Government of
Democratic Socialist Republic of Sri Lanka

Ministry of Power

CEYLON ELECTRICITY BOARD

Request for Proposals
Development of 100 MW_{AC} Solar PV Power Plant on Build, Own and Operate (BOO) Basis and Construction of 132 kV Transmission Facility on Turnkey Basis

REQUEST FOR PROPOSALS

(APPENDIX 5-B)

GENERAL TECHNICAL SPECIFICATION (GRID SUBSTATION)

CEYLON ELECTRICITY BOARD SRI LANKA

SIYAMBALANDUWA 100 MW SOLAR POWER PROJECT

CONSTRUCTION OF GRID SUBSTATIONS

GENERAL TECHNICAL SPECIFICATION

CONTENTS

1. CHAPTER 01 – GENERAL

This Technical Specification is prepared for lattice tower structures and later includes the details of poles. Wherever the wording "tower" comes alone, it refers to tower/pole where applicable.

1.1. GENERAL DESCRIPTION OF THE PROJECT

The overhead transmission lines to be supplied under this Contract form an extension to the Ceylon Electricity Board Transmission System and are intended to link different CEB substations (either existing or new). The Contractor shall coordinate his work with the other works in progress. The drawings included in Volume 6 of 8 of Employer's Requirements show the geographical location and preliminary proposed line routes.

1.2. GENERAL EXTENT OF CONTRACT

This specification includes the design, manufacture, supply, testing, galvanising, painting (where specified), insurance, packing for export, shipment to a tropical climate, delivery to the Site, custom clearance, unloading, soil investigation, clearing for and provision of access roads where necessary, complete erection, grounding (where necessary), setting to work and defect liability for a period of 365 Days of the specified transmission lines. The preliminary survey of the line routes shall be carried out by the Employer, and the check survey, detailed profile survey, towers spotting using specialised software (PLS-CADD) and pegging out tower positions on Site shall be carried out by the Contractor.

1.3. SPARE MATERIAL

The Contractor shall compulsorily supply the mandatory spare parts listed in Schedules of Rates and Prices.

The Contractor shall estimate items and quantities of spare parts that he thinks necessary or recommendable for maintenance work in the period specified shall be given under recommended spare parts schedule. The offered prices for recommended spares shall be valid until the end of the defect liability period. In the case of no specific rate is given in the Schedules, for a particular recommended spare item, the Contractor shall supply such item at a rate agreed by the Employer based on comparable Schedule rates.

Any spare material shall be strictly interchangeable with the parts for which it is

intended, packed or treated in such a manner as to be suitable for storage in the climate at the Site for an indefinite period, and each part is to be clearly marked for identification purposes, outside the package where applicable.

Spare tower or support material shall be delivered in sets for each individual support and shall be delivered and handed over to the Asset Management stores. In addition, a selection of plain, undrilled, rolled steel angles in 6 m lengths together with plates, bolts and nuts are required as specified in Schedules.

These materials shall be galvanised and be a representative selection of the sizes and thickness used for the Contract and shall be equal in strength to the highest grade of steel used for the equivalent tower components.

All packing remains the property of the Employer. Unwanted packing shall be removed from the Site as instructed by the Employer.

Spare conductor, earth wire and OPGW are to be provided in continuous lengths of a minimum of 1 km each on non-returnable steel drums protected as specified and treated in an approved manner to resist termite and fungus attack during long term storage. Conductor and Earthwire supplied in short lengths will be rejected.

Spare materials so provided shall be delivered into such stores as may be nominated by the Employer. Delivery will not be deemed complete until all packaged material has been checked by the Employer and a written "Good Received Note" acknowledgement obtained. A copy of the "Good Received Note" acknowledgement issued by the Employer must accompany the invoice when requesting payment. Prior to handing over the date of spare material, the Contractor shall be responsible for all security arrangements and the safe custody of the spare materials.

1.4. ELECTRICAL DESIGN DATA

The following are the general particulars governing the design and working of the complete electrical system of which the works will form a part:

- Electrical energy is generated at interconnected power stations as a three-phase current at a frequency of 50 Hz and transmitted therefrom by means of overhead lines.
- The existing transmission system in Sri Lanka consists of overhead lines operating at 50 Hz.

- The system will]continuously operate during the varying atmospheric and climatic conditions occurring at all seasons.

Description	400 kV	220 kV	132 kV
Maximum System Voltage (kV)	420	245	145
Nominal System Voltage (kV)	400	220	132
System Frequency (Hz)	50	50	50
Lightning Impulse Withstand Voltage (kV)	1425	1050	800
Switching Impulse Withstand Voltage (kV)	1050	NA	NA
Power Frequency Withstand Voltage (kV)	650	460	275
Symmetrical Short Circuit Current (kA)	40	40	31

1.5. ACCESS TO THE LINE

The drawing shows the preliminary proposed routes of the transmission lines to be provided under this Contract and their positions relative to important features in the area.

The main port of entry into Sri Lanka is Colombo.

The Contractor shall make his own arrangements for transporting materials to the project sites by whichever method he chooses, including arrangements for offloading, storage areas and distribution points. Any limitation on loads due to local conditions, such as restrictions on bridges, availability of railway wagons, etc., shall be taken into account by the Contractor. If any approvals are required, they shall be obtained by the Contractor from the relevant body.

Line routes marked in Survey Department Maps, scale 1: 50,000 showing road and rail communications, ground contours and local features in the area are available in Volume 6 of 8 of Employer's Requirements.

1.6. SAFETY OF PERSONNEL

The maximum safety, consistent with good erection practice in the case of line works above ground, must be afforded to personnel directly engaged on this Contract, or who in the normal course of their occupation find it necessary to utilise temporary works erected by the Contractor or frequent the working area. Reasonable measures shall be taken to afford adequate protection against material falling from a higher level onto personnel below.

Particular care shall be taken during work at places where the new lines of this Project shall run in close proximity to existing lines under operation (energised).

The operation of or connections to any items of equipment once made live shall be subject to a "Permit to Work" system and will be arranged by the Employer in accordance with the Employer's standard regulations for such work.

"Request for power interruptions (Shut-down)" with work schedule shall be submitted 30 days in advance by the Contractor to accommodate such facilities.

The Contractor shall be bound by the Employer procedures for the safety of workers and shall be adhered to relevant provisions of the Factories Ordinance No. 45 of 1942, including all the amendments.

1.7. OTHER SERVICES

1.7.1. LIVING ACCOMMODATION

The Contractor shall make his own arrangements with regard to accommodation for his expatriate staff and locally recruited Labour during the construction of the transmission line.

All dwellings and buildings existing or erected for the purpose by the Contractor shall comply with local regulations in regard to construction, water supply and sanitation and other requirements. Temporary construction camps shall be provided with proper sanitation and other necessary facilities. All accommodation shall be removed by the Contractor when no longer required and before the granting of the Final Certificate. After the removal of accommodation, the ground shall be left in a clean and tidy condition.

The Contractor shall provide and maintain living accommodation for the Employers and Employers supervision staff at the locations requested in the Scope of Works. The location of housing shall be to the approval of the Employer.

The accommodation may be provided in rented houses/ flats. Where the Contractor proposes to rent accommodation, the location, furnishing, fittings and other facilities shall be subject to inspection and approval by the Employer. It shall have separate bedrooms with attached bathrooms, and each bedroom will accommodate a maximum number of two persons. The accommodation should have sufficient parking space with driver's accommodation.

The Contractor shall provide staff for cleaning and for general duties in the Employer's living accommodation.

All accommodation shall be weatherproof, equipped with electricity, landline telephone facility, water, and connected to the sewerage system and supplied at no additional cost.

1.7.2. EMPLOYER'S SITE OFFICE

The site office shall be either temporary or permanent as requested in the Scope of work. The Contractor shall provide all services and fittings and maintain them up to the date of handing over the Project.

This site office shall be erected immediately as the Contractor commences operations on the Site in a position as directed by the Employer outside the chain-link fence.

The permanent site office shall be in accordance with the given drawing. The office shall be provided with all the services, including Water, Electricity, Air conditioning, Printing/ Scanning/ Fax machines, and Internet and Telephone facilities, to the satisfaction of the Employer. Service connections shall be provided for all the facilities, and the Contractor shall be responsible for all connection and consumption costs. Toilets shall be draining to a suitably sized septic tank with overflow to an enclosed soak away. The office building shall have a damp-proof floor and be provided with a roof. It is to have opening windows fitted with sunblind. The office and toilet facilities and all services shall be provided and maintained to the Employer's satisfaction. The services and maintenance (including security) shall be provided until the taking over the date of the work. The Contractor shall provide two executive tables, four chairs, two cupboards for the Employer's room, one conference table with eight chairs and all the equipment for the pantry as requested by the Employer.

Finishes shall be as follows;

Item	Description	Office room	Conference Room	Pantry	Toilet	Veranda
1	Floor	Tiled	Tiled	Tiled	Tiled	Tiled
2	Walls	Emulsion painted	Emulsion painted	Emulsion painted Tiled	Tiled	Emulsion painted
3	Ceiling	As instructed by the Employer				

4	Roof	Zinc Aluminium with Insulation	Zinc Aluminium with Insulation	Zinc Aluminium with Insulation	Zinc Aluminium with Insulation	Zinc Aluminium with Insulation
5	Doors	Plywood	Plywood	Plywood	Aluminium/PVC	Plywood
6	Windows	Timber with glazed shutters	Timber with glazed shutters	Timber with glazed shutters	Timber with glazed shutters	Timber with glazed shutters
7	Furniture and Fittings	Office Room table & 6 chairs	Conference table & 6 chairs	Pantry cupboard with kitchen sink dining table 4 chairs	Commode, cistern washbasin, shower mirror and other accessories	
8	AC and ventilation	AC and Ceiling fans	AC and Ceiling fans	Ceiling Fan		

The temporary site office shall be provided as instructed in the Scope of work. The Contractor shall provide staff for cleaning, maintenance, and general duties of the Employer's site offices.

1.7.3. STORAGE FACILITIES

The Contractor shall make his own arrangements for storage areas and campsites.

The Contractor shall, in all cases, obtain the approval of the Employer to the places along the route of the line where he intends to distribute line materials. In no case will this be outside the authorised line trace area unless special arrangements are made with the adjacent property owners at the Contractor's own expense.

1.7.4. ELECTRICITY AND WATER SUPPLY, LIFTING FACILITIES, MEDICAL ARRANGEMENTS

The Employer will not be able to assist the Contractor in any specific arrangement for the provision of the above items. The Contractor must therefore make his own arrangements in this respect.

1.7.5. TRANSPORT FOR EMPLOYER'S PERSONNEL

The Contractor shall provide, maintain, and keep available at all times the transport for the exclusive use of the Employer and the Employer's officers engaged in the Project. In the event of unavoidably due repairs or overhaul, the Contractor shall

provide an equivalent substitute.

The specification for the vehicles shall be as follows for the Contract.

(a). Cars with engine capacity of 1500 cc petrol engine, four doors, 4 passenger capacity with air conditioning, CD/ Radio/ MP3 and all other standard fittings and safety facilities such as seat belts, headsets, SRS airbags for front passenger/ driver, height-adjustable seat for the driver, power mirrors and ABS brakes with EBD.

(b). Off-Road four-wheel drive (double cab) turbocharged, common rail direct fuel injection Diesel engine with a displacement not less than 2400 cc, minimum torque of 250 Nm shall develop at 2500 rpm, five-speed forward and reverse having a single drive plate clutch or Automatic transmission with a minimum of four speeds and reverse, four doors, four-passenger capacity with air conditioning, CD/ Radio/ MP3 and all other standard fittings and safety facilities such as seat belts, headrests, SRS airbags for front passenger/ driver, height-adjustable seat for the driver, power mirrors and ABS brakes with EBD.

(c). Two-wheel drive (double cab/van) with engine capacity of 2500 cc of less diesel engine, four doors, four-passenger capacity with air conditioning, CD/ Radio and all other standard fittings and safety facilities such as seat belts, headrests, SRS airbags for front passenger/ driver, height-adjustable seat for the driver, power mirrors and ABS brakes with EBD.

All vehicles should be new when supplied and shall remain property of the Contractor throughout the duration of the Contract.

Within one month after the taking over certificate is issued, the vehicles shall be officially transferred to the Employer. They shall be in sound technical condition with new tires, including spares and a complete set of tools. The Contractor shall provide a sole agent company certificate about the vehicle condition. All damages shall be repaired, and full technical service performed to the satisfaction of the Employer.

The Contract rates for transport of the Employer's personnel shall include for each vehicle the fixed cost of the vehicle; comprehensive all-inclusive, insurance, revenue license, registration, license plates, fuel oils, lubricants, repairs, maintenance and the provision of one full-time competent driver and all other costs and charges not specifically mentioned but which may be incurred during running and keeping of the vehicles throughout the Contract.

The Employer shall have an option to request additional vehicles against the same rate if it becomes necessary.

Not later than two months from the Contract commencement date, the Contractor shall provide the vehicles as above.

The vehicle shall be made available for full use during the period of Contract working hours which are 7.00 to 18.00 hours from Monday to Saturday. The vehicle should be available on Sundays or after 18.00 hours if necessary.

1.7.6. STAFF TRANSPORT

The Contractor shall provide, at his own expense, all necessary transport for his own staff and materials.

1.7.7. GENERAL

Without prejudice to the generality of the several Clauses of the Contract and except for the facilities referred to in this clause, particular attention is drawn to the obligation of the Contractor to make his own arrangements at his own expense for supply and furnishing of offices, workshops, stores and store compounds and the watching and guarding of such.

1.8. TRAINING

The Contractor shall provide comprehensive training on the following modules. A detailed training proposal shall be submitted with the Bid, including areas/ stages with the time duration required to cover each section.

Training modules shall be provided as described below;

Computerised Transmission Line Design Using PLS Software

Intended to learn how to use modern integrated software to expedite the design and upgrading of transmission lines and practice using specialised line design software.

- Software system overview
- Survey data handling and terrain modelling
- Conductor design and modelling
- Structure modelling using PLS TOWER (methods 1 and 4)
- Structure modelling using PLS POLE
- Interactive line design and generation of construction documents

- Modelling existing lines, assessment and refurbishment
- Using detailed structure models for strength verification

Design of Transmission Lines, Structures and Foundations

a) Referring to basic principles of transmission line design and behaviour.
   - Surveying, selection of routes and tower spotting,
   - Design of lattice towers
   - Design of single and multiple pole structures
   - Foundation design
   - Conductor design and behaviour
   - Insulation coordination
   - Selection of insulators and other accessories

b) Referring to upgrading and uprating of existing transmission lines
   - Line assessment and upgrading concepts
   - Strength analysis of existing structures, foundations etc.
   - Lines uprating by reconductoring with advance conductors designed for increasing the power transfer capacity (HTLS or other types)

Erection and Hot Line Maintenance

It is Intended to learn best practices followed during the erection of overhead transmission lines and the use of hotline tools for the maintenance of four circuit transmission line towers and pole structures. The programme shall comprise class and on-field presentations, including practicals.

