material
10	Intercell Connector Performance
11	Discharge Capacity
12	Charge Retention during Storage
13	Float Service with Daily Discharge for reliable mains power
14	Recharge behaviour
15	Service Life at an operating temperature of 40°C for brief duration exposure time
16	Impact of Stress Temperature of 60°C for brief duration exposure time with 3hrs discharge test
17	Abusive Over Discharge
18	Thermal Runaway Sensitivity
19	Low Temperature Sensitivity
20	Dimensional Sensitivity at Elevated Internal Pressure & Temperature
21	Stability against Mechanical abuse of units during installation

14.22.3.16 Routine Test:

(i) Physical Examination Test
(ii) Visual Inspection
(iii) Dimensions, Mass & Layout
(iv) Marking & Packing

14.22.3.17 ACCEPTANCE TEST OF BATTERY

(i) Polarity Marking
(ii) Verification of Dimensions
(iii) Open Circuit Voltage of each Cell & Total Open Circuit voltage of the battery bank
(iv) Test of AH Capacity

14.22.3.18 LIST OF FACTORY & SITE TESTS FOR BATTERY

Sl. No.	TEST	FACTORY TESTS	SITE TESTS
1	Physical Verification	YES	YES
2	Capacity Test on the cell at 1/10th of Rated Capacity, corrected at 27°C	YES	
3	8hrs Charge & 15mins Discharge Test at Full Rated Load	YES	

14.22.4 48V BATTERY CHARGER

14.22.4.1 General:

This section covers the general requirement of 48 V DC SMPS Based Power Plants, based on High Frequency Switch Mode Techniques using switching frequencies of 20KHz and above for use in AEGCL.

14.22.4.2 SMPS Based Power Plants is intended to be used in **Auto Dual Float Rectifier cum Boost Charger (FR-BC)** mode as a regulated DC Power Source.

14.22.4.3 Power System Configuration:

The configuration of 48 V DC Power Plants with FR-FC & FRBC Modules shall be as under:

Sl No	Basic SMR Module	Configuration	Permissible Ultimate Capacity
1	25 A FR-FC	(n+1)	75 Amp
2	50 A FR-FC	(n+1)	150 Amp
3	25 A FR-BC	(n+2)	75 Amp
4	50 A FR-BC	(n+2)	150 Amp

The FR-FC or FR-BC modules shall be housed in (n+1) or (n+2) parallel configuration in a single rack where 'n' is the actual required number of FR-FC, FR-BC modules for meeting the particular load requirement.

AEGCL shall indicate the Type, Number and Configuration of SMR Modules, depending upon the load requirement. AEGCL shall also indicate Ultimate Expandable Capacity considering future expansion requirement.

14.22.4.4. The Battery Charger of 48V/25A (Ultimate capacity 150A) or 48/50A (Ultimate capacity 150A) N+1 configuration shall be of SMPS type and shall be chosen as per load demand of communication equipments of the substations. The system shall consist of DSA and Float Rectifier –cum-Charger (FR/FC) in a steel rack in a modular type. It should have menu driven microprocessor control technique for DSA as well as module for control, monitoring and alarm to achieve better reliability of the system.

14.22.4.5 Rack Configuration :

Rack is composed of following units accommodated in sub racks

a) Dual Float Rectifier cum Boost Charger (FR-BC) Modules.

b) Distribution-Switching-Control-Alarm Arrangement (DSCA)

c) The number and rating of FR-FC, FR-BC Modules shall be provided as per purchaser's requirement. The Distribution-Switching-Control-Alarm Arrangement (DSCA) shall be provided for the Ultimate Expandable Capacity. All factory wirings for the rack shall be for the Ultimate Expandable Capacity so that only plugging-in of FR-FC or FR-BC module shall enhance the DC Power output.

14.22.4.6 Parts & Components

The Parts & Components including Fuses and Circuit Breakers for manufacturing of the SMPS Based Power Plants shall be of Industrial Grade. These Parts & Components shall be procured from reputed manufacturers to ensure prompt and continuous service and delivery of spare parts.

Power Transformers and Chokes shall use Class B or Higher Grade of insulation. The Transformers and Chokes shall be wound with copper wire provided with adequate insulation.

Component mounting and fixing methods shall be secured.

14.22.4.7 Wiring:

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current voltage during fault and overload.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part

of Metal Panel or Cover, the hole through which they pass shall be suitably bushed with rubber grommet.

14.22.4.8 Bus Bars:

Bus bars shall be of high conductivity electrolytic copper strips capable to with-stand 1.5 times the maximum load current. The Bus bar shall be capable to carry current density of 2 Amps/mm2 but shall not be less than 25mmx5mm in any case. The size of bus bars chosen for battery and load path shall be capable to take care of the current of maximum power plant capacity for which it is designed.

Bus-bar Riser height wherever applicable shall be 250mm for both load and battery.

Earthing: All non-current carrying metal parts shall be bonded together and earthed. An earth terminal suitable for taking minimum 4 mm dia wire and with suitable marking shall be provided

The SMPS Based Power Plants shall be designed & manufactured for continuous operation at rated load in the ambient temperature range of 0ºC to 55ºC.

Insulation Resistance and Voltage Proof

The insulation resistance of a fully wired FR-FC and FR-BC Modules when tested with a 500V DC Megger shall be as given below:

a) AC input and Earth - Greater than 2 Mega Ohm
b) DC Output and Earth - Greater than 1 Mega Ohm
c) AC input and DC output - Greater than 5 Mega Ohm.

14.22.4.9 Lightning Protection :

The SMPS Based Power Plants shall have modular type Type I/Class B and Type II/Class C type surge protection in TT configuration of wiring. Both the Type I/Class B and Type II/Class C arrestors should be from the same manufacture and shall be mounted as per the specific installation recommendations of the manufacturer to achieve perfect coordination.

Radio Frequency Interference Suppression: The module shall be designed to minimize the level of electromagnetic interference (EMI), both conducted and radiated, detected in its vicinity and generated by Switch Mode Power Conversion Equipment operating within the rack.

14.22.4.10 Name plate :

A name plat etched/engraved/anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each rack/module and contain following information.

1. Specification Number
2. Type of Unit
3. Manufacturer's name and identification
4. Model No.
5. Unit Serial No.
6. Input Voltage and phase
7. Output Voltage and current
8. Year of manufacture
9. Suitable for battery capacity

14.22.4.11 AC input supply: The Power Plant using FR-FC or FR-BC modules of 25 Amps shall operate from single phase AC input and FR-FC or FR-BC modules of 50A capacity may operate from single phase or 3 phase 4 wire AC input. The nominal input frequency is 50Hz which may vary from 48-52Hz. The input voltage range shall be as given below:

a) Single Phase (nominal 230V) :

For Power Plant to be used at stations having reasonable power supply regulation, incoming power supply range shall be from 165 V AC to 260 V AC.

b) Three Phase/4 Wire 400V+10%/ - 15% (Nominal 400V)

14.22.4.12 There shall be an automatic arrangement for shutting off the FR-FC or FR-BC Modules wherever the input voltage is beyond the specified operating limits with suitable alarm indication. It shall resume normal

working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the FR-FC or FR-BC Modules. A tolerance of ±5V may be acceptable for protection & alarm operation. All the FR-FC or FR-BC Modules shall switch OFF simultaneously.

14.22.4.13 FR-FC or FR-BC Modules working from 3 phase/4 wire input shall work satisfactorily for unbalance of ±10% of nominal input. The module shall be isolated (if required for the protection of the unit) in the event of unbalance beyond 10% and shall restore when the input is within limits.

14.22.4.14 The SMPS battery charger shall be capable of continuous operation with float voltage 2.23 to 2.25 Volt per cell and 2.3 Volt per cell for charge voltage while supplying the constant DC load.

14.22.4.15 The SMPS battery charger shall have constant voltage characteristics throughout the range (from zero to full load) at floating value of the voltage so as to keep the VRLA batteries fully charged but without harmful overcharge.

14.22.4.16. The float cum boost charger works on 415 V AC, 50 Hz supply (or 230 V AC, 50 Hz supply). The battery charger should be capable of delivering the full rated load at the specified voltage at the output terminals. The set output voltage is maintained for AC input variation of + 10% and load variation from 0-100% of rated full load.

14.22.4.17 The charger voltage in float mode of operation is normally be set at 54 V DC and the same shall be adjustable between 48 and 54 V DC through variable potentiometer. When the charger is selected to boost mode, it should supply charging at the rated current maximum. This shall be adjusted from 20% to 100% of rated current through potentiometer.

14.22.4.18 All these circuits are housed in freestanding cabinet of folded sheet steel (thickness of sheet steel should not be less than 2.5mm) construction finished in stove enamel light gray colour conforming to shade of 631 of IS: 5. The cabinet is provided with front and back doors for easy accessibility. All meters, meter selector switches, control switches and LCD display (Microprocessor unit) etc are to be provided on the front panel. The AC input and DC output MCCB'S and control switches are provided on middle inside of the breaker panel. The cable terminations are provided on front side of the cubicles.

14.22.4.19 PARTICULARS

Type	FLOAT CUM BOOST CHARGER Hot swappable rectifier modules 25A/48V, N+1 configuration.		
Rating	48 V (Capacity as per Battery Sizing Calculation) Dual float cum boost charger (suitable for MF-VRLA battery)		
AC INPUT			
A	Voltage	415 V AC+ 10% (230V AC +10%)	
B	Phase	3 phase, 3 wire (single phase)	
C	Frequency	50 Hz+5% (50Hz+2Hz)	
D	Power factor	(Better than 0.7 lagging)	
DC OUTPUT			
A	Float voltage	:	48 V- 54 V DC
B	Boost voltage	:	48 V-55.2 V DC
C	Output current	:	35A
D	Voltage regulation	:	Better than + 1% of set value
E	Ripple	:	Less than 1% r m s
F	Efficiency	:	(Better than 90%)
G	System output voltage	:	55.2V DC+1%(at load terminal)

METERS		The microprocessor based controller should have metering facilities namely (a) Load Voltage (b) Load Current, (c) Battery Voltage (d) Battery Current (e) Battery Temperature, (f) Voltage and current of individual module.	
PROTECTION			
Over voltage trip at the output	:	Over voltage cutback	56.5+ 0.5 V DC
DC under voltage at battery input	:		42+ 0.5 V(1.75 V X 24)
Fuse at AC input	:	Fast acting semiconductor fuse	Fast acting semiconductor fuse
Fuse at DC out put to load	:	MCCB	Fast acting semiconductor fuse
Reverse polarity at battery input	:	Protected	Protected
Out put current limiting	:		Battery charging current limit
AC input MCCB	:	Required	Required
Blocking diode	:	Required	Required
Charger over load	:	Required	Required

INDICATION		
AC input ON	:	Required
DC output ON	:	Required
Float ON	:	Required
Boost ON	:	Required
AC under voltage	:	Required
AC over voltage	:	Required
DC over load	:	Required
DC over voltage	:	Required
Short circuit	:	Required
Reverse polarity	:	Required
Mains fail		Required
Charger fuse fail		Required
Battery over voltage		Required

CONTROLS AND SWITCHES	
AC input MCCB	ON/OFF switch at input
DC output MCCB	Three way switch to select auto / manual float / manual boost operation
Auto/manual float/boost mode selector switch	Two way switch to read charger output current or battery charge / discharge current
Auto /manual voltage regulator selector switch	Single tern potentiometer for float voltage adjust
Float and boost voltage variable potentiometer	Single tern potentiometer for boost voltage adjust
Manual voltage adjust variable potentiometer	Single tern potentiometer for charger total current adjust
Battery current adjust potentiometer	Single tern potentiometer for battery current adjust
Heaters power supply switch	

Socket power supply switch	
ADDTIONAL FEATURES	
Soft start on DC side	Auto float / boost operation

14.22.4.20

a). The Battery Charger shall have Dual Source AC Input (AC Input 1 and AC Input 2) with individual MCCB and shall be provided with Auto Changeover arrangement.

b). The Battery Charger shall have an IP Rating of IP42 or better. The Charger shall be type tested for IP42 or better rating.

14.22.5 Power Distribution and Protection

The Employer will furnish only one source primary 240 VAC. It shall be the Contractor's responsibility for the connection and distribution of all Primary AC and 48V dc source power, in full compliance with all local and national electrical codes.

The Employer shall indicate during the survey by Contractor, on the primary source, the feeders/points that can be used by the Contractor. The Contractor shall supply & install Primary AC and -48Vdc feeder cables to Contractor-furnished distribution panels.

The Contractor shall provide required distribution panels, circuit breakers and appropriate Panel Disconnects. Distribution Panel feeders, Panel Disconnects, distribution panels and circuit breakers shall be sized and equipped to support at least 100% expanded load requirements.

The Contractor shall provide and install all required primary power distribution sourced from the distribution panels. The Contractor shall also be responsible for Load Balancing.

The Contractor is responsible for all inter-rack (enclosure) and intra-rack (enclosure) power distribution required to support equipment supplied under this specification. The Contractor shall provide all cabling, fusing, switching and circuit breaker and surge protection required.

Partially equipped subsystems shall be installed with provision for expansion. Equipment power supplies provided under this specification, shall be sized to support fully equipped subsystems. Primary power distribution protection shall be sized to support and protect maximum operating load potential whether or not the actual projected load shall meet that maximum load potential.