- Best erection practices for overhead lines
- Predictive and preventive maintenance of transmission lines
- Inspection and Condition monitoring of techniques
- Safe working distances for overhead line maintenance
- Live Line Maintenance

The entire cost of the training, including course fee, course material, food etc., shall be borne by the Contractor.

1.9. SOFTWARE PACKAGES

The software package used for transmission line design shall preferably be PLS CADD and TOWER (developed by "Power Line Systems Inc." USA). The Contractor shall submit all his PLS designs written on a compact disc to the Employer for

approval. Once the designs and construction are finalised, complete Project backup files, including structure files (method 1 and method 4), feature code files, criteria files, aerial images etc., shall be handed over to the Employer written in an electronic format. The final design will be the property of the Employer.

In the case where other software packages are used, prior approvals shall be obtained from the Employer, and they shall be freely accessible to the Employer throughout the Project Period. Output data files of such software programmes shall also be submitted to the Employer in electronic format.

1.10. DESIGN AND CONSTRUCTION

Each and every part of the Plant which is designed and constructed shall ensure long and continuous service life with a high economy and low maintenance costs.

All material used under this Contract shall be new and of the best quality and workmanship and shall be of the highest standard throughout the designs and dimensions of all parts such that the stresses to which they are subjected shall not render them liable to distortion or damage under the most severe conditions encountered in service. Welding, filling, plugging, or any repair to defective parts shall not be permitted without approval in writing from the Employer.

All equipment shall operate without undue vibration and with the least possible amount of noise and shall not cause a nuisance.

The detailed design shall be such as to facilitate inspection, cleaning, repairs, simplicity of operation and hotline maintenance. All apparatus shall be designed to ensure satisfactory operation under the atmospheric conditions prevailing in the area where the lines are to be constructed, irrespective of season, and under such variations of load and voltage as may occur under the working conditions of the system. The design of all line supports, conductors, insulators and fittings shall be such as to minimise the risk of damage due to deterioration or damage in service of any part of the transmission lines. The design shall incorporate any reasonable precaution and provision for the safety of those concerned in the maintenance of the Contract Works and all associated works supplied and executed under other Contracts.

All corresponding parts shall be made to gauge, shall be interchangeable wherever possible throughout the Contract Works, and are to be such as will facilitate the fitting of replacement parts.

1.11. COMPLIANCE WITH STANDARDS

Unless another standard is mentioned explicitly in this specification, all materials used and provided under the Contract must, where such standard exists, be in accordance with the Standards of the International Electrotechnical Commission (IEC) or the British Standards Institution (BS) latest published standard prior to the date of closing of Bids or in accordance with such other authoritative standard appropriate to the country of manufacture as in the opinion of the Employer ensures to be equivalent or higher quality.

At the bidding stage, the standards to which the equipment is manufactured and to which materials conform must be clearly stated if it is different from the standards of the IEC or BS.

If the Contractor offers materials or equipment which conform to standards other than those published by the International Electrotechnical Commission or the British Standards Institution, full details of the differences between the proposed standard and equivalent IEC/ BS, in so far as they affect the design or performance of the equipment, are to be supplied by the Contractor to the Employer for approval. In this case, a copy of the relevant standard in the English Language shall be provided to the Employer.

If the Contractor requires third party assistance with regard to the content of this specification during the designing or construction stage, the Contractor shall obtain prior approval from the Employer to seek the third-party consultation.

1.12. STATUTORY REGULATIONS

The Works and all Plant, equipment and materials forming part of this Contract are to comply in all respects with any relevant local Statutory Regulations, Bylaws and Orders currently in force.

1.13. LANGUAGE

The English language is to be used in all documents contained in the Contract and in all correspondence between the Contractor and the Employer. Whenever anything is required under the terms of the Contract to be written, marked, printed or engraved, the English language is to be used except where otherwise specified in this document.

1.14. CORRESPONDENCE

All correspondence on matters arising out of the Contract is to be addressed by the

Contractor to the Employer.

1.15. UNITS OF MEASUREMENTS

International System of Units (SI) is to be employed in all correspondence, technical Schedules and drawings etc.

Angular measurement shall be in degrees, with 90 degrees comprising one right angle.

1.16. ERECTION AND CHECKING AT SITE

All work at Site shall be carried out in such a manner as not to obstruct operations of any other Contractor on any Substation or the operation of any existing Grid Substations and power lines.

The carrying out of all work included in the Contract shall be supervised by a sufficient number of qualified representatives of the Contractor, and full facilities and assistance shall be afforded by the Contractor for the Employer to check the Works. The supervisors shall have a good command of the English Language, and any instruction given to them by the Employer shall be interpreted as having been given to the Contractor. The supervisors shall be well qualified by having the required training and experience in the installation and operation of equipment of the charter covered by the specification. They shall supervise and assist in installing, testing and placing in the operation of the line, complete with ancillary apparatus. For all purposes, the English language shall be used. The qualifications and experiences of the Contractor's proposed supervisory staff shall be communicated to the Employer for approval.

The Contractor shall obtain the details of the parts which the Employer wishes to inspect, but such inspection shall in no way exonerate the Contractor from any of his obligations. The Contractor, if requested by the Employer, is to open up for inspection before re-erection any equipment which has been delivered to the Site partly assembled.

The Contractor shall keep the Site, on which he erects or stores plant, reasonably clean, removing all waste material resulting from the Works as it accumulates and as reasonably directed. On completion of the Works, the Site shall be left clean and tidy to the satisfaction of the Employer. Any damage done to buildings, structures and Plant or property belonging to the Employer or any other third party shall be made

good at the Contractor's expense.

The Contractor shall be responsible for satisfying himself as to the correctness of the electrical and mechanical connection to all Plant supplied under the Contract before such Plant is brought into commission.

1.17. TRANSPORT TO SITE

The Contractor shall bear all expenses in connection with the importation and transportation to the Site of all Plant, material and things needed for the purpose of the Contract, including warehouse rent, handling and other charges.

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

The Contractor shall observe any regulations which limit loads on the roads and bridges over which material may be conveyed. Before moving any heavy traffic onto highways, roads and bridges, the Contractor shall make suitable arrangements with the appropriate Governmental authorities and obtain their approval for the passage of such traffic.

The handling and storage of any plant at the Site are to be at the risk of the Contractor and without responsibility to the Employer.

The Contractor shall arrange for the protection, to the satisfaction of the Employer, of all material against corrosion and mechanical damage during storage and erection at the Site.

1.18. DEFECT LIABILITIES

The Contractor shall guarantee the efficient and good working of the Works supplied under the Contract for a period of 365 days from the date on which the Employer is Taking over the Works in accordance with the General Conditions of Contract.

1.19. CONTRACTOR'S EMPLOYEES

The Contractor shall fulfil all his obligations in respect of accommodation, feeding and medical facilities for all personnel in his employ, in accordance with the responsibilities imposed on him by Clause 1.7.1 or as necessary to ensure satisfactory execution of the Contract. He is also to comply with all local statutory

employment regulations requirements.

The Contractor shall be responsible for the behaviour on Site of all personnel employed by him.

1.20. CONTRACTOR'S RESPONSIBILITIES

Unless explicitly stated to the contrary in the Bid with full supporting explanations, the Contractor will be deemed to have concurred as a practical manufacturer with the design and layout of the Works as being sufficient to ensure reliability and safety in operation, freedom from undue stresses and satisfactory performance in all other essentials as a working plant.

The Contract shall include the whole of the Works which are described in or implied by the Contract document. All matters omitted from the Contract document, which may be inferred to obviously necessary for the efficiency, stability and completion of the Works shall be deemed to be included in the Contract Price.

Works shown upon the drawings and not mentioned or described in the specification and works described in the specification and not shown on the drawings shall nevertheless be held to be included in this Contract, and execution shall be covered by the Contract Price in the same manner as if they had been expressly shown upon the drawings or described in the specification.

The Contractor shall, in conjunction with the Employer, set out terminal tower positions from which the Contractor on his own responsibility shall duly set out all other Works, but under the direction and to the satisfaction of the Employer and according to the drawings supplied or approved by the Employer, and the Contractor shall also find all Labour, stakes, instruments and other things and do all other things necessary for the use of the Employer for checking such setting out and also for the periodical measurement of Works executed and materials supplied.

The Contractor's representative on the Site or his nominated deputy shall be given full responsibility to enter into negotiations regarding points arising out of erection so that the work may be expedited with as few delays as possible.

The carrying out of all work on the Site included in this Contract shall be supervised throughout by a sufficient number of qualified representatives of the Contractor who have had a thorough experience of the erection and commissioning of similar works.

Unless otherwise specified, the Contractor shall supply the whole of the Labour and equipment required for the completion of the Works.

The Contractor shall arrange for all necessary permissions for temporary access routes, storage areas and working areas required to construct the works, including payment of any compensation to stakeholders (if any).

1.21. DETAILS OF OFFER AND VARIATIONS FROM SPECIFICATION

The Bid is to be accompanied by any necessary additional detailed specification of the various items of Plant and equipment, which are offered, and the Schedules in the specification are to be completed.

Notwithstanding, any description, drawings or illustrations which may be submitted with the Bid, will be deemed to be in accordance with the specification and the standard specifications and codes referred to therein.

No departures from the specification, except for those shown in the tabulated statement and approved by the Employer, are to be made without the written approval of the Employer.

1.22. WORKING DRAWINGS/ DOCUMENTS (MANDATORY DOCUMENTS TO BE SUBMITTED FOR DESIGN REVIEW)

Working drawings for all elements of the work, including details of materials to be used, shall be submitted in 4 (four) hard copies and 4 (four) softcopies written in a CD/ DVD to the Employer for approval before the works are undertaken and at an early stage of the Contract. Scanned copies are not allowed other than test reports. The following essential drawings/ documents shall be submitted for approval;

a) Drawings, type test reports, catalogues, manufacturer's reference list, performance certificates and latest ISO certificates of the following items;
    a. Conductor
    b. GSW
    c. OPGW
    d. Insulator units
    e. Hardware fittings for insulator strings
    f. Hardware for Conductor, GSW and OPGW
b) Route Maps, including the list with all angle points final GPS coordinates (in UTM format / SLD99)

c) Design initial and final conductor, earth wire and OPGW sag and tension calculations and charts

d) Wind span/ angle of deviation application charts for each type of angle tower

e) Creep compensation calculations/results provided/authorised by the conductor manufacturers

f) Detailed wire clearance diagrams for all tower types showing any special equipment required, e.g. insulator set extension linkages, weighted pilot suspension insulator sets, etc. Softcopies shall contain both AutoCAD and pdf versions

g) Towers outline diagrams showing main leading dimensions, electrical clearances, design spans, body and leg extensions and main equipment characteristics (type of conductors, Earthwires, OPGW, insulators, etc.)

h) Tower/ Pole design calculations and stress diagrams, including the critical foundation reactions, in both hard-copies and soft copies, preferably using PLS TOWER/ PLS POLE design. The corresponding tower/pole models (.tow/.pol file) corresponding to each tower/pole type shall be provided as well in soft format

Computations shall be presented in a clearly arranged format and worked out in detail to demonstrate clear evidence of each stage of work. The use of computers and appropriate software programs is desirable. Computer input data and results shall be provided without any restrictions or copyrights. Graphical calculation of forces is not admissible. The applied formulae for computation of tower member stability shall be clearly stated to enable subsequent checking. Applied formulae for computation and relevant references shall be clearly stated

The software used and the design shall be freely accessible to the Employer for checking tower designs and conductor behaviour. A copy of the software design shall be handed over to the Employer for approval before the construction begins (see clause 1.9)

i) Tower detailed (analytical) loading calculations corresponding to each loading design assumption and the resulting loading diagrams (loading trees)

j) Detailed Longitudinal Profile Survey including geo-referenced aerial photographs. Additionally, the Contractor shall provide survey data of the XYZ terrain model in soft format (.csv or .xls file)

k) Complete Line Design in PLS-CADD in two variants for analysing towers/poles strength:

- Method 1 using dummy (sketch) tower/pole models
- Method 4 using full 3D tower/pole models.

In both cases, the Contractor shall submit hard copies of the longitudinal profile with towers/poles spotting together with soft copies, including the complete line design (.bak) file and in the case of Method 4, all the (.tow/.pol) models for each of the tower/pole types used within the towers/poles spotting

l) Stringing Charts

m) General arrangement and shop drawings, erection diagrams and material lists for each type of tower, tower extension, auxiliary cross-arm, cross-arm extension and any other special supports, extensions and parts of supports (as required), giving total weights of steelwork above and below ground and showing all types of foundation stub steelwork, details of the insulator and earth wire clamp attachment, details of earth wire bonding to tower tops and buried earth wire connections to the tower base, complete with all necessary information, stub setting templates

n) Tower accessory drawings

o) Foundation design calculations and detailed drawings for each type of foundation and type of soil considered together with relevant soil test reports, steel reinforcement schedules and stub setting template drawings

p) Access route maps (1: 50,000) for each location

q) Material Schedules (see Clause 1.35) and line Schedules (see Clause 1.36). These Schedules may be combined

r) Wind span/weight span application charts for the suspension towers (used for limiting vertical suspension insulation strings inclination in case of 132 kV and 220 kV lines)

s) Drawings of conductor and Earthwire/ OPGW drums

t) Drawings of Tower Identification Plates and Accessories

u) Method statements describing the main construction procedures (foundation and earthing system installation, tower erection, conductors and OPGW stringing, etc.)

v) Stringing Schedules and drum schedules

After approval of all design calculations and drawings by the Employer, the Contractor shall supply further or revised copies as required.

All design documentation (Calculations and Drawings) shall be submitted in both hard copies and soft copies as instructed by the Employer at the time of the design review stage.

Except as otherwise explicitly approved, all drawings shall be of a size not greater than A0 and not smaller than A4.

If the Contractor requires early approval of any drawing to avoid delay in the delivery of the Contract Works, he shall advise the Employer to such effect when submitting the drawings.

However, it is to be understood that approval of the drawings shall not exonerate the Contractor from any responsibility in connection with the work.

All drawings submitted by the Contractor or by a sub-Contractor shall have the following particulars in the lower right-hand corner in addition to the Contractor's name, date, scale, number and title of the drawing, Contract number and plant description;

Ceylon Electricity Board

(Name of the Project)

Revision details are to be clearly and comprehensively recorded. Reference to the revision shall be made by a suffix to the drawing number.

All prints shall be folded to A4 size, and the title, drawing number and revision suffix shall remain visible.