The Contractor shall provide equipment and rack safety earthing in compliance with this specification.

14.23.0 Equipment Construction, Assembly and Installation

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

14.23.1 Identification

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable as per the following:

14.23.2 Equipment

Each equipment component to the level of printed circuit card, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture and revision level. Changes to components shall be identified by an unambiguous change to the marked revision level. The Contractor shall be responsible for maintaining the master revision level list until the Contractor has complied with all requirements of this specification. Where custom components and parts are provided, each component/part shall be marked to specifically identify that component/part. Printed circuit card cages are defined as an equipment component and as such, shall be clearly identified as stated within this specification. Equipment chassis and printed circuit card

cages having wired back-planes, shall be clearly marked with the manufacturer's part number, serial number, month/year of manufacture, revision level and an additional identifier corresponding directly to the applicable backplane wiring diagram/list.

14.23.3 Power Distribution

Power distribution panels shall be clearly marked with their unique identifier, source feed information, and remote source feed emergency disconnect location and identity.

Power distribution panel "Main Disconnect" and circuit breakers shall be clearly marked with aunique identifier. Circuit breaker feed lists shall be clear, accurate and the feed list information shall be posted inside each distribution panel door.

Inter-rack and intra-rack (enclosure) power distribution shall be clearly identified with source feed, voltage and power rating information. All power feed cabling shall be clearly identified near the point of termination.

All power distribution identification shall utilize heat-resistant permanent marking techniques such as stamped non-metallic tags, embossed labels, etc. Marking techniques are subject to approval by the Employer. Power distribution identifiers and information shall agree with the Contractor's power cable plant drawings.

14.23.4 Signal Cabling

Connectorised signal cabling/wiring requires marking with a unique identifier at each connectorised end. The signal cable/wire identifier shall include a cable identifier and the location of both terminations.

Signal cable/wiring installed on terminal blocks requires marking with the cable identifier and distant end location. The cable tag shall be clearly visible at the cable fanout point.

All signal cable, wiring and terminations shall be clearly labelled/tagged with identifiers consistent with Contractor supplied cable plant records. Marking techniques are subject to approval by the Employer.

14.23.5 Equipment Racks and Enclosures

All equipment racks, enclosures and equipment, including distribution frames, shall be clearly labelled with unique identifiers consistent with Contractor supplied floor plans and rack elevations.

14.24.0 Installation Hardware

Equipment racks, enclosures, cable raceways and installation hardware shall, at a minimum, comply with the following requirements:

14.24.1 Equipment Sub-Racks and Cabinets (Enclosures)

All equipment provided under this specification, shall be physically mounted in sub-racks andcabinets (enclosures). The Contractor shall determine and propose for the Employer approval, thetype, size, weight and manner of installation for each location.Selection of equipment sub-racks and cabinets (enclosures) shall meet the following requirements:

(A) Equipment Sub Rack Construction

Equipment Sub Racks provided for installation in environmentally controlled facilities, shall meet the following minimum requirements:

(1) Equipment Sub Racks shall be steel/aluminium fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment covers shall be provided for exposed components mounted in equipment sub Racks.

(3) Dust and moisture protection shall meet or exceed IP20 standards.

(B) Equipment Cabinet (Enclosure) Construction

(1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

(2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secure fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.

(3) All doors and removable panels shall be fitted with long life rubber beading. All panels shall be fabricated from minimum 2.0mm thickness steel sheet. However, for racks with load bearing Aluminium extrusion frame, door panels and side panels may be fabricated from minimum 1.6mm thickness steel sheet and the top & bottom panels shall be fabricated from minimum 2.0mm thickness steel sheet.

(4) Equipment cabinets (enclosures) shall be dust and moisture-proof as per IP41 specification, or better.

14.24.2 Cable Raceways

The Contractor is required to provide and install all additional necessary indoor and outdoor cable raceways. The cable raceways shall be in conformance with the following:

(1) Signal cabling and power cabling shall require separate cable raceways. Signal and power cabling shall not share the same raceways and shall be installed as far apart as is practical. Adequate shielding shall be provided as required.

(2) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.

(3) Outdoor cable raceways shall be of corrugated construction and shall be fitted with solid covers overlapping all sides of the cable raceways.

(4) Outdoor 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 anti-corrosion measures shall be taken. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.

(5) Indoor cable raceways fabricated of aluminium or galvanized iron, shall not normally need special finishing or painting, unless otherwise stipulated by the Employer. Steel fabricated raceways shall require a red oxide primer coat at a minimum.

14.24.3 Signalling Distribution

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

(1) All signal wiring connections to the communications equipment shall be via Krone type or equivalent terminal blocks.

(2) The Contractor shall provide subscriber level wiring and patching wherever required.

14.24.4 Lightning and Transient Voltage Protection

The Contractor shall be required to provide protection from lightning and transient voltages for all wideband communications equipment, in accordance with the following:

(1) At the outside cable plant point-of-entry of all cabling penetrations for all cabling installed by the Contractor, the Contractor shall provide lightning and transient voltage isolation for the inside plants cabling, wiring, and all terminations and equipment.

(2) All equipment installed under this specification that requires 240VAC primary power, shall be surge protected.

14.24.5 Station Safety Earthing and Signal Grounding

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

(1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards.

(2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.

(3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.

(4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.

(5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall extend the existing station earth to the equipment room using suitable G.I. earthing strip (50 x 6 mm), wherever required.

The Contractor is responsible for providing all required earthing/grounding cable and installation. Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the Employer's approval.

The Contractor shall be responsible for determining the suitability of existing station earth for the equipment to be supplied under this contract. In case existing earthing arrangement at the site is not adequate, the Contractor shall either make improvement in the existing earthing arrangement or make new earthing as per requirement.

14.25.0 Interconnections

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor supplied as-built drawings.

The Contractor shall supply and install all primary power cords, power-strips, receptacles, circuit breakers, fuse panels, switches, earth fault detectors, surge protectors, distribution cabling, and power connectors required to support all equipment enclosures and system components furnished and installed under this specification, except as specifically excluded.

Plug-type power connectors with captive fastening (such as "Twist-Lock") shall be used for interconnection of source power to the equipment enclosures or racks.

Plug-type connectors with captive fasteners (ie. DB-25, etc) shall be used for the interconnection of all inter and intra-enclosure signalling cable.

14.26.0 Finish Colors

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss

medium grey enamel on the outside. Only brushed aluminum trim shall be used. Employer reserves the right to approve the proposed color scheme.

14.27.0 Location of Equipment, Cable Routes and Associated Civil Works

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the Employer and the Contractor regarding equipment
siting, intra and inter facility interconnectivity and necessary associated civil works.

14.27.1 Locations for Supplied Equipment

All transmission equipment and associated DDFs, shall generally be co-located in the same communications room located in the Control Building whenever possible.

14.29 Inspection, Test and Availability

i) 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.

ii) 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.

iii) The entire cost of testing for factory & site acceptance, routine tests, production tests and other test during manufacture & site activities specified herein shall be treated as included in the quoted unit price of materials, except for the expenses of Inspector/Employer's representative.

iv) Acceptance or waiver of tests shall not relieve the Contractor from the responsibility to furnish material in accordance with the specifications.

v) 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.

vi) 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.

vii) 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. All security related features shall be demonstrated during FAT/SAT as required by the Employer.

14.29.1 Inspection

Access to the Contractor's facilities during system manufacturing and testing and to any facility where systems/ equipment are being produced/ tested/ integrated for the fibre optic communication network, shall be available to the Employer. At all times the Employer shall have full facilities for unrestricted inspection of such materials or equipment. To facilitate this, the Contractor shall submit for the Employer approval, a comprehensive Quality Assurance Plan using ISO 9000 as a general guideline. In addition, the Quality Assurance Plan shall satisfy the following:

(a) Sufficient office facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification shall be provided by the Contractor to the Employer.
(b) Inspections to be performed by the Employer will include visual examination of hardware, cable dressings and labeling. Contractor's documentation will also be examined to verify that it adequately identifies and describes all offered items and spare parts.
(c) Access to inspect the Contractor's standards, procedures, and records that are applicable to the supplied equipment shall be provided to the Employer. Documents will be inspected to verify that the Contractor has performed the required quality assurance activities.
(d) The inspection rights described above shall also apply to sub Contractors who are responsible for supplying major components described in this Specification. These items shall be inspected and tested at the sub Contractor's factory by the Employer's representatives prior to shipping this equipment to the Contractor's facility or directly to the Employer.
(e) The above inspection rights shall also apply to sub Contractors supplying assemblies, subassemblies and components. However, such items will normally be inspected and tested by the Employer's representatives at the Contractor's site before acceptance.

14.29.2 Test Plans and Procedures

a) Test plans and test procedures for both factory and site acceptance tests shall be provided by the Contractor. Test plans and test procedures shall ensure that each factory and site test is comprehensive and verify all the features of the equipment to be tested. Test plans and test procedures shall be modular to allow individual test segments to be repeated upon request.

b) The Contractor shall submit a Test Schedule for the Employer's approval within one (1) week after the award of contract for Type Tests and three (3) months after the award of contract for all other tests. The test
c) schedule shall list the tests to be carried out, and the approximate test duration. The test periods shall also be indicated in the PERT chart or equivalent for the work.

d) The Contractor shall give the Employer twenty one (21) days written notice of any material being ready for testing. Fifteen days prior to the scheduled testing, the Employer shall provide written notice to the Contractor of any drawings, equipment, material, or workmanship which, in the Employer’s opinion, are not compliant to the specification. The Contractor shall give due consideration to such objections, if valid, effecting the corrections as necessary or shall prove, in writing, that said modifications are unnecessary for contract compliance.

14.29.3 Factory and Site Test Plans

A test plan for factory and site acceptance tests shall be submitted for approval, at least four (4) weeks before the start of testing. The test plan shall be a single overview document that defines the overall schedule and individual responsibilities associated with conducting the tests, documenting the test results,
and successfully completing the test criteria. Test Plans shall include, at a minimum, the information contained in

Table 4-1.

Table 4-1
Factory & field Test Plan Requirements

Items	Description
1	Test Schedule
2	Record-keeping assignments, procedures and forms
3	Procedures for monitoring, correcting and retesting variances
4	Procedure for controlling and documenting all changes made to the communications equipment after the start of testing.

14.29.4 Test Procedures

Test procedures for factory and site testing shall be submitted for the Employer approval at least four (4) weeks before each individual test. Fully approved test procedures shall be submitted to the Employer at least four weeks prior to the commencement of testing. Testing shall not commence without approved test procedures. At a minimum, test procedures shall include the items listed in Table 4-2.

All test equipment and/or instruments shall bear calibration stickers indicating valid calibration on and beyond the testing date. The time lapsed since last calibration shall not exceed the test equipment/ jig manufacturer recommended calibration interval or the interval recommended in the test lab's internal quality procedures.

The Contractor shall ensure that all testing will be performed by qualified testing personnel well experienced in performing such tests.

Table 4-2
Test Procedure Requirements

Item:	**Description:**
1	Test Title and Revision Level, if applicable
2	List of Standard(s) complied with
3	Function(s) / parameter(s) to be tested
4	Purpose of each test segment
5	List of required test equipment
6	Description of any special test conditions or special actions required. This includes complete descriptions, listings and user interface procedures for all special hardware and software tools and/or display formats to be used during the test.
7	Test setup including test configuration block diagrams and/or illustrations.
8	Test procedures to be followed.
9	Required inputs and expected outputs for each test segment
10	Acceptance criteria for each test segment.
11	List of test data to be supplied by the Contractor(s) and copies of any certified data to be used
12	Format of test reports.

14.29.5 Test Records

Complete and indexed records of all factory and site acceptance tests results shall be maintained and provided to the Employer by the Contractor in hardcopy. The records shall be keyed to the steps enumerated in the test procedures. The minimal items required in test records are described in Table 4-3.

Table 4-3

Test Record Requirements

Item:	Description:
1	Test Title and Revision Level, if applicable; contract references
2	Date and time for test start and test completed
3	Test title and reference to the appropriate section of the test procedures
4	Description of any special test conditions or special actions taken (Includes test case data).
5	Test results for each test segment including an indication of Passed, Conditional Pass, Incomplete or Failed.
6	Test procedure modifications made during testing.
7	Variance Report(s) tracking information and copies (if variance(s) was detected).
8	Contractor's test engineer(s) identification, signature and remarks
9	Employer's test witness identification, signature and remarks
10	List of all attachments
11.	Attachments (including system logs, printouts, variances, hard copies of visual test result displays, etc.)

All principle test records, test certificates and performance curves shall be supplied for all tests carried out as proof of compliance with the specifications and/or each and every specified test. These test certificates, records and performance curves shall be supplied for all tests, whether or not they have been witnessed by the Employer within the specified duration after the completion of test. Information given on such test certificates and curves shall be sufficient to identify the material or equipment to which the certificates refer, and shall also bear the Contractor's reference and heading.

14.29.6 Rejection of Elements

Any item or component which fails to comply with the requirements of this Specification in any respect, at any stage of manufacture, test, erection or on completion at site may be rejected by the Employer either in whole or part as considered necessary. Material or components with defects of such a nature that do not meet the requirements of the Specification by adjustment or modification shall be replaced by the Contractor at his own expense. After adjustment or modification, the Contractor shall submit the items to the Employer for further inspection and/or tests.