1.23. PROGRAMME OF WORK

Within one month of acceptance of the Bid, the Contractor shall forward to the Employer four copies of Gantt charts in MS Project format detailing the plant manufacture, delivery and erection programme for the Transmission lines for approval. The Contractor shall provide copies of the approved charts as required by the Employer with a soft copy.

The charts are to indicate all the various phases realistically of work for every item from the commencement of the work to its final completion, e.g. design, ordering of

materials, manufacture, testing, delivery, erection and commissioning. Some of the above-mentioned activities have to be shown separately for the time components like survey, access roads and wayleaves, foundations, towers, insulator sets, conductors/ earth wire accessories, and conductors/ earth wires.

If at any time during the execution of the Contract it is found necessary to modify the approved charts, the Contractor shall inform the Employer and submit modified charts for approval. Such approval shall not be deemed to be consent to any amendment of the completion dates stated in the Schedule.

The Contractor shall provide for the Employer on Site, weekly, a summary of erection work he proposes to carry out during the following week, including exact locations, name of gang's leader, number of gangs involved, time of start and completion.

The Contractor shall arrange for shipment of materials inadequate time to suit the site erection program. He shall not, however, ship materials unnecessarily early in the Contract in order to take advantage of the supplier's favourable prices, thus involving the Employer in unnecessarily early payment.

1.24. PROGRESS REPORTS AND MEETINGS

At monthly intervals after approval of the program for the works charts referred to in Clause 1.23, the Contractor shall submit to the Employer detailed progress reports (in triplicate) in an approved form, indicating the stage reached in the design, financial progress, ordering of material, manufacture, delivery, transport and erection of all components of Plant in comparison with the target and actual plan ("S" curves). These reports shall be forwarded promptly so that on receipt by the Employer, the information contained therein is not more than seven days out of date. Copies shall also be forwarded to the Employer on Site.

Monthly progress meetings shall be scheduled with the Contractor during the course of the Project. It is anticipated that the meetings will be held during the first full working week of each month, and the progress report should be submitted a minimum of five working days in advance of the meeting.

During the progress of the work, the Contractor shall provide a reasonable number of colour photographs of an approved type at the direction of the Employer. These photographs shall supplement the Progress Reports and Records where necessary and show any unusual form of construction or foundation work. Up to three prints of photographs so ordered along with the soft copies shall be handed over to the

Employer.

If, during the execution of the Contract, the Employer considers the progress position of any section of the work to be unsatisfactory, he shall be at liberty to call such meetings as he deems to be necessary. If required by the Employer, the Contractor's Project Manager with necessary officials shall attend such meetings.

Access to the Contractor's and sub-Contractor/s works shall be granted to the Employer at all reasonable times for the purpose of ascertaining progress.

1.25. PROTECTION OF THE ENVIRONMENT AND ADHERENCE TO THE ACTS, REGULATIONS AND GUIDELINES

The selected Contractor is responsible for full compliance with the following acts, regulations and/or guidelines with respect to the execution of this Project.

- National Environmental Act No. 47 of 1980 including all the subsequent amendments.
- Guidelines for Environmental and Social Considerations.

The bidders also shall take into consideration the relevant costs that will be incurred for the strict adherence to the environmental safeguard measures stipulated in the environmental approvals and the relevant documents forming part of such approvals obtained under the above acts/regulations/guidelines with respect to this Project.

1.26. OPERATING AND MAINTENANCE INSTRUCTIONS

Before commencement of conductor stringing, the Contractor shall submit to the Employer for approval fully detailed operating and maintenance instructions for compression tools and the method of making compression joints and any other working equipment.

The instructions shall be as simple and straightforward as possible, fully illustrated with drawings and diagrams as necessary and detailed with part numbers for ordering replacements. Two copies shall be supplied for the use of the Employer during erection work.

A further six copies shall be reproduced as a book or books of approximately A4 size and bound into strong black durable imitation leather covers inscribed upon the front generally in the form of the title page to this document except that the references to Specification, Conditions of Contract, Drawings, etc., shall be replaced by "Operating

and Maintenance Instructions".

The finished books shall be handed over to the Employer no later than one month before the Taking-over Certificate is issued for the last transmission line on this Contract.

1.27. PACKING

The whole of the Plant shall be packed where necessary in non-returnable cases or on non-returnable drums or otherwise prepared for overseas shipment to a tropical country in a manner suitable to withstand rough handling without sustaining damage.

Bundles of steel angle sections shall be properly tied together by an approved method, and care shall be taken to ensure that they are robust and not of excessive length for handling during shipment. All labels shall be of stamped metal.

Unless the Contractor can offer an equally acceptable method, bundles of angles shall be arranged in a rectangular formation with notched outer stout wooden battens to locate the angles, the battens being compressed on the bundles by outside tie bolts - , the above binders being located at sufficiently close intervals to form a solid and homogeneous element.

Bundles shall be as large as practicable to provide stiffness and resistance to careless handling.

Packing cases where used shall be strongly constructed and in no case is timber less than 25 mm in thickness to be used. The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens. Cross battens supporting weight in any direction shall not rely for their support on nails or screws driven lengthwise into the grain of the wood but shall be supported by cleats secured from the inside.

Bolts and nuts shall be crated for shipment.

Crating together components of dissimilar metals is unacceptable.

Particular attention shall be given to strutting before packing cases are fastened down. Cases shall be upended after packing to prove that there is no movement of the contents.

Timber wedges or chocks shall be firmly fastened in place to prevent their

displacement when the timber shrinks.

If light parts are fastened to the sides of a case, hoop iron straps secured by screws shall be used for the purpose. Nails driven in and bent over shall not be permitted.

Where bolts are used, large washers shall be fitted under the head and nut to distribute the pressure, and the timber shall be strengthened by means of a pad.

Drums for conductor and earth wire and OPGW shall be stoutly constructed of good quality timber and clearly marked with the length and type of conductor in a manner not easily removable. Drums shall be securely battened around the perimeter and shall be lined with an approved material to give maximum protection to the conductor. Drums shall be suitable for rolling on the flanges without causing damage to the conductor or earth wire, and the direction of rolling shall be clearly shown.

All drums and battens shall be protected from deterioration on Site by termite or fungus attack by an approved impregnation treatment at the works before dispatch.

The first layer of the conductor shall be secured to the hub in a manner avoiding damage to subsequent layers and shall be covered with an approved waterproof lining.

The packing of Room Temperature Vulcanisation (RTV) Silicone coated insulators shall be taken up by means of Styrofoam boxes that can be manipulated safely in order to avoid the risk of damage to the coating either in the factory or during transportation and installation. Additionally, the string shall be stored vertically to avoid rubbing on the shell of the crate as well as to avoid getting excessive weight on top of each other.

The Contractor's attention is drawn to the provisions of Clause 1.33, wherein the Contractor shall be required to protect all steelwork before shipment to prevent damage to galvanised surfaces by white rust.

All stencil marks on the outside of casings shall be either of waterproof material or protected by shellac or varnish to prevent obliteration in transit.

The use of wood wool as a packing material shall be avoided at all times.

Waterproof paper and felt linings shall overlap at seams at least 13 mm and the seams secured together in an approved manner, but the enclosure shall be provided

with screened openings to obtain ventilation.

Each crate or package shall contain a packing list in a waterproof envelope, and copies in triplicate shall be forwarded to the Employer prior to dispatch. All items of material shall be clearly marked for easy identification against the packing list.

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

The Employer may require inspecting and approving the packing before the items are dispatched, but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transport, and such inspection shall not exonerate the Contractor from any loss or damage due to faulty packing.

1.28. ERECTION MARKS

All tower members shall be stamped with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks shall be impressed before galvanising and shall be clearly readable afterwards.

1.29. LINE SCOPE LIMIT OF SUPPLY AND INTERFACE WITH SUBSTATION

The interface between the transmission line and substation are the gantry structures at the end substations

- Terminal towers, including their foundations, line side tension insulator strings, inverted tension insulators, and tension clamps at the substation gantry structures, shall be the responsibility of the line Contractor (both supply and installation).
- Phase conductors shall be terminated at the substation gantry structures by the line Contractor.
- Gantry structures, including their foundations, jumper suspension insulators attached to the gantries, as well as down droppers to the substation equipment, shall be the responsibility of the substation Contractor (both supply and installation) unless otherwise specified in the Scope of work.

The Scope and limits of supply and installation of OPGW are:

- The line Contractor shall install the OPGW link between the substation ends
- OPGW supply and installation up to substations gantries, dropper to the terminal box and terminal box installation at the base of the gantries, including splicing

works, shall be the responsibility of the line Contractor.

- Installation of OFAC inside substations between terminal boxes on gantries and patch panels inside the communication room of the control building shall be the responsibility of the Line Contractor.

1.30. BOLTS, NUTS AND WASHERS

Members of lattice steel structures, including stub-setting templates, shall be secured by means of bolts and nuts with approved spring washers. All bolts and nuts shall conform to ISO 898-1 and shall preferably have screwed threads of ISO form. Nuts and heads of all bolts shall be of the hexagonal type. Nuts (except locks nuts) shall be full bearing on one face.

The minimum size of bolts for all structural connections shall be 16 mm in diameter for both mild steel and high tensile steel.

All bolts and screwed rods shall be galvanised, including the threaded portions. All nuts shall be galvanised with the exception of the threads, which shall be oiled. The nuts of all bolts attaching insulator set droppers, U bolts and earth conductor clamps to the towers shall be locked in an approved manner. The screwed thread of any bolts or studs shall not form part of a shearing plane between members. When in position, all bolts or screwed rods shall project through the corresponding nuts for at least a complete turn, but such projection shall not exceed 10 mm.

Where for any type of tower, high tensile steel bolts are employed, then bolts of this type shall be used for all connections for every type of tower on the line in order to avoid the use of mild steel bolts in error where high tensile type should be employed. High tensile steel bolts shall bear a mark on the heads to allow identification of grades.

All washers shall be included under this Contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the Employer. Taper washers shall be fitted where necessary.

Nuts shall be finger tight on the bolt and will be rejected if they are, in the opinion of the Employer, considered to have an excessively loose or tight fit. Bolts with threads re-died after galvanising will be rejected. Nuts and bolts of the same size shall be interchangeable and supplied from one manufacturer.

The Contractor shall select two samples of each type of bolt, nut and washer to be used in the Contract and submit these two samples to the Employer for approval

within one month of the date of issuing the suborder. The Employer will then reject bolt consignments which fall in any respect below the standard of samples submitted and approved. The importance of supplying good quality, well-finished nuts and bolts cannot be overemphasised.

To prevent the theft of tower members, special measures shall be taken, or special bolts connections shall be installed for the connection of all diagonal members and secondary bracing members below the anti-climbing device. The Contractor shall describe his offered system and verify the effectiveness of the anti-theft device and mechanical strength capacity, bolt geometry, and corrosion resistance compared to an ordinary bolt connection.

1.31. CASTINGS

All castings shall be as free from blowholes, flaws and cracks as is practicable. No welding, filling or plugging of defective parts shall be done without the sanction of the Employer and then only with his approval in writing. All cast-iron shall be of close-grained quality approved by the Employer.

1.32. WELDING

In all cases where fabrication welds are liable to be highly stressed, such as may be the case in parts subject to reversal of stresses in operation, the Contractor shall supply the Employer with a general arrangement drawing of the fabrication and, at a later date, but before fabrication commences, a detailed drawing of all proposed weld preparations on the fabrication. Before such welding commences, the Contractor shall satisfy the Employer that the welders or welding operators are qualified in accordance with the requirements of the appropriate section of BS.4872 or other relevant Standard Specification approved by the Employer.

After scrutinising the general arrangement and welding detail drawings, the Employer shall inform the Contractor of the stages at which inspection will be required. It shall be the Contractor's responsibility to notify the Employer when one or more of the inspection stages will be reached, and no further work shall be carried out until the specified stage has passed the Employer's inspection.

In addition to the above, the Employer reserves the right to visit the Contractor's Works at any reasonable time during the fabrication of the Plant items and familiarise himself with the progress made and the quality of the work to date.

In the event of the Contractor wishing to make an alteration to any part of the weld preparation, he shall first submit to the Employer a copy of the revised drawing showing the amended preparation in detail and await confirmation of its acceptance or non-acceptance.

1.33. GALVANISING

All steelwork shall be hot-dip galvanised in accordance with internationally recognised standards such as EN ISO 1461, or equivalent, providing a smooth, clean and uniform zinc coating of min 85 µm thickness for bars and plates and 55 µm for bolts and nuts. The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.

All defects of the steel surface, including cracks, surface laminations, laps and folds, shall be removed. All drilling, cutting, welding, forming and final fabrication of unit members and assemblies shall be completed before the structures are galvanised.

The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the items to be galvanised. After galvanising, holes shall be free from nodules of spelter.

It is essential that the shape of steel members and assemblies which are to be hot-dip galvanised shall conform to the requirements of the process and contain drainage (vent) holes as required.

On removal from the galvanising bath, the resultant coating shall be smooth, continuous, and free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross. Excessively thick or brittle coatings due to high levels of silicon or phosphorus in the steel, which may result in an increased risk of coating damage and/or other features that make the final product non-fit-for-purpose, shall be considered as a basis for rejection.

Bolts, nuts and washers, including the threaded portions, shall be hot-dip galvanised and subsequently centrifuged. The threads shall be cleaned of all surpluses on packing, clear of the ground and away from all materials that might stain or corrode the galvanising. Dies shall not be used for cleaning threads other than on nuts. Nuts shall be galvanised and tapped 0.4 mm oversize, and threads shall be oiled after galvanisation to permit the nuts to be finger turned on the bolt for the full depth of the nut.

Materials on which galvanising has been damaged shall be re-dipped unless in the opinion of the Employer, the damage is local and can be repaired by applying a coating of galvanising repair paint.

Where such repair is authorised, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits of xylene, followed by wire brushing. After wire brushing, the area shall be re-cleaned with solvent to remove residue and shall be given one heavy brush coat of galvanising repair paint. The percentage of pure zinc by weight in a dry film of galvanising repair paint shall not be less than 85%.

Zinc repair paint or spray of approved quality is to be provided with the tower steel supply in sufficient quantity to enable touch-up repairs of damaged areas.

In areas more prone to corrosion, the minimum zinc coating shall be 915 g/m2 (127 microns). All galvanised steel in areas other than C1 and C2 corrosively environments (as per ISO/EN 12944) should be protected with an appropriate paint coating with Epoxy Primer. During painting, it is compulsory to use stripe coating prior to the first coating to ensure continuous dry film thickness all over the surface. Stripe coating is a part of the first coating and shall not be considered a separate coating layer. The durability of the coating should be considered as more than 15 years, as mentioned in ISO/EN 12944. The corrosivity environment category of the Site should be referred from the Site environmental conditions of the Scope of work of this Contract document.