14.30.0 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 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 five (5) years prior to the date of bid opening. In case the test reports are older than five years (5) ago on the date of bid opening, the Contractor shall repeat these tests at no extra cost to the purchaser.

(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.

(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.

(g) 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.

14.30.1 Type Test Samples

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 a random. At least three samples of each of the proposed equipment shall be offered for selection, out of which one sample for each equipment shall be selected.

14.30.2 List of Type Tests

The type testing shall be conducted on the following equipment

(a) SDH Equipment with all types of cards (optical card, Tributary card or any other equipment as part of repeater less links)

14.30.2.1 List of type test to be conducted on Telecom equipment

The type tests for SDH Equipment with all types of cards, Primary Multiplexer & Drop- Insert Mux with subscriber interface card and DACS are described below:

14.30.2.1.1 Temperature and Humidity Tests

The tests listed below are defined in IEC Publication 60068.

(a) Low Temperature Test: Operation to Specifications

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and

operated for sixteen (16) hours. Its performance is checked during the test.

(2) Degree of Severity: Test shall be done at 0°C

(3) Acceptance Criteria: No degradation of performance during and after the test.

(b) Low Temperature Test : Operation without Damage

Low temperature tests shall be conducted as defined in IEC Publication 60068-2-1, test method Ad, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*)

(2) Degree of Severity: Test shall be done at -10° C

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(c) Dry Heat Test: Operation to Specifications

Dry heat test shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours.

(2) Degree of Severity: As per table 5-1: operation to specification range.

(3) Acceptance Criteria: No degradation of performance during and after the test.

(d) Dry Heat Test: Operation without Damage

Dry heat tests shall be done as defined in IEC Publication 60068-2-2, test method Bd, with the following specifications:

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).

(2) Degree of Severity: Test shall be done at 55ºC.

(3) Acceptance Criteria: Degradation of performance is allowable during the however there shall be no degradation of performance in the *post-test*.

(e) Damp Heat Test

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 60068-2-3 with the following specifications

(1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.

(2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

(f)Temperature Variation Test

Temperature variation testing shall be as per IEC Publication 60068-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

(1) Number of cycles required is five (5)
(2) The degree of severity: temperature TL:0°C, TH: As per table 5-1 (Operation to specification range)
(3) Cycle duration for each temperature is three (3) hours.
(4) Ramp : 1 oC/minute.
(5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

14.30.2.2 Power Supply and EMI/EMC tests

The test procedure and acceptance criteria shall be as defined in IEC 60870-2-1.

Immunity Tests

The list of Immunity tests are specified below in Table 4-4:

Table 4-4: Recommended Immunity Tests

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	Voltage Fluctuations	Yes	Yes	N/A	N/A	Table 11 of IEC 60870-2-1: 1995 - **Level : 1**
2	Voltage dips and Interruptions	Yes	Yes	N/A	N/A	
3	100/1300 µs surge	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995
4	1.2/50 - 8/20 µs surges	Yes	Yes	N/A	N/A	Table 12 of IEC 60870-2-1: 1995 - **Level : 4**
5	Fast transient bursts	Yes	Yes	Yes	N/A	
6	Damped oscillatory waves	Yes	Yes	Yes	Yes	
7	10/700 µs surges	**N/A**	**N/A**	**N/A**	**Yes**	
8	Electrostatic discharge	**Yes**				Table 13 of IEC 60870-2-1: 1995 - **Level : 4**
9	Power frequency magnetic field	**Yes**				Table 14 of IEC 60870-2-1: 1995 - **Level : 4**
10	Damped oscillatory magnetic field	**Yes**				
11	Radiated electromagnetic field	**Yes**				Table 15 of IEC 60870-2-1: 1995 - **Level : 4**
12	Power Frequency voltage on control	**N/A**	**N/A**	**Yes**	**Yes**	IEC 61000-4-16 : 2002-07

Sl No	Immunity Test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
	and signal lines					**Level : 4**
13	DC voltage on control and signal lines	**N/A**	**N/A**	**Yes**	**N/A**	IEC 61000-4-16 : 2002-07 **Level : 4**

(a) Emission Tests:

The list of Emission tests are specified below in Table 4-5

Table 4-5:

Recommended Emission Tests

S. NO.	Emission test	AC Power Supply	DC Power Supply	Control & Signal	Telecom Line	Parametres
1	LF disturbance voltages CCITT Recommendation P.53	N/A	Yes	N/A	N/A	Table 17 of IEC 60870-2-1: 1995 - Class **: B**
2	Transient disturbance voltages	Yes	Yes	N/A	N/A	
3	RF disturbance voltages CISPR 22	Yes	Yes	N/A	N/A	
4	RF disturbance currents CISPR 22	N/A	N/A	N/A	Yes	
5	RF radiated fields CISPR 22	**Yes**				

(c) Insulation Withstand Voltages

As per section 6 of IEC 870-2-1. Recommended class : VW1 of Table 18.

14.30.2.3 Mechanical Tests

(a) Mechanical Vibration Test

The procedure for this test is described in IEC Publication 60068-2-6. The testing procedure shall be carried out in the sequence 8.1 + 8.2.1 + 8.1 as described in document 60068-2-6.

For the vibration response investigation (clause 8.1 of 60068-2-6), the test shall be carried out over a sweep cycle under the same conditions as for the endurance test (described later), but the vibration amplitude and the sweep rate may be decreased below these conditions so that the determination of the response characteristics can be obtained.

The endurance test conditions are selected according to the vibration withstand requirements. Transportation tests shall be performed with the equipment packed according to the Contractor's specifications.

Shock Test

The procedure of this test is defined in IEC Publication 60068-2-27 (each test) with a semisinusoidal shape (clause 3.1.1.2).

The recommended severity shall be A = 294 m/s^2, D = 18 ms. Three shocks per axis per direction shall be

applied to the equipment packed according to the Contractor's specifications.

Or Free Fall Test

This test could be performed as an alternative to the shock or Bump test. The procedure is defined in IEC publication 60068-2-32. The equipment shall be packed according to the Contractor's specifications. The drop height shall be defined in accordance with IEC 68-2-32. The surface of the packing case which comes into contact with the ground is the surface on which the packing case normally rests; if the packing does not have any features (inscription, special shape, etc.) identifying this surface, the test is carried out successively on all the surfaces of the packing.

Or Bump Test

This test could be performed as an alternative to Shock test or Free Fall test. The procedure is defined in IEC 60068-2-29.