Steel tower materials shall be treated with Sodium Dichromate or Preton W20 solution after galvanising to prevent the formation of white rust. During transportation and storing of hot-dip galvanised parts, provisions shall be kept to ensure proper circulation of air between stacked parts to prevent forming white rust.

All steel wires shall be galvanised by an approved process before stranding. The zinc shall be smooth, clean, of uniform thickness and free from defects and shall withstand the tests set out in BS 443. The requirements in respect of stranded steel buried counterpoise earth wire are given in Clause 2.7.

If any galvanised part is found to be imperfect, it shall be replaced. The whole of the expense involved in the replacement of the defective part shall be borne by the Contractor.

The Contractor shall provide an instrument for checking galvanising thickness, e.g.

Coating Thickness Gauge, or otherwise agree with the Employer an approved method of testing galvanising on Site.

If, in the opinion of the Employer, the extent of damage found on Site to a galvanised part appears capable of repair, the Contractor may, after receiving such agreement, attempt to effect repair by approved methods. The agreement to attempt repair shall not bind the Employer to accept the repaired part when this is re-offered for inspection.

In the event that it is found that galvanised parts are subject to the formation of white rust or damage resulting from chemical contamination, during shipment or storage on Site, the Employer shall either;

(a) Approve a system of scrubbing and protective painting to be applied on Site if, in his opinion, this is expedient, or

(b) Forthwith, order that the affected parts shall be condemned and that all future shipments shall receive, before dispatch from the works, special dip or spray treatment to individual members to his approval without extra charge to the Employer.

Either of the above measures shall not be held as a cause for failure to meet the Line Completion Dates.

1.34. SUB-CONTRACTED PARTS AND MATERIAL

Triplicate copies of all sub-Contracted Plant and material orders, including revisions thereto, shall be submitted to the Employer for approval at the time any such order is placed. Copies submitted shall be clearly marked on the first page with the reference and title stated in Clause 1.22 and a statement that the Plant and materials shall be inspected by the Employer.

The Contractor shall also provide the Employer on Site with names and details or local sub-Contractors before such subcontracts are placed. The Employer reserves the right to withdraw his consent to local sub-Contract arrangements if such is considered unsuitable, but consent shall not be unreasonably withheld.

1.35. MATERIAL SCHEDULE

As soon as final tower positions are selected and approved, the Contractor shall provide promptly complete lists summarising all materials to be supplied.

1.36. RECORD MAPS, PROFILES, SCHEDULES

During the progress of the work, the Contractor shall record on profiles, approved line Schedules and on a set of Survey Map transparencies to 1: 50000 or other approved scale, such particulars as will allow an accurate reference to be made afterwards in case of any faults or projected modifications to the lines. The map and/ or profile sheets shall show the exact position of every support with approved reference marks so that, in conjunction with the line Schedules, the types of structures, foundations, insulators, the position of tension joints, etc. and the number of circuits can be ascertained quickly. The maps shall be supplemented, or profiles marked, by sketches where necessary, to delineate boundary positions of towers that cannot be clearly indicated on the maps. The data included on the maps, profile, sketches and line schedules shall include provisional and final tower numbers, spans, wind spans, weight spans, angles of deviation, types of towers, types of insulators and earth wire attachment, the earthing system installed, and any other information considered necessary for reference during the operation of the Contract and shall be to the approval of the Employer, to whom facilities shall be given for examining such records during the progress of the work. The maps, sketches, profiles and schedules shall be prepared for the Employer but will be in charge of the Contractor until the completion of the particular section of the work to which they refer.

1.37. CROSSING OVER TELECOMMUNICATION LINES / RAILWAY

Where the transmission line crosses over a telecommunication line/ railway, crossing guards may be fitted at crossings as directed by the Employer where the guards are required during the course of the Contract. Guard shall generally be in accordance with the Drawings of this bidding document for telecommunication line crossings. Guard wires shall be adequately earthed.

1.38. TRANSPOSITION

Transpositions are not required.

1.39. CONTRACTOR'S PLANT OR EQUIPMENT

At the conclusion of the Contract, should it be desired to retain possession of all or any of the Contractor's Plant or equipment, the Employer shall be at liberty to do so upon paying for the same such price as shall, in case of difference, be fixed by the Employer.

1.40. ELECTRICITY AND WATER SUPPLY

The Contractor shall make his own arrangements for electricity and water necessary for constructional purposes, and all expenses shall be deemed covered by the several rates contained in the Schedules.

Any apparatus and provisions necessary for the distribution and use of such electricity and water must also be provided by the Contractor at his own expense.

The Contractor shall also make his own arrangements direct with other Contractors for any such services which they are prepared to provide.

1.41. FINAL RECORDS ("AS-BUILT" DOCUMENTATION)

After all items of the Plant have been manufactured and erected, six white prints on heavy-duty paper shall be submitted showing the details and arrangements of the Plant As-Built and installed.

A soft copy consisting of Drawings in AutoCAD and PDF format, calculations and other relevant documents in Microsoft Excel or Word formats, and line design outputs of PLS CADD and PLS TOWER, shall be provided in five (05) Compact discs. Scanned softcopies are not permitted.

The following documents, drawings and calculations will be required;

a) Tower and foundation designs and calculations, along with the relevant tower design software files used

b) Manufacturing/ Shop drawings for all types of towers/poles and foundation details, including all types of extensions

c) Insulator string sets plus component parts

d) Earth wire/ OPGW suspension and tension sets plus component parts

e) All types of connectors, spacers, dampers and joints

f) Conductor and earth wire, OPGW initial/final sag tension charts

g) Wire clearance diagrams

h) PLS designs (Profile designs including method 1 and 4 structure files), Tower designs and PLS Pole including 3D models of poles

i) Detailed Survey Data AutoCAD file comprising geo-referenced aerial imagery

j) Material lists for each tower

k) Stub setting templates

l) Line schedules

m) Record of sagging particulars

n) Tower identification/ warning plates and accessories

o) Profile with tower locations

p) OPGW Suspension and Tension set plus components

q) Drum Schedules and stringing charts

r) All Product/ material details and the FAT reports

s) The following parameters for each line;

Positive sequence impedance, zero sequence impedance, mutual impedance, positive sequence capacitance, zero sequence capacitance

A list showing drawing numbers and titles and covering all record drawings shall form part of the final records. Final record copies shall be handed over before the issue of the Taking over Certificate.

1.42. GENERAL LINE AND ROUTE REQUIREMENT

Since the transmission lines cross several 33 kV and lower voltage lines, it is anticipated to realise such crossings using standard towers with extensions. If it is deemed necessary by the Employer, 33 kV and lower voltage lines may be modified or deviated at crossing positions. In such cases, the Employer will arrange to carry out this work.

The power interruption necessary for the execution of connection works will be arranged by the Employer but limited to daytime only. The rates are deemed to allow meeting any constraints.

All dismantled materials and equipment shall be delivered to the Employer's stores and handed over to the Employer.

1.43. AUTHORISATION OF DOCUMENTS/ DESIGNS

The following drawings and design reports shall be submitted to the Employer immediately after the Employer's approval.

a) The complete report of towers and foundation design calculations for each tower type and their extensions.

b) Shop drawings of towers and templates for each tower type and their extensions.

c) Erection drawings of towers and templates and their extensions.

d) Detailed drawings of foundations and stubs and their extensions.

e) PLS design files for towers and profile

All the above-mentioned drawings and design reports submitted to the Employer and approved by the Employer shall become the sole property of the Employer. The Contractor shall transfer all the rights with respect to the above designs and drawings to the Employer so that the Employer can use them without any restrictions and conditions for his use in future.

1.44. INFORMATION TO BE SUPPLIED WITH THE OFFER

Details with descriptive matters, catalogues indicating the drawings, references and literature of the items offered in accordance with relevant clauses of the Technical Specification, including the following particulars, shall be furnished with the offer.

a) The Bidder shall ensure that each main equipment offered under this Contract is manufactured by a manufacturer with a minimum of fifteen (15) years of successful experience in manufacturing comparable equipment, in rated voltage and capacity, to the equipment offered under the Contract. In addition, a minimum of ten (10) years of experience shall be in manufacturing for orders from outside the country of the manufacturer.

b) In respect of each main equipment offered under this Contract, the Bidder shall ensure that equipment identical in design had been in service for a minimum period of five (05) years. In addition, a minimum of three (03) years of service shall be outside the country of the manufacturer.

c) Company Profile, Constructional features, datasheets, materials used for components etc

d) Drawings for each of the main components, indicating main dimensions and relevant technical characteristics

e) Manufacturer's Authorization Letter

f) Certificate of type tests carried out in accordance with the specified standard and issued by an independent testing authority (Accredited based on ISO/IEC Guide 17020). The Tests have been conducted in an accredited laboratory based on ISO/IEC guide 25/17025 or EN 45001 by the National Accreditation Body of the country where the laboratory is located. The test certificates should

cover all the relevant tests as stated in the applicable standards/ technical specifications.

g) Performance certificate with regard to manufacturing, supply and utilisations of all major items offered

h) The technical particulars and guarantees (if any) requested in Volume 07 of 08

i) Certificate issued by an independent international organisation to ensure compliance to the ISO 9001 (latest) standards by the manufacturers

Failure to furnish these particulars may result in the manufacturer being rejected.

CHAPTER 2 - CONDUCTORS AND ACCESSORIES

CONTENT

CLAUSE TITLE PAGE

2. CHAPTER 02 – CONDUCTORS AND ACCESSORIES

2.1. APPLICABLE STANDARDS

The equipment or components supplied shall be in accordance with the standards specified below or the latest editions and/or amendments thereof. Offers of Items manufactured to any other internationally recognised standards or specifications not less rigid shall accompany an English version of such standards.

a)	BS 215	-	Part 2 (1970) Aluminium conductors, steel reinforced
b)	BS EN 50182	-	Conductors for overhead lines - round wire concentric lay stranded conductors
c)	IEC 62420	-	Concentric lay stranded overhead electrical conductors containing one or more gap(s)
d)	IEC 61232	-	Aluminium-clad steel wires for electrical purposes
e)	IEC 60888	-	Zinc - coated steel wires for stranded conductors
f)	IEC 60889	-	Hard drawn Aluminium wires for overhead line conductors
g)	BS EN 61284	-	Overhead lines, Requirement and tests for fittings
h)	IEC 61854	-	Requirements and tests for spacers
i)	IEC 61897	-	Requirement and tests for Stockbridge type Aeolian vibration dampers
j)	BS EN 50189	-	Conductors for Overhead lines – Zinc coated steel wires
k)	IEC 61089	-	Round wire concentric lay overhead electrical stranded conductors.
l)	BS EN10244-2-		Steel wire and wire products — Non-ferrous metallic coatings on steel wire — Part 2: Zinc or zinc alloy coatings.
m)	BS 183	-	General purpose Galvanised Steel Wire Strand
n)	BS 3288	-	Insulator and Conductor fittings for Overhead lines
o)	IEC 61597	-	Overhead electrical conductors - Calculation methods for stranded bare conductors

p)	IEC 61394	-	Overhead lines - Requirements for greases for aluminium, aluminium alloy and steel bare conductors
q)	IEC 61395	-	Creep Test Procedures for Stranded Conductors
r)	BS EN 50326	-	Conductors for overhead lines. Characteristics of greases
s)	IEC/ BS EN 62219	-	Overhead electrical conductors. Formed wire, concentric lay, stranded conductors

2.2. GENERAL

The line conductor shall be of Aluminium Conductor Steel Reinforced (ACSR) as specified under Employer's Requirements, Scope of Work. On all transmission lines, two earth wires shall be installed: one Galvanised Steel Wire (GSW) and one Optical Fibre Ground Wire (OPGW).

The Galvanised Steel Wire (GSW) shall be of type 7/3.25 mm for 132 kV and 220 kV lines according to BS 183/ BS EN 50189.

The Optical Fibre Ground Wire (OPGW) shall be mechanically equivalent to the corresponding Galvanised Steel Wire (GSW).

Conductors and earth wires shall have characteristics entered in the Technical Particulars and Guarantees in Volume 03 of 08. For the details of OPGW, please refer to Chapter 03 of this document.

2.3. CONDUCTORS

2.3.1. ACSR CONDUCTORS

Except where otherwise specified or approved, the Aluminium Conductor Steel Reinforced shall comply in all respects with the requirements of IEC 61089, BS 215 or other approved standards. The outer layer wires and steel core wires shall be pre-formed so that they remain inert when the conductor is cut. Complete conductor except the outer layer shall be greased according to IEC 61089 Annex C: Case 2. The type of grease shall conform to requirements as per BS EN 50326. The stranding of each layer of the conductor shall be as close and even as possible. The outermost layer of the conductors shall be stranded with a right-hand lay. The conductor materials, grease and current-carrying fittings are to be suitable for continuous operation at 80°C without deterioration.

The aluminium shall be of the highest purity commercially obtainable, but the aluminium content shall not be less than 99.5%. The minimum conductivity of aluminium shall be 61% IACS. The Contractor shall submit certificates of analysis giving the percentage and nature of any impurities in the metal from which the wires are made. There shall be no joints in the individual wire.

Unless the Contractor can produce evidence in the form of service records, test certificates etc., which demonstrate to the satisfaction of the Employer that this requirement is met, the Contractor shall carry out such tests as the Employer may require at no additional cost to the Employer.

The conductor shall have the following characteristics;

Stranding Details	Aluminium	54 × 3.18 mm diameter
	Steel	7 × 3.18 mm diameter
Conductor Diameter		28.62 mm
Total Cross-Sectional Area		484.5 mm^2
Mass of conductor without grease		1621 kg/km
DC Resistance		≤ 0.0674 Ω/ km
Final Modulus of Elasticity		69 000 N/mm^2
Ultimate Tensile Strength		≥ 131.9 kN
Coefficient of linear expansion		19.3 × 10-6 /C

2.4. ALUMINIUM CLAD STEEL EARTH WIRE

Aluminium Clad steel earth wire shall be according to BS EN 50182: type 49-A20SA for 132 kV line and 220 kV line. The individual component ACS wires shall comply with IEC 61232 class 20SA type A or higher. The aluminium used for covering shall have a minimum purity of 99.5% and quality sufficient to meet thickness and electrical resistance requirement of the standard. Conductors shall generally be stranded with such lay ratios that each individual wire in a layer is in contact with adjacent wires in the same layer. All wires shall be of uniform circular section, smooth and free from surface imperfections.

Aluminium clad steel wires shall be preformed so that they remain inert when the conductor is cut. The outer layer shall be right-hand lay. There shall be no joints in individual wires in a drum length.

2.5. GALVANISED STEEL EARTH WIRE

Galvanised steel earth wire complete conductor shall be according to BS 183: type 7/3.25 mm of minimum Grade 1000 for 132 kV line and 220 kV line. Conductors shall

generally be stranded with such lay ratios that earth individual wire in a layer is in contact with adjacent wires in this same layer.

2.6. COUNTERPOISE EARTH

Counterpoise earth shall be 7/4.0 mm stranded galvanised steel wire. It shall be electro- galvanised to provide a coating of at least 580 g of Zinc per square meter of surface.

2.7. GALVANISING

Except where specified to the contrary, all-steel wires shall be galvanised by an approved process before stranding. The Zinc shall be smooth, clean, of uniform thickness, free from defects, and withstand the test set out in BS EN 10244. The requirements in respect of stranded steel Counterpoise wire are given in Clause 2.6.

2.8. JOINTS, CLAMPS AND CONNECTORS

2.8.1. GENERAL

All conductor and earth wire clamps and fittings shall be designed in accordance with BS 3288; Part 1. They shall comply with the requirements of this specification and shall be approved by the Employer.

The Contractor shall ensure close and continuous liaison between the manufacturers of conductors, clamps, insulators and fittings so that the equipment will be perfectly adapted. Besides, the Contractor shall assure perfect fitting of the insulator set to the tower steel construction.

The design of all joints and clamps and any special tools to be used in their assembly shall minimise the possibility of faulty assembly. All external nuts shall be locked in an approved manner. There shall be no relative movement within the clamp between individual layers of the conductor itself. Bolts and nuts shall be in accordance with an approved specification. Bolt thread shall be coated with approved grease immediately before packing.

In order to maintain low corona and low radio interference, the design of all clamps and fittings shall avoid sharp corners or projections, which would produce high electrical stress.

The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under

service conditions. Particular care shall be taken during the manufacture of clamps and fittings and during subsequent handling to ensure smooth surfaces are free from abrasion.

All line fittings concerned shall allow for live-line maintenance and shall be dimensioned and designed to withstand the short circuit currents shown in Clause 1.4. The Employer may require tests to be carried out to demonstrate the short circuit characteristics of each type of insulator set and connection-to-tower set. The cost of such tests shall be borne by the Contractor.

An adequate bearing area shall be provided between different fittings. Point contacts shall be avoided.

All ferrous parts of the assembly's component elements and accessories for conductors and OPGW shall be hot dip galvanised with a minimum zinc weight of 700 g/m^2, except bolts, nuts, and washers, a minimum zinc weight of 500 g/m^2 will be accepted. The split pins of all clamps and fittings shall be of stainless steel.

2.8.2. SUSPENSION CLAMPS

The conductor suspension clamps shall be of high-tensile corrosion-resistant aluminium alloy, suitable for a continuous working temperature of 80°C. The clamping components shall be forged or cast. In the case of casting, an additional reinforcing strap is foreseen.

The suspension clamps shall be as light as possible and a vibration-proof cover type. They shall be such as to form fully articulated support for the conductors. The clamp bodies shall be centrally pivoted, and the rotational axis of the clamp shall be preferably at the same level as the conductor centre line or below but not above. The clamp body shall be able to pivot at least 45° above and below the horizontal line. Special attention shall be paid to the mass moment of inertia of the clamp in order to avoid resonance of the clamp plus conductor system by wind-induced vibrations. The Contractor shall ensure by appropriate calculations and design a suitable suspension clamp for the specified conditions also from this point of view.

The phase conductors shall be protected within the suspension clamps by means of armour rods, and the dimensions of the clamps shall allow for this requirement. The armour rods shall be designed in such a way as to strengthen the conductor in the suspension points and to reduce the static and dynamic bending strains in the strand wires of the outer conductor layer.

The suspension clamp components shall be dimensioned and shaped in such a way that no undue crushing or bending stresses are imposed upon the conductors and armour rods.

The conductor supporting groove shall be curved at its ends in the vertical plane to an appropriate radius to allow the conductor to leave the clamp at the maximum inclination angle (20°).

The mouth of the supporting groove shall be slightly flared in the plan. The grooves in the clamping piece shall be bell-mouthed at each end, and all conductor grooves and bell mouths shall be smooth and free from waves, ridges or other irregularities.

The bolts used in the suspension clamps shall be hexagonal hot-dip galvanised (500 g/sq.m) or stainless-steel bolts. The washers underneath the bolt head shall be made from stainless steel only.

Subsequent to tightening bolts to the torque as recommended by the manufacturer, the clamp shall be capable of withstanding the maximum working tension of the conductor without any conductor slippage. They shall permit the conductor to slip at a load lower than the conductor breaking load.

Attention must be paid to the elimination of fair-weather corona emission from all parts of conductor suspension clamps under specific site conditions.

The suspension clamp shall allow its live–line disengagement from the insulator string.

2.8.3. TENSION CLAMPS AND MID-SPAN JOINTS

Conductor tension clamps and joints shall be of the compression type, suitable to withstand a continuous working temperature of 80°C. The coupling element of the tension clamps to the string shall be clevis-type, hot-dip galvanised.

The electrical conductivity and current carrying capacity of the tension clamps, joints and jumper terminals shall be not less than those of the equivalent length of the conductor.

Attention must be paid to avoid fair weather corona emission from the conductor tension clamps and joints.

Dead end clamps and tension joints shall be of the compression type and shall be

made so as not to permit slipping of or cause damage to or failure of the complete conductor at a load less than 95% of the ultimate strength of the conductor.

The design of all compression fittings for each type of conductor shall be such that only one pair of dies for steel and one pair of dies for aluminium are necessary for the compression of all the steel or Aluminium sleeves provided. All the fittings shall comply with the tests according to IEC 61284.

Joints and tension clamps shall be made of aluminium alloy steel. The split pins used shall be of stainless steel. Joints and tension clamps shall be supplied with filler compounds to protect the assembly clamp-conductor against corrosion.

All Aluminium compression type clamps, connectors and joints shall be of a purity of not less than 99.5%. Non-ferrous alloys shall be such as to withstand atmospheric conditions without painting or other protection. The Contractor shall submit certificates of analysis for the various parts of fittings.

Dead end clamps and tension joints for the galvanised steel earth wire shall be of austenitic stainless steel. The construction and grade of stainless steel should be such as to limit the degree of work hardening caused by compression of the fitting. Fitting will not be accepted if they show a hardness after compression of more than 350 (Vickers Pyramid No.) or equivalent.

Jumper terminals shall be of the compression type and suitable for connecting to tension clamps by bolting. The mating faces of the jumper terminals and tension clamps are to be protected at the manufacturers' works by a strippable plastic coating or any other approved means.

Mid span joints shall be of compression type and shall have at least 95% of the ultimate strength of the conductor. Their use shall be minimised, while the fullest possible use shall be made of maximum conductor lengths. Where these are unavoidable, the mid-span joint shall not be used less than 30 m from the nearest conductor bind or clamp, and there shall not be more than one joint per conductor in any one span.

Mid span joints shall not be used in single span sections, where lines cross over other power lines, communication circuits or pass over or in close proximity to buildings.

All joints shall be made with proper care, in preparation and execution. The conductor

shall be properly cleaned with a wire brush, immediately before the joint is made. All connections involving ACSR conductors shall be pre-packaged with suitable grease to prevent corrosion of the conductor and ensure a low resistance joint after completion.

Rates for supply and erection of all mid span joints shall be deemed to be included in the appropriate conductor or earth wire.

T connectors for conductors (where applicable) shall take the form of an aluminium sleeve, which is compressed over the through conductor, with an attached lug for bolting to a jumper terminal.

2.8.4. JOINTS AND REPAIR SLEEVES

Conductor repair sleeves shall not be used without the permission of the Employer, which will be granted only in exceptional circumstances.

Joint sleeves and repair sleeves for the conductors shall be of the compression type. The joint sleeves shall consist of a steel compression sleeve for the core of the conductor and an aluminium compression sleeve for the complete conductor. The aluminium compression sleeves shall be of aluminium alloy conforming to the specification in IEC 60889 standard or equivalent, and the steel compression sleeves shall be of carbon steel conforming to the specification in BS 970 part 1.3 standard or equivalent.

Damages that reduce the strength of the outer layer of the conductor by an amount equivalent to one strand but not more than three strands shall be treated as follows:

Repair with compression repair sleeve. Do not allow repair sleeve or patch rods within a distance of three (3) metres from the centre of the suspension clamp. Should damage occur within this distance, move the conductor until the damaged area is beyond the three (3) metres range.

Damage in excess of three broken strands or any damage to strands of the inner layer, Cut out and splice with a compression joint. Any strand that has lost 50 per cent or more of its cross-sectional area is to be considered as having lost all of its strength.

After compressed, the electrical resistance of the joint sleeve must be less than that of the jointed conductor with the same length as the sleeve, and the ultimate tensile

strength of the joint sleeve must not be less than 95% of the ultimate tensile strength of the conductor.

2.9. VIBRATION DAMPING SYSTEM

Spacer and vibration dampers shall satisfy the requirements specified in this specification and IEC 61284, 61854 and 61897 as relevant.

Control of vibration and spacing within the bundled phase conductor shall be done by means of a combination of vibration dampers (Stockbridge Damper) and spacer dampers.

The efficiency of the proposed system for damping aeolian vibrations shall be demonstrated by calculation, i.e. the supplier must have developed suitable computer programmes which have been verified against experimental investigations and the behaviour of actual transmission lines so that he is able to simulate the behaviour of the bundle when subject to wind-excited vibrations, either at low frequency (sub-span oscillations) or at higher frequency aeolian induced vibrations. Based on the type of conductor and its tensile load, the supplier shall submit a damping study, with calculations of vibration amplitude and strain on conductors with and without spacer dampers and dampers.

Phase conductor bundle separation for 132 kV line and 220 kV line shall be 400 mm.

2.10. VIBRATION DAMPERS

Vibration dampers of asymmetrical Stockbridge type shall be installed at all phase conductors and OPGW/ Earthwire suspension and tension points and shall be mounted on armour rods. A minimum of two dampers per span shall be provided; one damper per span is not permitted. The continuous operating temperature shall be 80°C. A minimum number of Stockbridge dampers to be installed is as follows;

- Span < 300m - two (02) dampers (one at each end)
- 300< Span <500 - four (04) dampers (two at each end)
- 500< Span - six (03) dampers (three at each end)

Two dampers per span shall be fitted to each conductor for spans up to 300m, four between 300m and 500m and six where the span exceeds 500m.

Regarding the damping characteristics of the vibration damper, the Contractor shall guarantee that close to the suspension clamps as well as to the damper own clamp, the amplitudes of the wind vibrations are kept within acceptable limits over the entire range of possible frequencies. The Contractor shall guarantee by means of

corresponding calculations that the bending stress of the conductor will be restricted to maximum of 150 micrometers per meter and the expected life of the conductors is at least 100 years.

The Contractor shall submit all data and calculations regarding the characteristics, number and placement of the vibration dampers to be used for the various ranges of spans. The calculations shall take into considerations the local conditions of the terrain morphology, the wind velocities and directions and the medium height above ground of the conductors and OPGW. All data for the calculations shall be in responsibility of the Contractor and shall be subject for approval of the Employer.

The damper clamps shall be of forged aluminum alloy and shall be designed to ensure that dampers do not damage the conductors and OPGW for which they are used.

As function of the necessary distance between the first vibration damper and the mouth of the suspension clamp on the phase conductor, the damper clamp shall be dimensioned taking into account the installation on conductor or on the armour rods.

The clamping bolts shall be of steel having a minimum tensile strength of 80 N/sq.mm and shall be designed to facilitate an easy damper mounting. The screws shall be locked in an approved manner. The washers shall be made of stainless steel.

Elastomers or other non-metallic materials if used shall have good resistance to ageing and be capable of withstanding temperatures between +0°C and +80°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultra-violet radiation and air pollution over the entire temperature range.

The damper shall be designed to eliminate water collection. If this is not possible, they shall have drainage holes with a minimum diameter of 6 mm.

All ferrous parts of the damper component elements shall be hot dip galvanised with a minimum zinc weight of 700 g/sq.m except bolts and nuts where a minimum zinc weight of 500 g/sq.m will be acceptable.

The conductor dampers shall be corona-free and shall not generate radio noises.

2.11. SPACER DAMPERS

Spacer dampers shall be provided in each span and installed in accordance with the

manufacturer's recommendations, subject to the approval by the Employer.

They shall be efficaciously distributed along the spans at approved unequal intervals, but at minimum 2 m away from any mid span joint or repair sleeve or any other fitting attachment to the conductor so that the following requirements are met. The Contractor will guarantee by means of corresponding calculations that the bending stress of the conductor will be restricted to maximum 150 micrometers per meter and the expected life of the conductors is at least 100 years.

Spacer dampers shall be designed to maintain or restore the specified geometric configuration of the conductor bundle, even when the latter is subjected to different actions (e.g. wind, short-circuit etc).

Sub-conductor contacts under normal service conditions are excluded; the conductor bundle must have a satisfactory torsional stability; damage of sub-conductors and of spacer dampers themselves by short-circuit is excluded.

All bolts of the spacer dampers shall be captive and the shape of the clamp shall provide a large radius around the conductor in order to guarantee a corona-free level similar to that of the conductor bundle.

The clamps shells and the spacer himself shall be made of corrosion-resistant high-strength aluminum alloy, resistant at working temperatures of 80°C.

The clamps shall not be less than 120 mm long and shall be provided with an adequate clamping surface secured by not less than two bolts and with a radius at the clamp mouth to prevent damage to the conductor. Alternative designs of clamp and bolt arrangements can be considered on evidence of satisfactory service experience.

The clamping bolts shall be of steel having a minimum tensile strength of 80 N/sq.mm. No bolt or nut shall require a tightening torque greater than 44 Nm. Nuts shall only need slackening, not removal, in order to fit the spacer to the conductors. The nuts or bolts shall be locked in an approved manner against vibration loosening.

Spacer clamps shall incorporate an approved arrangement to ensure that the correct clamping pressure is maintained when conductor strands move due to bedding down, creep and tension or temperature variation. Clamps shall not damage the conductor at any time.

Elastomers or other non-metallic materials shall have good resistance to aging and be capable of withstanding temperatures between 0°C and +80°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultra-violet radiation and air pollution over the entire temperature range.

The bolts and nuts used in the spacer clamps shall be galvanised (500 g/sq.m) or of stainless steel. The washers underneath the bolt head shall be made from stainless steel only.

The spacer dampers shall be capable of the movements shown below without damaging the conductors:

- Longitudinal movement parallel to the conductor max 90 mm
- Vertical movement at right angle to the conductor max 50 mm
- Torsional movement (angular movement in a vertical plane parallel to the conductor) max 2 deg.