14.30.2.4 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 SDH Equipments, associated line & tributary cards, Termination Equipments (Primary Mux, Drop/Insert, DACS, associated Subscriber Line Interface Cards etc), Network Management System etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Equipment 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 test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. List of factory acceptance tests for Fibre Optic Transmission system, Termination Equipment Sub-system and NMS are given in specified Tables in this section. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. The factory acceptance tests for the other 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, alarms and diagnostics etc.

For Test equipment & clock, FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

14.30.2.5 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. In case a number of equipments are required for demonstration of the performance of any equipment during FAT, the sample size shall be taken as that number of equipments which are necessary to demonstrate the performance, irrespective of the percentage.

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.

14.30.2.6 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), along-with information such as sampling frequency, applicable standards, acceptance criteria etc.

Table 4-6:
Factory Acceptance Testing for Fibre Optic Transmission System

Item	Description
1	Physical inspection for conformance to DRS, BOQ, drawings and appearance of equipment
2	Optical output power
3	Transmitter lightwave spectral analysis
4	Low receive level threshold
5	Generation of bit error rate curve
6	Measurement of analog and digital service channel parameters as well as service channel functionality
7	Performance of supervision, alarm, Craftsperson interface, diagnostics, loop backs etc.
8	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, cable compensation, and line rate tolerance for multiplexers
9	At a minimum tests on Ethernet interface shall include demonstration of ping test, throughput test, Latency test, Packet Loss test as per RFC 2544
10	Simulation of failure conditions and failover of each redundant unit.
11	Test of spare card slots
12	Checks of power supply/converter voltage margins
13	Random inspections to verify the accuracy of documentation
14	Test of spare parts/modules/cards as per applicable tests

14.30.2.7 Site Acceptance Tests

The Contractor shall be responsible for the submission of all equipment & 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 Telecom equipment, NMS 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 Telecom equipment 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.

14.30.2.8 Phases for Site Acceptance Testing

The SAT shall be completed in following phases:

14.30.2.9 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense. In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated. The minimal installation testing requirements for fiber optic transmission subsystem, Termination equipment sub-system and NMS are provided in respective Tables in this section.

14.30.2.10 Link Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Delay measurement, Bit Error measurements & service channel performance monitoring shall be made on the fibre optic links to verify compliance with designed link performance.

For Ethernet interface: At a minimum the following test requirements shall be demonstrated as per RFC 2544:

a) Ping test
b) Throughput test
c) Latency test
d) Packet Loss

10% of the total links (Chosen by the Employer, generally to cover links from all configurations used) shall be tested for a duration of 12 Hours. Rest of the links shall be tested for 1 Hour. In case a link does not meet the performance requirements during 1 hour, then the duration of the test shall be increased to 12 hours.

In case any link does not meet the performance requirements during 12 hour, then the cause of failure shall be investigated and the test shall be repeated after rectifying the defects. This phase of testing shall be conducted by the Contractor and witnessed by the Employer. Field adjustments shall be made to meet established standard, however if the field adjustments fail to correct the defects the equipments may be returned to the Contractor for replacement at his own expense. In case any adjustments are required to be made during the interval of the test then the test shall be repeated.

14.30.2.11 Integrated Testing

Prior to commencement of integrated testing the overall system shall be configured as required to provide all the channels required to interconnect the various User's interfaces. The integrated testing for batch shall

include end-to-end testing of back-bone network included in that batch. Integrated testing for last batch shall include testing of the entire backbone. The intent of integrated testing is to demonstrate that the equipment is operational end to end under actual conditions, that all variances identified during factory and field installation and communications testing have been corrected, and that the communication equipment is compatible with other equipment at all locations. The Integrated System Test shall include all fibre optic transmission equipment, the network management subsystem and other components.

At a minimum the following tests shall be included in the integrated testing:

(1) Equipment configuration shall be checked to establish that it supports the channel routing.

(2) Testing of Craft Terminal to demonstrate proper operation of all functions: Configuration Management, Performance Management, Fault, Management and Security management. All the standard features of the Craft Terminal based NMS shall be demonstrated for proper functioning.

(3) Demonstration of Protection switching and synchronization of equipment as per synchronization plan.

Table 4-7

Fibre Optic Transmission system Installation Testing

Item	Description
1	Physical Inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2	Station power supply input and equipment power supply (DC-DC converter) output voltage measurements
3	Terminal transceiver performance testing (Tx power, Tx spectrum, receive signal strength, connector losses etc.)
4	Service channel performance
5	Craftsperson interface, alarm and control functional performance
6	Rack and local alarms: No alarms shall be present and all alarms shall be demonstrated to be functional
7	Network management interface and supervision performance
8	Correct configuration, level setting & adjustments and termination of Input/output interfaces
9	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10	Simulation of failure conditions and failover of protected components.

14.31 Training and Support Services

This section describes the requirements for Contractor-supplied training, support services, and maintenance of the FOTS. The intent of the training and support program is to ensure a smooth transfer of systems and technologies from the Contractor to the Employer, and to ensure that Employer staff is fully trained to operate, maintain and expand the integrated telecommunication network.

14.31.1 Training

The Contractor shall provide a comprehensive training program that prepares the Employer's personnel for on-site installation support, operation, and maintenance of the telecommunication network.

Training may be conducted by the Contractor, the Contractor's subcontractors, and/or original equipment manufacturers (OEMs). The training requirements of this Specification shall apply to all such courses.

Training courses shall be conducted by personnel who speak understandable English and who are experienced in

instruction. All necessary training material shall be provided by the Contractor. The training charges quoted by the Contractor shall include training materials and all associated expenses. However, for all training courses in India or abroad, the travel (e.g., airfare) and per diem expenses covering fooding and Lodging of the participants will be borne by the Contractor. For courses conducted abroad, however, the Contractor shall extend all necessary assistance for making appropriate lodging arrangement.

Hands-on training shall be provided with equipment identical to that being supplied to the Employer. The schedule, location and detailed training contents shall be submitted by the Contractor to the Employer for approval.

14.31.2 System Design & Overview Training

This training shall provide a functional description of the fibre optic transmission system and a discussion of the failover and alternate routing schemes inherent in the configuration. The training shall include an overview of the network configuration and indicate the functional responsibilities of all major subsystems including the network monitoring system hardware and software. The training shall highlight all significant methodologies or concepts utilized by the hardware and software to perform the required functions. High-level hardware configuration block diagrams and network/sub-network block/flow diagrams shall be included to enhance the understanding of the overall capability incorporated into all network and sub-network equipment.

The training shall be oriented to a user's point of view. The Employer/Owner users will include managers, design & planning personnel, communication support staff and maintenance personnel. As part of the proposal, the Contractor shall identify the number of days deemed appropriate for this training.