The spacer dampers shall be designed and manufactured by an approved company which can show that similar spacer dampers have been supplied by them to Electrical Power Utilities for overhead transmission lines with double conductors and can also show that the equipment supplied has provided several years of trouble free service with those Utilities. The Contractor shall provide details which include a full and complete specification of the materials, manufacture and guaranteed performance of the spacer dampers.

The Employer will accept only the spacer dampers which are guaranteed by the Contractor to meet satisfactorily the test requirements specified below:

- working temperature : 80^0C;
- corona: no visible fair-weather corona discharges under the specific site conditions.
- static compression and tensile performance: 5 kN for 1 minute and the separation of the clamps before and after the test shall not differ by more than 5%;
- impulse compression performance by short-circuit: 30 kA peak with one clamp offset longitudinally by 60 mm, conductors at everyday tension;
- compression and tensile fatigue performance: 10 million cycles at 1 Hz each clamp loaded to 500 N:

- longitudinal fatigue performance: 1 million cycles at 1 Hz with a relative displacement of the clamp of 60 mm (400 mm conductor spacing);
- vertical fatigue performance: 100 million cycles at 20 Hz with a relative displacement of the clamp of 60 mm.
- torsional fatigue performance: 100 million cycles at 20 Hz with a relative displacement of the clamp up to 2 degrees;
- clamp slip: max. 1 mm by a load of 6 kN applied for 10 minutes.

2.12. RIGID SPACERS

Each jumper connection shall be provided with at least two spacers fitted symmetrically, which may be of rigid design and which may incorporate jumper weights if the latter are necessary to limit jumper swing. Additional spacers shall be provided where necessary to ensure that the maximum distance between spacers is 5 m.

Slack spans shall be fitted with rigid spacers at a maximum distance apart of 30 m. The spacers shall provide the spacing of the sub conductor in the bundle as specified (400 mm or 450 mm).

The metallic material of spacers shall be aluminium alloy. Spacers shall satisfy the requirements in IEC 61284, 61854 and 61897 as relevant.

2.13. ARMOUR RODS

Preformed armour rods shall be used to protect the phase conductors in suspension assemblies, except jumper suspension points. The direction of the armour rod lay shall be equal to the direction of the outermost wire lay of the conductor. The suspension clamps offered for the phase conductors shall accommodate the increased diameter resulting from armour rods.

The ends of the armour rod wires shall be well rounded, without sharp edges, to avoid an increase in corona level.

Armour rods shall be of a material that is compatible with the material of the line conductor or sub-conductor to which they are attached such as to eliminate any effects arising from any dissimilar metal corrosion.

Armour rods shall be suitable for maintenance using hot line tools.

2.14. BIRD FLIGHT DIVERTERS

A. Helix Type

Helix Type Bird Flight Diverters shall comprise with a diverter section and a gripping section. The unit shall be manufactured by UV resistant high impact polyvinyl chloride material and shall not deteriorate due to severe weather conditions. The diverter section shall increase the visible profile of the wire to a degree that ensure safety, but avoids an undesirable bulky outline. The minimum length of the complete unit shall be 300 mm and the weight of the unit shall be approximately 100 grams. The colour of the unit shall be yellow.

They shall be installed on the two earth wires alternatively keeping a space of at least 15 m. The diverters shall be light in weight and shall offer less resistance to wind. They can be quickly fixed on the wires by hand. Once applied on the wire, the grip of the fitting shall remain the item in the same position without moving along the line under vibrations.

B. Fire Fly Diverters

This type of diverters shall comprise with an Impact resistant UV-stabilized acrylic "flapper" section that could be hanged on the wires with the use of a clamping device. The device shall withstand temperatures ranging from –30 F to 160 F. They shall use a heavy duty, stainless steel ball bearing swivel that is resistant to salt spray and adverse weather conditions. Flapper material shall refract sunlight and provides sparkle effect visible to birds. Material shall glow at night and under fog conditions, using a suitable luminescent element for up to at least 12 hours.

The spacing between any two FF diverters shall be 15 m. The device shall be quickly mounted on the wires by hand or a drone. Clamp shall prevent the line. Once applied on the wire, the grip of the fitting shall remain the item in the same position without moving along the line under vibrations.

2.15. CORONA AND RADIO INTERFERENCES

The design of all line conductor fittings, vibration dampers, etc., shall avoid sharp corners or projections which would produce high electrical stress under normal working conditions. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions.

Particular care shall be taken during manufacture of conductors and fittings and

during subsequent handling to ensure smooth surfaces to be free from abrasion.

2.16. EARTHWIRE FITTINGS

At suspension towers, earth wires shall be supported by suspension sets. The suspension set shall consist of a suspension clamp, fittings and a bonding wire. Bonding wire shall be galvanised steel stranded wire and shall be designed to ground the suspension clamp to the steel work. At tension towers, earth wires shall terminate in dead end clamps but shall be made electrically continuous by means of jumpers. In addition, at tension towers the earth wires shall be bonded to the tower steelwork. At substation, earth wires may be terminated either at the terminal tower or on substation earth wire mast as decided by the Employer. Complete tension set shall comprise with dead ends and clamps for both the sides of the strain tower and earthing system.

2.17. ADDITIONAL INFORMATION TO BE SUPPLIED WITH THE OFFER

Other than what is mentioned in Clause 1.44 in the Chapter 1, following information shall be submitted along with the bid;

a) Complete dimensional drawings of the offered conductor, Drums etc.

b) For ACSR Zebra conductor, it is required to include a list of names and addresses of seven (07) purchasers for the particular item with the same or higher quantity, other than the country of origin. The list shall comprise the purchased quantity and the date of purchase.

   For the items that had already been used successfully by the Employer from the particular manufacturer, the bidder only needs to provide the details of the supply to the Employer of identical item.

Failure to furnish these particulars may result in the manufacturer being rejected.

CHAPTER 3 – OPTICAL FIBRE GROUND WIRE

CONTENT

3. CHAPTER 03 - OPTICAL FIBRE GROUND WIRE (OPGW) AND FIBRE OPTIC APPROACH UNDERGROUND CABLE (OFAC)

3.1. APPLICABLE STANDARDS

Unless otherwise specified elsewhere in this specification, the rating, performance and testing of the Optical Fiber Ground Wire (OPGW), Optical Fiber Approach Underground Cable (OFAC) and accessories shall conform to the latest revisions, available at the time of placement of order, of all relevant standards listed below;

3.1.1. IEC (International Electrotechnical Commission):

a) IEC 60304 - Standard colours for insulation for low-frequency cables and wires.

b) IEC 60383 - Insulators for overhead lines with a nominal voltage above 1000 V.

c) IEC 60529 - Degrees of protection provided by enclosures (IP Code).

d) IEC 60693 - Dimensions of optical fibres.

e) IEC 60708 - Low-frequency cables with polyolefin insulation and moisture barrier polyolefin sheath.

f) IEC 60793-1 - Optical fibres - Part 1. Generic Specification.

g) IEC 60794-1 - Optical fibre cables - Part 1. Generic Specification.

h) IEC 60815 - Selection and dimensioning of high-voltage insulators intended for use in polluted conditions.

i) IEC 60874 - Connectors for optical fibre and cables.

j) IEC 60889 - Hard-drawn aluminium wire for overhead line conductors.

k) IEC 61089 - Round wire concentric lay overhead electrical stranded conductors.

l) IEC 61232 - Aluminium clad steel wires for electrical purposes.

m) IEC 61284 - Overhead lines - Requirements and tests for fittings.

n) IEC 61395 - Overhead electrical conductors - Creep test procedures for stranded conductors.

3.1.2. CCITT (The International Telecommunication Union – Telecommunication Standardization Sector (ITU-T):

a) Recommandation G.650 - Definition and test method for the relevant parameters of single mode fibres.

b) Recommendation G.652 - Characteristics of a single-mode optical fibre and cable.

c) Recommendation G.653 - Characteristics of a dispersion-shifted single-mode optical fibre cable

3.1.3. ISO (International Organization for Standardization)

a) 9223-1992 - Corrosion of metals and alloys – Corrosivity of Atmospheres - Classification.

3.1.4. ANSI/EIA (American National Standards Institute/Electrical Industry Association)

a) EIA/TIA – 455 - Standard test procedures for Fiber Optic fibres, cables. Transducers, sensors, connecting and terminating devices and other fiber optic components.

b) 598B - Optical fibre cable colour coding.

3.1.5. IEEE (Institute of Electrical and Electronics Engineers)

a) IEEE Std. 812 - Standard Fibre Optics, Definition of Terms.

b) IEEE Std. 1138 - Standard Construction of Composite Fibre Optic Overhead Ground Wire (OPGW) for use on Electric Utility Power Lines.

c) IEEE Std. 1222 – Standard for All-Dielectric Self-Supporting Fibre Optic Cable.

3.1.6. BSI (British Standards Institution)

a) BS EN 187200 - Optical cables to be used along electrical power lines (OCEPL).

b) BS EN 50182 – Conductors for Overhead Lines – Round wire concentric

c) BS EN 50183 - Conductors for overhead lines, aluminium – magnesium – silicon alloy wires.

d) BS 4803 - Radiation safety of laser products and systems.

- Part 1 - General.
- Part 2 - Specification for manufacturing requirements for laser products.
- Part 3 - Guidance for users.

e) BS 1559 - Reels and drums for bare wire.

f) BS EN 60794-1 – Optical Fibre Cables, Generic Specifications

3.1.7. ASTM (American Society for Testing and Materials)

a)	ASTM B117	Standard Specification for Salt Spray Testing
b)	ASTM B415	Standard Specification for Hard Drawn Aluminium Clad Steel Wire
c)	ASTM B416	Standard specification for Concentric Lay Stranded Aluminium-Clad Steel Conductor
d)	ASTM B399/M	Standard specification for Concentric Lay Stranded Aluminium Alloy 6201-T81 conductors
e)	ASTM -A153-82	Zinc coating (Hot Dip) on Iron and Steel Hardware

3.1.8. Conference Europeene des Administrations des postes et des telecommunications (CEPT)

i. The latest edition or revision of these Standards shall apply.

The OPGW/OFAC shall be manufactured, installed, tested and commissioned in accordance with a quality assurance and quality control system in conformity with ISO 9001 (latest). The manufacturer and installation, testing and commissioning teams shall be certified by an official independent organization for ISO 9001.

3.2. REQUIREMENT

The OPGW shall serve as ground wire for the protection of transmission line against direct lightning strokes and the optical fibre embedded in it shall serve as carrier for the telecommunication system.

3.3. GENERAL CONTENT

The Scope of OPGW shall include the design, manufacture, testing before shipment, packing, supply and delivery, erection, site test and commissioning of the OPGW/ OFAC system in totality, (Excluding optical line terminal equipment and repeaters), for;

a) OPGW with all associated accessories and hardware (i.e., tension clamp set, suspension clamp set, vibration damper, grounding clamp, armour grip suspension, etc.).

b) Shield wire joint boxes suitable for splicing of OPGW-OPGW along the line.

c) Terminal joint boxes suitable for splicing of OPGW and OFAC at substation ends.

d) Termination boxes suitable for termination of the OFAC and connection to the OLTE (Optical Line Termination Equipment)

The Contractor shall ensure supervision by staff from the OPGW/OFAC manufacturer, during installation of OPGW/OFAC and provide guidance at site to the Contractor's and Employers' staff, including for testing, commissioning and successfully putting into operation of the OPGW/OFAC system in totality.

Joint box of OPGW/OFAC shall be located on the terminal gantries at each end of the line and the locations of joint boxes of OPGW/OPGW along the line shall be subjected to the approval of the Employer.

Termination box used for termination of the OFAC and connection to the OLTE (Optical Line Termination Equipment) shall be located in the communications room of the substation control building which is about 100m distance from the switchyard/terminal gantry.

All OPGW cables shall be supplied on drums with cable ends suitably sealed. The drum length of the fiber optic cable shall be optimized to reduce the number of joints required. The joint locations shall be approved by the Employer.

Drums shall be constructed in accordance with an approved national standard so as to enable the cable to be run out smoothly and in lengths as long as can be conveniently handled and installed. Drums shall be marked with type, size and length of cable and also with an arrow to show the correct direction of rotation for rolling. The inner end of the length of cable must be passed through the flange and be secured external to the barrel. Wooden drums and battens shall be constructed from seasoned softwoods and be impregnated with a preservative against fungal and termite attack. The preservative shall not react with the cable and the barrel and sides of drums shall be covered with a waterproof paper or equivalent so as to ensure no damage to the cables. All nails/screws to be countersunk and the drum construction must be proved adequate to transport and handle the cable weight.

However, OPGW ordered under mandatory spares shall be provided in steel drums.

All equipment supplied shall be fully suitable for operating at the temperature and humidity as specified in the General Technical Specification. The Contractor shall

duly consider such local conditions when designing, constructing and installing all equipment and materials supplied under the Contract.

OPGW cable including fiber itself and all associated installation hardware shall have a minimum guaranteed design life span of 30 years. Documentary evidence in support of guaranteed life span of cable and fiber shall be submitted by the Contractor during detailed engineering.

All aluminium and aluminium alloy material and coatings shall be formulated to resist corrosion (including general pitting and inter-granular, galvanic, crevice and stress corrosion) when exposed to the severe environment of the overhead transmission line detailed in the General Technical Specification and as generally described by pollution level IV of IEC 60815 and by pollution Class 4 to 5 of IS0 9223 (SO2 Pollution Class P2 and Chloride Pollution Class S1).

3.4. TECHNICAL REQUIREMENTS OF OPGW, OFAC AND HARDWARE

3.4.1. OPTICAL FIBRE GROUND WIRE (OPGW)

3.4.1.1. OPTICAL FIBRE GROUND WIRE CONSTRUCTION

OPGW shall be comprised of buffered flexible glass optical telecommunications fibers contained in a protective central fiber optic unit surrounded by concentrically laid stranded metallic wires in single or multiple layers. The stranded metallic wire layer/layers shall be made up of aluminum clad steel strands, with or without aluminum alloy strands to fulfill the requirements regarding mechanical strength, lightning discharge, fault current, corrosion resistance capacity and protection of the optical fibers. All these factors/data shall be proven by means of calculations and tests as specified.

The wires shall be of uniform circular section, smooth and free from surface imperfections. The diameter of the wires shall not vary more than 2% from the standard figures stated in the Technical Schedule. Steel wires shall be pre-formed so that they remain inert when the conductor is cut. The lay of the outer layer shall be right-hand. The wires in each layer shall be evenly and closely stranded around the underlying wires or around the central core. There shall be no joints in individual wires in a reel length unless specifically approved.

Each layer of earth conductor except the outer layer shall be covered with a high-quality grease of applied mass per unit length determined in accordance with IEC 61089 and as stated in the Technical Schedule. The extent of grease to be applied shall be case 2 as described in IEC 61089.

The OPGW earth conductor shall be capable of carrying a lightning stroke current and the associated power frequency fault current, which may from time to time occur, with negligible temporary effect on the attenuation of the optical cable and no permanent damage to the optical characteristics. The OPGW earth conductor shall be capable of withstanding the short circuit current specified in the Technical Schedule.

The OPGW design shall be such that any heating due to lightning strikes or short-circuit fault current shall be confined as much as possible to the outer layers of the OPGW earth conductor and shall not affect the characteristics of the optical fibers or cause any permanent deterioration of the data transmission characteristics. The cable shall be rated to operate at 70°C continuously and at intermittent short-term temperatures up to 200°C without any degradation of performance.

The Aluminum Clad Steel (ACS) wires of the OPGW shall have the conductivity higher than 20.3% IACS. The aluminum coating shall be smooth, clean, uniform thickness and free from defects, and there should be no joints permitted in any individual ACS wires after the cladding of the steel wires. The aluminum cladding on each individual steel wire shall provide sufficient and uniform thickness, and strong bonding strength at the boundary between aluminum layer and steel core.

The properties of the metallic wires shall be in conformity with ASTM-B415 and ASTM-B416.

The construction of the OPGW shall be so that enough strain margin is provided to avoid the degradation of the mechanical and transmission characteristics of the fibres for the worst expected loading conditions.

The OPGW types shall be mechanically equivalent to the corresponding GSW cables specified i.e.: type 7/3.25mm of minimum Grade 1000 for 132 kV line and 220 kV line, according to BS 183 with mechanical characteristics as required in Employer`s Requirements.

The short circuit current rating of the OPGW shall not be less than 40 kA^2s for without exceeding maximum allowable temperature of OPGW. Minimum lighting withstand of OPGW shall be according to IEC 60794 class 1.

All aluminum material, strands and tube, shall be alloyed to resist corrosion when exposed to the environment of the transmission line, including general pitting, intergranular and stress corrosion. Precautions shall be taken during manufacture,

storage and erection of OPGW to prevent the possibility of contamination by copper and other materials which may adversely affect the aluminum

3.4.1.2. OPTICAL FIBRE UNIT

The optical fibre unit design shall incorporate twenty-four (24) single mode fibre. It shall be of loose tube type, with the fibers housed in buffer tube in the central core of the OPGW. The central loose tube (buffer tube) shall consists of a stainless-steel inner tube enclosed with an aluminum/aluminum alloy outer tube.

The overall construction of the OPGW shall be so that enough strain margin is provided to avoid any degradation of the mechanical and transmission characteristics of the fibers for the worst expected loading conditions.

Buffer tubes shall be filled with a compound to provide resistance to water penetration, vibration damping and for shock absorption. The cable design shall allow the fibers to move longitudinally within the buffer tubes to minimize stress on the optical fibers and that an extension of 0.6 per cent will not produce strain in the fibers and not result an increase in attenuation.

Elongation of the tube caused by cable elongation shall be in proportion to such cable elongation. The inside of the tube shall be smooth and, in case of stainless-steel tubes with a welded seam, no welding debris shall be left inside the tube. Lengths of tube shall not be welded together; i.e. there must be no transverse welds. The tube shall be free of pinholes.

The Bidder shall furnish full details together with test results and field performance reports with his offer to establish that no galvanic corrosion will be formed between the stainless-steel central tube and aluminum/aluminum alloy over clad tube or in ACS wires.

The tube shall not deform and shall continue to fulfill its function when the OPGW is subjected to the following situations.

- The electrical, thermal and mechanical loads stated in this technical requirement
- The high-frequency (>1Hz) and low-frequency (<1Hz) vibrations occurring in the high-voltage line.
- Use with the prescribed suspension and tensioning equipment and vibration dampers.
- All regular and permissible conductor assembly and stringing processes.
- Non-circularity of the tube shall be ≤ 2%.

The Bidder shall fully describe in his offer that the proposed solution for the optical fibre unit, confirming the maximum allowable temperature in the event of a fault current, and how moisture ingress in the optical unit is prevented.

The cross-sectional drawings of the OPGW offered shall be furnished with the complete description of metallic and fibre optic components, grease and optical fiber tube filling compound.

3.4.1.3. FIBER OPTIC UNIT FILLING COMPOUND

The optical fibre tube shall be filled with a suitable compound to prevent ingress of any moisture and other impurities from outside and to prevent any water migration penetration along the fiber optic unit. The filling compound/jelly shall be compatible with the optical fibers and all the other components with which it may come in contact. The water-blocking compound shall retain its characteristics up to the rated fault current temperature.

The requirements of the filling compound are as follows.

- It shall not inhibit movement of the fibre within the tubes.
- It shall be free of air entrapment.
- It shall remain pliable and maintain its water resistance properties over the operating temperature range and over the OPGW service life.
- It shall not cause hydrogen (H_2) gas generation over the operating temperature and be compatible with other materials used.
- It shall be dermatological safe.
- It shall be a non-corrosive agent and no reaction with contact materials.

Full details of the filling compound and the method of removing the compound prior to cleaving and fusion splicing shall be supplied by the Bidder with the Bid.

3.4.1.4. OPTICAL FIBRES

The optical fibers shall be of single mode type conforming to IEC 60793, IEC 60794 and ITU-T recommendation G.652D. The fiber shall have dual operative windows, at 1310 nm and 1550 nm. Under all conditions, prior to and after installation, the maximum optical attenuation shall be 0.35 dB/km at 1310 nm, and 0.22 dB/km at 1550 nm.

Characteristics of OPGW shall be as per Table 2 – ITU-T G.652.D attributes.

The Bidder shall offer the typical attenuation spectral curves in the 1200 nm to 1600 nm wavelength range. The additional attenuation introduced for 100 turns of un-

cabled optical fibres (loosely wound) with 37.5 mm radius mandrel and measured at 1,310 nm at +20°C shall be less than 0.5 dB compared to the initial value measured before winding. The additional temporary attenuation compared to the initial value measured at +20°C due to;

- Temperature cycle (-20°C to +80°C) shall be less than 0.05 dB/km
- Temperature rises on account of lighting stroke shall be less than 0.1 dB/km
- Temperature rises on account of short circuit current shall be less than 0.25 dB/km

The above increase in attenuation shall only be temporary. There shall be no measurable increase in the fibre attenuation after normalcy is restored. The attenuation of the fibres embedded in the OPGW shall be distributed uniformly throughout its length so that there are no point discontinuities in excess of 0.05 dB. The fibre length in reel shall be continuous. No splice of fibre within a reel of OPGW shall be accepted. The optical wave-guide fibres shall completely be protected from water/moisture penetration and environmental conditions. The Bidder shall indicate index of refraction of the fibre core and cladding at 1,310 nm and the effective group refractive index for use with Optical Time Domain Reflectometer (OTDR).

The splicing loss of any two fibres in any case shall not exceed 0.10 dB/splice. Ageing shall not cause increase of the nominal optical attenuation at ambient temperature at 1310 nm by more than 0.05 dB/km of fibre over a period of 30 years.

A single mode optical fibre cable shall have following dispersion characteristics.

i)	Zero dispersion wavelength	1,310 nm
ii)	Maximum tolerance on the zero-dispersion wavelength	+/- 15 nm
iii)	Maximum chromatic dispersion coefficient in operation window from 1288 nm to 1339 nm wavelength region	≤ 3.5 ps/nm x km

The fibre shall be manufactured from high-grade silica and doped, as necessary to provide required transmission performance. The chemical composition of the fibre shall be specifically designed to minimize the effect of hydrogen on the transmission

properties. The fibre shall be heat resistant. The Bidder shall submit a certificate issued by an accredited laboratory to guarantee the maximum rated temperature of the fibre.

3.4.1.5. FIBRE COATING AND COLOR CODING

In order to prevent damage to optical fibre the optical fibre shall be suitably coated. The coating provided shall guarantee a sufficient mechanical protection while splicing optical fibres. The fibre coating shall be easily strippable during splicing and termination with a mechanical stripping tool. The stripping shall not induce any mechanical stress or notches that weaken the optical fibre.

The optical fibres are to be coated with a tight outer UV-hardened acrylate protective coating having a nominal diameter of 250 µm ± 10 µm. The coating shall mechanically and easily be removed over a length of up to 50 mm for the purpose of cleaning, cleaving and fusion splicing.

The optical fibre coating material shall not generate hydrogen (H_2) gas around the optical fibres that will increase the optical loss as specified above over the designed life span of the optical fibre. The Bidder shall provide details of the methods employed to minimize the generation of H_2 gas.

Each optical fibre for identification shall be color-coded corresponding to sequential numbering. The color shall be integrated in the fibre coating and shall be homogeneous. The color shall not be erased when handled during splicing. The original color shall be discernible through the design life span of the OPGW. The color should not bleed from one fibre to the other and not fade when wiping the fibre with acetone or alcohol.

The applied colors coding shall neither degrade the optical cladding/core mechanically nor optically.

The details of the coating material, dimensions and minimum bending radius of the coated fibres shall be provided with the Bid by the Bidder. All coatings/ colors are to be compatible with fusion splices utilizing the Light Inject Detect (LID) method and profile alignment method.

3.4.2. FIBRE OPTIC APPROACH CABLE

Approach fiber optic cable shall be installed to provide a fiber optic link between the substation Communication Racks/patch panel and the OPGW joint box closure located outside at the overhead line gantry.

Approach fiber optic cable shall have the necessary mechanical and thermal characteristics to accommodate stretching, bending and crushing forces, vibration effects and widely varying operational temperatures. The complete fiber optic cable and individual components shall have the characteristics stated in the Technical Schedules.

All components of the cable shall be dielectric. The cable shall provide protection against rodents.

The fiber optic cable shall be of a loose tube type, with the fibers over fed into buffer tubes which are helically wound around a central strength member. The buffer tubes shall be composed of a suitable polymer and be sufficiently strong to hold their shape and provide protection for the optical fibers against deformation and friction. The buffer tubes shall be fitted with a suitable water blocking compound, which shall not freeze or drip out over the temperature range stated in the Technical Specification. The compound shall not be detrimental to the other cable elements, shall not cause swelling of the buffer tubes and shall have a relatively low thermal expansion coefficient. The compound shall also be easily removed from the fiber and shall be non-toxic.

The fiber optic cable shall be designed so that the fibers shall be free from longitudinal strain under all conditions of loads and ambient temperatures specified. The design of the fiber optic cable shall be such that an extension of 0.6 per cent will not produce strain in the fibers and not result in an increase in attenuation.

The fiber optic cable shall be rated to operate at the continuous and intermittent short term temperatures without degradation of its mechanical or optical performance. The surface of the cable jacket shall be designed to minimise the accumulation of dust and shall resist abrasion. The fiber optic cables shall be able to withstand temperature cycling in the range as specified in the General Technical Specification without changing the optical values during laying, installation, stocking and transportation.

Polyethylene is the preferred material for sheathing outdoor cables. The cable shall withstand longitudinal water penetration when immersed to a depth of 1 metre in water at a temperature of 200C for a period of 24 hours and under the conditions specified in IEC 60708.

The OFAC shall match the OPGW cable in the shape and in fibre type, count and shall not produce toxic substances in operation, termination or burning.

The fibre optic approach cable shall entirely be suitable for direct burial in the cable duct and placement on cable trays. No intermediate joints shall be permitted in any run of approach cable between its two termination points. The cable sheathing shall have additive to prevent rodent attack.

The fibre optic approach cable has a minimum outer jacket thickness of 3.0 mm and shall meet the following requirements;

- Fire retardant and no acid gas evolution,
- Resistance to ultra-violet deterioration,
- Anti-moisture penetration, and
- All other requirements set for the OPGW.

The jacket material shall conform to ASTM-D-1248 and ASTM-D 1765 standards.

Each fibre and unit bundle (tube, package, insulation) shall be identified by a color code associated with certain sequential numbering. Fibre color coding used for OFAC shall match that of OPGW cable to be terminated.

Each fibre shall be distinguishable by means of a color coding according to IEC 60304. The fibres shall be colored with ultraviolet (UV) curable inks.

OFAC pulling conduits shall have the following characteristics;

- Conduits shall be UV resistant corrugated flexible High-Density Polyethylene (HDPE) pipes of 50 mm diameter
- A pilot wire shall be available inside to pull the cable into the pipe.
- This HDPE pipe shall be suitable for direct burying and laying in outdoor cable trenches.

The Bidder shall submit the pulling instructions, include minimum bending radius. The construction of the cable trench and cable trays is the responsibility of the Substation Contractor. The supply of the pipe is the Line Contractor's responsibility.

The cable shall be raised to the Transition Joint Box mounted at the Gantry, in a pipe fixed on a metallic tray. The Contractor shall splice the OPGW and the OFAC fibres in the Transition joint box.

OFAC Cables shall be terminated with optical connectors, which shall connect every single fibre to the optical terminal box in the control room of the substations.

The line Contractor shall be responsible for supply and installation of suitable optical terminal box (patch panel) with single mode pig tail (FC) terminations at the control room. The approach cable shall be terminated at the patch panel.

3.4.3. OPGW HARDWARE

3.4.3.1. GENERAL

All clamps and fittings shall comply with the requirements described hereafter and must be approved by the Employer. They shall be suitable for the OPGW type proposed by the Contractor. The suspension towers will be equipped with suspension sets and the tension towers with tension sets.

Contractor shall ensure close and continuous liaison between the manufacturers of OPGW and clamps and fittings so that the equipment will be perfectly adapted. The detailed design of OPGW suspension and tension hardware shall be coordinated with the manufacturer of the OPGW. The installation techniques and procedures shall be submitted to the OPGW manufacturer and his written approval for the complete design and materials intended to be used with the approved OPGW type will be presented to the Employer before the final approval for the hardware and OPGW will be granted.

All clamps and fittings except for vibration dampers shall be supplied by the same manufacturer. Splitting up of the supply of clamps and fittings will not be permitted.

Besides, the Contractor shall assure perfect fitting of the OPGW sets attachment assemblies (connecting hardware) to the tower steel construction. The design of adjacent metal parts and mating surfaces shall be such as to prevent corrosion of the contact surfaces and to maintain good electrical contact under service conditions.

At all suspension, tension towers and substation gantries, the OPGW shall be electrically connected to the tower's steelwork by means of grounding jumper wire of the same size and material as the OPGW as well as by means of suitable grounding clamps.

All ferrous parts of the assemblies' component elements and of the accessories for OPGW/earth wire shall be hot dip galvanized according to ISO 1461.

For lowering the OPGW to the joint boxes at jointing locations, OPGW shall be attached directly to the tower main legs / cross arms by bolted clamps without drilling or any other modification of the tower.

The split pins of all clamps and fittings shall be of stainless steel.