The overview training shall be customized for the specific functions, features, and equipment purchased by the Employer; it shall not be a general presentation of the Contractor' standard equipment repertoire. Personnel assigned by the Contractor to implement the Employer's system shall conduct this overview training. The Employer shall review and approve the contents of the overview training at least four (4) weeks prior to the course.

14.31.3 Installation & Maintenance Training

There shall be separate modules of the installation & maintenance training for the FO Transmission System.

The installation & maintenance trainings shall enable the Employer to be self-sufficient in preventive & restorative maintenance of the respective communications subsystems purchased by the Employer. **In addition to that the Bidder shall provide Video Tutorials or necessary documentation for maintenance and trouble shooting.**

14.31.4 Network Management Training

The Network Management training shall familiarize the Employer's telecommunication personnel with the concepts and techniques for configuring, programming, maintaining, and troubleshooting the Contractor supplied NMS and its associated database. The Network Management training course shall provide the course participants with hands-on experience using the actual system being supplied.

14.31.5 Training Course Requirements

This section describes general requirements that apply to all training courses

14.31.5.1 Class Size

The Employer plans to send a number of participants to the training courses for a specified duration as described in Appendices.

14.31.5.2 Training Schedule

The Contractor shall provide training in a timely manner that is appropriate to the overall project schedule. All training courses shall be available to the Employer for a minimum of five years after final acceptance of the communication system. The training courses shall be offered in one cycle, such that none of the courses within the cycle overlap.

The Contractor shall take the above requirements into account in developing the preliminary training schedule. Contractor shall develop a final training schedule in consultation with the Employer after contract award.

14.31.5.3 Manuals and Equipment

The Contractor, subcontractor, or OEM shall prepare training manuals and submit them to the Employer for review at least one month prior to the start of classroom instruction. The training manuals shall be prepared specifically for use as training aids; reference manuals, maintenance manuals, and user's manuals may be used as supplementary training material. Principal documents used for training shall be tailored to reflect all the Employer requirements specified.

Each course participant shall receive individual copies of training manuals and other pertinent material at least two weeks prior to the start of each course. The Employer shall retain the master and two additional copies of all training manuals and materials as reference documentation. A complete set of instructor's manuals and training aids shall also be provided. Upon completion of each course, instructor's manuals, training manuals, and training aids shall become the property of the Employer. As part of the delivered system documentation and the final documentation, the Contractor shall supply the Employer with all changes and revisions to the training manuals and other training documentation. The Employer reserves the right to copy all training manuals and aids for use in the Employer-conducted training courses. The Contractor shall furnish for use during training courses all special tools, equipment, training aids, and any other materials required to train course participants.

14.32 Support Services

Throughout design, implementation, factory testing, and field installation and testing, the Contractor shall supply consulting assistance, as required by the Employer for site preparation, field installation, and other areas where technical support may be required. The Contractor shall be responsible for minor facility renovation, and maintenance of the supplied system up to and including successful completion of the Site Acceptance Test. After final acceptance of the communications equipment, the Contractor shall offer continuing technical support and spare parts for the designed life of the equipment or 7 years after the declaration of withdrawal of equipment from production whichever is earlier. However the termination of production shall not occur prior to Operational Acceptance of the system by the Employer.

14.32.1 Technical Support

Consultation with Contractor's technical support personnel and trained field service personnel shall be readily available on a short-term/long-term basis to assist the Employer personnel in maintaining, expanding, and enhancing the telecommunication network upon expiration of the warranty period. The Contractor shall include in their offer(s), a proposal for ensuring continued technical support as stated above

14.32.2 Contractor's Future Hardware/Software Changes

The Employer shall be informed of all alterations or improvements to the hardware supplied under this Specification. The Employer shall be placed on the Contractor's mailing list to receive announcements of the discovery, documentation, and solution of hardware/software problems as well as other improvements that could be made to supply equipment. The service shall begin at the time of contract award, and shall continue for 10 years. The Contractor shall also include a subscription to the hardware subcontractors' change notification service from the time of contract award through the warranty period, with a Employer renewable option for extended periods.

14.32.3 Spare Parts and Test Equipment

The spare parts and test equipment shall be provided for each subsystem as described below.

14.33 Mandatory Spare Parts

Appendices provides the Mandatory Spare Parts Requirements described in **subsystem sets**. The mandatory spare parts table represents the minimum spares the Contractor shall be required to supply. The **subsystem set** of spare parts is defined to include all equipment modules, subunits and parts required to effect replacement, repair and restoration to full operational status of a defined unit of a subsystem.

14.33.1 Test Equipment

Appendix-B provides mandatory test equipment requirements, to be provided. The parameters / features of the mandatory equipments are enumerated in Table 6.2 below and shall be as per the Chapter "spares and tools"

Table 6.2

Sl. No.	Test equipment	
	SDH Analyser	
	Handheld 2Mbps BER Tester	
	Digital Multimeter	
	Ethernet Tester (with dual port, 10/100 ports Mbps Ethernet option, layer-1 & layer-2 functionality)	

In 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.

The Contractor shall provide in their bid, additionally recommended test equipment list necessary to support system availability figures specified in technical specifications. These lists shall include all relevant technical descriptions and recommended minimum quantities based upon the guidelines consistent with the telecommunications resource management hierarchy and continuing maintenance concept. The recommended test equipment shall not be considered for evaluation and may be included in the final scope of supply.

14.34 System Maintenance

As per DoT guidelines, operation and maintenance of the network shall be entirely by Indian engineers and dependence on foreign engineers shall be minimal within a period of two years from the date of LoA. The contractor shall be responsible to maintain the confidentiality of the Employer's System Information that Employer shares with the contractor for maintenance period.

14.34.1 Warranty Period

The one year period commencing immediately after the operational acceptance is called the Warranty Period/Defect liability Period. In addition to the responsibilities covered under Vol I Condition of Contracts during Defect Liability Period, the Contractor shall also be responsible for maintenance of the Fibre Optic Transmission System supplied under this Package. The specification for the maintenance of the system after Operational Acceptance is enclosed at Annexure-I.

14.34.2 Contractor's Maintenance Responsibility

The Contractor shall be responsible for carrying out "Non-Comprehensive Maintenance" of the Communication System for a period of six years after warranty period for ensuring the successful operation of the system. The Contractor shall be responsible for achieving the system availability and the response time mentioned in

technical specifications. The tenderer shall quote the Annual Maintenance Charges for six years after Warranty Period which shall be considered in the bid evaluation. Tenderer shall submit the detailed procedure for achieving above in the bid. The specification for the maintenance of the system is enclosed at Annexure-I. Upon expiry of the six years AMC period Employer may, at its discretion, extend this Maintenance for additional one year at the same price & terms and conditions.

14.34.3 Miscellaneous Supplies

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance. However, if there are any problems in the SAT and additional consumables are required, the same shall also be supplied by the Contractor at no additional cost.

14.35 Documentation

The Contractor shall submit following documents during detailed engineering:

(a) Data Requirement sheets
(b) Link Budget calculations
(c) MQP, FQP
(d) Bill of Quantity including mandatory spares
(e) Previous Type test reports
(f) Factory Test report
(g) Manuals for each equipment
(h) Schematic drawing
(i) Numbering, Marking, labelling document
(j) Synchronization plan
(k) Test schedule
(l) Training manual
(m) Configuration diagram
(n) Transportation & handling Procedure
(o) Installation Manuals
(p) Maintenance Manual

APPENDIX-D

BILL OF QUANTITIES OF FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT
(REFER PRICE SCHEDULE FOR BOQ FIBRE OPTIC TERMINAL COMMUNICATION EQUIPMENT)

APPENDIX-E
(The following data shall be furnished for each of the manufacturer)
DRS Form 01
DATA REQUIREMENTS SHEETS for
OPTICAL LINE TERMINATION EQUIPMENT (OLTE)

GENERAL OLTE FEATURES

Sl No	Parameter:	As per Technical Specification	As per Tenderer Offering
1	SDH hierarchy level: Capacity Aggregate Bit-rate: CEPT E-1 Ports: SDH Heirarchy Level: STM-16	STM-16 620 Mbps 252 x E1	
2	Minimum No. of protected (MSP) directions	Five	
3	No. of E1 ports in E1 tributary Cards	minimum 63	
4	No. of ethernet ports in Ethernet interface tributary cards	minimum 8	
5	Service Channel provision a) Voice Channel b) Data Channel	Yes Minimum 8 Minimum 4	
6	Power Supply cards of SDH Equipment Common Control* Card of SDH equipment	1:1 APS 1:1 APS	

GUARANTEED TECHNICAL PARTICULARS FOR VALVE REGULATED LEAD ACID BATTERY
(To be filled in and signed by the Tenderer)

1	Type/ Designation	48V, 200AH battery bank
2	Manufacturer's type designation	
3	Ampere-Hour capacity 10hrs rate of discharge to 1.75V	
4	Total No. of Plates per cell	
5	Nominal Cell Voltage (V)	
6	No. of Cells in each Bank	
7	No. of Spare Cell, if any, in each Bank	
8	Internal Resistance for each Cell	
9	Resistance of the Battery including Inter-connection between the Cells (Ω)	

1	**Type/ Designation**	**48V, 200AH battery bank**
10	Cell Discharge rate in Ampere (from rated Voltage to final discharge rate in Ampere (i) 5hrs Discharge rate in Amp (ii) 2hrs Discharge rate in Amp (iii) 1hr Discharge rate in Amp (iv) 30min Discharge rate in Amp (v) 10min Discharge rate in Amp (vi) 1min Discharge rate in Amp (vii) 30sec Discharge rate in Amp (viii) 1sec Discharge rate in Amp (Please furnish a graph showing Amps against time for the type of battery offered)	
11	Short Circuit Current (Amps)	
12	(i) Material of Cell Containers (ii) Material used for Battery Box (iii) Trays	
13	Thickness, Type & Material of Separators	
14	Constructional details and dimension: Surface area plates of (i) Positive Plate (ii) Negative Plate in Sq.mm.	
15	(i) Ampere Hour efficiency (%) (ii) Watt Hour efficiency (%)	
16	(i) Recommended Float Charge Current & Voltage (ii) Recommended Boost Charge Current & Voltage	
17	Time required for Boost Charging from Discharged condition	
18	(i) Max. Charging Current/Cell (ii) Nominal Charging Rate	
19	(i) Whether explosion proof or vent plugs provided (ii) Whether vent is spill proof	
20	Type of Inter Cell connection & whether they are covered with plastic sleeves	
21	(i) Dimensions of each 2V Block/Cell a. Length (mm) b. Width (mm) c. Height (mm) (ii) Thickness of Container (mm)	

SECTION-15
TECHNICAL SPECIFICATION AAAC CONDUCTORS AND ACCESSORIES FOR CONDUCTOR

15.1.0 SCOPE

15.1.1 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.

15.2.0 POWER CONDUCTOR

15.2.1 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.

15.2.2 TECHNICAL PARTICULARS

All Aluminium Alloy Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

15.2.3 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.

15.2.4 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.

15.2.5 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.

15.2.6 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.

15.2.7 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

15.2.8 PACKING

15.2.8.1 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.

15.2.8.2 All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

15.2.8.3 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.

15.2.8.4 The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

15.2.8.5 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.

15.2.9 TECHINCAL DATA SHEET FOR CONDUCTOR

AAAC Zebra

Sl. No	DESCRIPTION	PARTICULARS
I	II	III
1	Type of Conductor	All Aliminium Alloy Conductor (AAAC), Strande
2	No of Strand x size	37 x 4.00 mm
3	Conductor over all diameter	38.00 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)	
	Wire Diameter Standard:) Maximum:) Minimum:	 4.00 mm 4.04 mm 3.96 mm
	Resistivity of wire	0.0328 ohms.mm^2/m
	Density	2.70 kg/dm^2
	Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	Cross Sectional area of Aluminium wire	12.57 mm^2
	Approximate Total weight of each strand	33.93 kg/km
	Calculated resistance at 20°C (D.C.)	2.663 ohm/km
	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 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

Sl. No	DESCRIPTION	PARTICULARS
		IV
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
9	Calculated maximum resistance/Km of Conductor at 20°(	0.1182 ohms/km
10	Particulars of Aluminium Alloy Wires (strands)	
	Wire Diameter) Standard:) Maximum:) Minimum:	 3.15mm 3.18 mm 3.12 mm
	Resistivity of wire	0.0328 ohms.mm^2/m
	Density	2.70 kg/dm^2
	Co-efficient of Linear expansion	23.0 x 10^{-6} /^{0}C
	Cross Sectional area of Aluminium wire	7.793 mm^2
	Approximate Total weight of each strand	21.04 kg/km
	Calculated resistance at 20°C (D.C.)	4.290 ohm/km
	Minimum Breaking Load of each strand	2.41 kN – before stranding 2.29 kN – after stranding

15.3.0 GROUND WIRES

Optical ground wire (OPGW) shall be used as mentioned in Bid.

15.4.0 FITTINGS AND ACCESSORIES FOR CONDUCTORS

15.4.1 The accessories for conductors shall conform to IS: 2121 and 2486 (Latest version) in all respects.

15.4.2 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.

15.4.3 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.

15.4.4 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.

15.5.0 FITTINGS AND ACCESSORIES FOR GROUND WIRES

Fittings and accessories for OPGW shall be used as per Bid.