Particular care shall be taken during manufacture of clamps, fittings and during subsequent handling to ensure smooth surfaces free from sharp edges.

3.4.3.2. SUSPENSION ASSEMBLIES

Armour grip suspension clamps shall be used for OPGW. The clamp body shall be of high-tensile strength corrosion-resistant aluminum alloy and shall be preferably forged or cast. In the case of cast ones an additional reinforcement shall be foreseen. The spiral rods (armour rods) shall also be of aluminum alloy and shall not have diameters less than 4 mm. Each clamp shall be capable of holding the OPGW without slipping or damaging the OPGW under an unbalanced tension of 25% of the ultimate tensile strength of the OPGW.

The material of the clamps should satisfy the norms EN 1559 for aluminum alloy castings and EN 1562 for malleable cast iron.

The neoprene or other non-metallic material shall have good resistance to aging and be capable of withstanding temperatures between –35°C and +45°C without changing of essential properties. The material shall have adequate resistance to the effects of ultra-violet radiation, ozone or pollution factors.

The rotational axis of the clamp shall be in the longitudinal axis of the OPGW to avoid unacceptable distortion of the OPGW wire due to unbalanced longitudinal loads. The Contractor shall ensure by appropriate design a suitable performance of the clamp-OPGW wire assembly by wind induced vibration. In addition to the suspension clamp, connecting hardware is required for a suitable mechanical and electrical connection to the tower and the Contractor is responsible to supply the complete set of the suspension assembly.

3.4.3.3. TENSION ASSEMBLIES

The OPGW attachment clamps to tower shall be of helical grip type consisting of two helical parts (fittings), one for OPGW protection and the other one as actual dead-end fitting. Preformed helical dead-ends shall have "cabled loop" eyes. The material of the spiral rods shall be high-tensile strength aluminum clad steel.

The material of the clamps should satisfy the norms EN 1559 for aluminum alloy castings and EN 1562 for malleable cast iron.

The clamp shall have a breaking strength of not less than the OPGW. The clamp shall be capable of carrying the maximum current for which the OPGW is designed without overheating or loss of mechanical strength.

The protection part is defined to protect the OPGW against radial forces produced by the high longitudinal tensions during operation. The protection part must be laid in the opposite direction of the outer layer of the OPGW and the dead-end part must be laid in opposite direction to the protection part. The grip strength shall be at least 95 % of the ultimate tensile strength of the OPGW/earth wire.

The tension attachment devices must correspond to the OPGW type and dimensions. The protection part (armour rods) must be longer than the tension (dead-end) part and the length must be sufficient to install vibration dampers.

The number and diameter of the spiral rods of the two parts are generally different but must be coordinated to meet the operational requirements.

3.4.3.4. BONDING CLAMP, PARALLEL GROOVE CLAMP

Each clamp shall be capable of holding the OPGW using bolts and nuts.

Bolts, nuts and washers shall be hot-dipped galvanized malleable iron or steel.

3.4.3.5. VIBRATION DAMPERS

Vibration dampers of Stockbridge type shall be installed at all OPGW suspension and tension points and shall be mounted on armour rods. Minimum two dampers per span shall be provided; one damper per span is not permitted. The operating temperature shall be 80°C.

The dampers shall have an aluminium clamping bolt, or other suitable device, on the galvanized wire between the weights, and be suitable for attachment to the OPGW. The damper clamp shall be designed to permit installation and removal using hot line tools. Each damper weight, subject to the accumulation of moisture, shall be provided with one drain hole positioned at the bottom of the weight when the damper is installed in the vertical plane. Damper weights shall be made of hot dip galvanized cast iron or steel.

The vibration damper shall restrict the OPGW dynamic strain to 150 micro-strains under normal/ aeolian vibration conditions. The dampers shall not be dynamically overloaded during operation to prevent damper fatigue. It is considered that at tension tower locations two dampers shall be installed on OPGW on each side of the tower and at suspension locations one damper shall be installed on each side of the tower. The damper manufacturer shall provide detailed damping / vibration study with results and conclusion referring to the proposed damper, including installation charts and number of vibration dampers recommended for different tower spans.

3.4.3.6. ARMOUR RODS

The armour rods for the OPGW shall be of aluminum alloy preformed type with a diameter not less than 4 mm. They shall be smooth and free from corrosion, splitting, cracking, or any other defects. They shall be designed to effectively protect the OPGW from fatigue caused by vibration.

3.4.3.7. Mid span joints for OPGW

The OPGW shall not be jointed in the spans.

All hardware shall be in accordance to the relevant drawings in the Part C, Volume 6 of 8.

3.4.4. JOINT BOXES

On the substation gantries and at every 3 to 5 km on tension towers, connections between OPGWs and between the OPGW and the OFAC shall be realized by means of fibre fusion splices protected and properly packed inside joint boxes.

At the tension towers not provided with Joint Boxes, the Contractor shall provide suitable attachment fittings to by-pass the tower without any additional joint. At all angle points the prescribed minimum bending radius shall be observed. If necessary, special tandem or multiple stringing blocks have to be used for stringing the OPGW at angle points. The OPGW between tension clamps and joint enclosures on joint towers (where joint boxes are provided) shall be supported on and electrically bonded to the structure by means of cleats at least at 1000 mm centers on vertical members and at 600 mm centers on horizontal members. The cleats shall be designed so that no damage during installation is caused to the galvanized surface of the steelwork. To permit the joint enclosure to be moved to the ground for jointing purposes a length of OPGW, minimum 15m, is to be coiled in a coiling device and supported on the structure.

The joint boxes shall be of the 'hood' type with encapsulated cable entry and they shall be mounted within the framework of the transmission towers above the anti-climbing device. The OPGW access to the joint box casing should be via weather tight glands in the base, properly sized and sealed to prevent moisture ingress. The same joint casing shall be suitable for jointing OPGW with OFAC by substitution of appropriate glands in inlets.

The joint boxes shall include all necessary hardware to terminate, protect and fix the spliced fibres. The size of the enclosure shall be sufficient to meet the bending

requirements of the fibers and fiber optic cable. Optical losses shall be no more than 0.05 dB at average per splice and no single splice loss shall exceed 0.10 dB.

A finished splice shall be supported within the joint box by suitable clips or restraints. It shall be possible to remove and replace the splice in the support device without risk of damage to the splice or fibre.

The enclosure is to be re-enterable and re-sealable without detriment to the integrity of the enclosure and optical fibres. Enclosure re-entering and re-sealing shall not require power tools and use a minimum number of special tools.

The joint boxes shall be airtight, waterproof and weatherproof. The cover shall be securely fastened to the case by non-loosening fasteners. Both the case and the cover shall be made of non-corrosive aluminium alloy.

The joint box shall be sufficiently rugged and sturdy to withstand outdoor climatic and environmental conditions. The joint box shall accommodate sheath protected arc-fusion splices and up to 1.5 m of additional fibre on each side of the splice; guides shall be provided to keep the extra fibre well above the allowable bending radius of the fibre. The spliced parts of the optical fibre within the joint box shall be reinforced and free from tension after completion of the splicing.

The OPGW/OPGW joint boxes conforming to IP55 enclosures protection standard shall include all the necessary hardware to retain, terminate, protect and splice the 24 fibres, as well as suitable clamps for fixing to the tower without any need of drilling holes in the tower structure.

The OPGW/OFAC terminal joint boxes conforming to IP55 shall include all the necessary hardware to retain, terminate, protect and splice the 24 fibres, as well as suitable clamps for fixing to the substation gantries without any need of drilling holes in the tower structure.

The OPGW/OFAC shall be terminated/ spliced at the splice locations using joint boxes, which shall be located approximately 10 m above ground. Spare length of 15 m of optical fibre shall be coiled and attached to the tower near the joint boxes. Recommended coiling devices and down lead clamps shall be provided by the contractor.

The Bidder shall describe in detail the proposed method of jointing the optical fibres. The Contractor shall provide detailed drawings showing the location of all joints which shall be consecutively numbered.

As part of the jointing procedure the Contractor shall monitor the optical performance of each joint using an Optical Time Domain Reflectometer (OTDR). Upon completion of jointing and prior to sealing the joint casing an estimate of joint loss and measurement of the total fibre attenuation shall be made. If the total fibre loss is projected to exceed the designed installation loss, then the joint shall be remade until the specified performance is achieved.

The fusion splice tray shall comply with the minimum bending radius of the fibres and shall not have any sharp edges or protrusions which may damage the optical fibre.

Number tags for fibre and tube identification are to be included.

The Contractor is responsible for the operational continuity of the optical fibre system including the interface point between line and underground cable.

All design documents shall be submitted to the Employer for approval before starting of the manufacture in the workshop.

3.4.5. OPTICAL TERMINAL BOXES (Patch Panel)

An optical terminal box (OTB)/ Patch Panel shall be installed in the Communication room and shall have the following characteristics:

a) Cable gland suitable for fiber optic cable with minimum 48 single mode fibers.
b) Designed to accept minimum of 06 fiber optic cables.
c) Equipped with connectorised pigtails.
d) Maximum optical attenuation shall be 0.05 dB per splice.
e) The OTB housing shall be wall-mounted and of rugged construction.
f) Ingress protection rating shall be Class IP 54.
g) The OTB shall be provided with lockable cover.
h) The OTB shall be provided with a removable side wall cover (Facing FC connector plane) in order to provide easy access in connecting patch cords.

The interface between the fiber optic communication system supplied by others and the fibers of the approach cable at the terminal sites shall be at the OTB using low loss de-mountable optical connectors of the plug-in type. The maximum insertion loss for a pair of mated connectors shall be 0.5 dB. Mating connectors shall be provided as part of the Contract. Connectors shall be of the of FC/PC type. Caps shall be provided for each coupler to prevent dust ingress to the couplers of unused fibers. The Bidder shall state the manufacture and type of connectors proposed. All

connectors shall be so positioned to facilitate necessary working space for connecting and removal of patch cords, easy cleaning and inspection. All spare fibers shall be terminated with appropriate optical connectors. Auxiliary connectors shall be provided to simplify the testing of the fiber optic communication equipment supplied by others.

3.5. ADDITIONAL INFORMATION TO BE SUPPLIED WITH THE OFFER

Other than what is mentioned in the Clause 1.44 in the Chapter 1, following information shall be submitted along with the bid;

a) Complete cross-sectional drawings of OPGW, FOAC, Joint Box, and Optical Terminal Box indicating the components, materials and dimensions.

Failure to furnish these particulars may result in the manufacturer being rejected.

CHAPTER 04 – INSULATORS AND FITTINGS

CONTENT

CLAUSE TITLE PAGE

4. CHAPTER 04 – INSULATORS AND FITTINGS

4.1. APPLICABLE STANDARDS

The equipment and components supplied shall be in accordance with the standards specified below or latter editions and/ or amendments thereof. Offers of items manufactured to any other internationally recognized standards or specifications not less rigid shall accompany an English version of such standards.

a)	IEC 60060	-	High voltage test techniques
b)	IEC 60120	-	Dimensions of ball and socket couplings of string insulator units
c)	IEC 60305	-	Characteristics of insulator units of cap and pin type
d)	IEC 60372	-	Locking device for ball & socket couplings of string insulator units: Dimensions and Tests
e)	IEC 60383	-	Tests on insulators of ceramic material or glass for O.H. Lines with a nominal voltage greater than 1 kV
f)	IEC 60437	-	Radio interference test on high voltage insulators
g)	IEC 60507	-	Artificial pollution tests on H.V. insulators to be used on a.c. Systems
h)	IEC 60575	-	Thermal-mechanical performance test and Mechanical Performance test on string insulator units
i)	IEC 60672	-	Specification for ceramic and glass insulating materials
j)	IEC 60815	-	Guide for the selection of insulators in respect of polluted conditions
k)	BS EN 60383	-	Insulators for overhead lines with a nominal voltage greater than 1000V
l)	BS EN 60305	-	Characteristics of Insulator units of the cap and pin type
m)	BS EN 1SO 1461	-	Hot dip galvanized coating on fabricated iron and steel articles Specifications and test methods
n)	BS EN 60060	-	High voltage test techniques

o)	BS EN 12163		-	Copper and copper alloys Rod for general purposes
p)	BS EN 12164		-	Copper and copper alloys. Rod for free machining purposes
q)	BS EN 12167		-	Copper and copper alloys. Profiles and rectangular bars for general purposes
r)	BS 3288	Part 1	-	Performance and General requirements
		Part 2	-	Specification for a range of fittings
		Part 3	-	Dimension of Ball and Socket coupling of string insulator units
		Part 4	-	Locking devices for Ball and Socket coupling of string insulator units: Dimensions and tests
s)	IEEE 1523- 2002		-	IEEE Guide for the Application, Maintenance, and Evaluation of Room Temperature Vulcanizing (RTV) Silicone Rubber Coatings for Outdoor Ceramic Insulators
t)	ITU-T G 652		-	The International Telegraph and Telephone Consultative Committee (CCITT) Red Book (1984), Volume III, FASCICLE III. 2-International Analogue Carrier System. Transmission Media, Characteristics.
u)	IEC 60071-1 (2011)		-	Insulation co-ordination - Part 1: Definitions, principles and rules
v)	IEC 60071-2 (1996)		-	Insulation co-ordination - Part 2: Application guide
w)	IEC 61284		-	Overhead Lines - Requirements and Tests for Fittings

4.2. BASIC FEATURES

4.2.1. DESIGN

The insulators will be in service in a damp tropical saliferous climate where intense lightning storms at certain periods of the year are expected. The design shall take that into account as well as to minimize the effect of local corona formation and discharge likely to cause radio interference. The detailed design shall be such as to facilitate inspections, cleaning, repairs, simplicity of operation and hot line maintenance. Further, it shall provide reasonable precautions and provisions for the safety of all those concerned in the maintenance of transmission lines. All corresponding parts shall be made to gauge and to be interchangeable whenever possible.

4.3. CONSTRUCTION

4.3.1. GENERAL

Insulators shall be made of proven insulating material of toughened glass or brown glazed porcelain and hardware shall be suitable to receive the type and sizes of conductors as specified in Technical Particulars in Employer's Requirements. It shall have correct shed formation to satisfy the specified flash over characteristics.

4.3.2. BOLTS AND NUTS

All bolts and nuts to conform to the standard specified in accordance with the appropriate clauses of this specification and shall be locked in an approved manner. The nuts and heads of all bolts should be hexagonal type.

4.3.3. GALVANIZING

Except where specified to the contrary, all iron and steel parts to be galvanized after the process such as sawing, shearing, drilling, punching, filling, bending and machining are completed. Galvanizing shall be applied by hot dip process to comply with the relevant specification.

4.3.4. RTV SILICONE COATING

The main steps of the silicone coating process shall be consisted of initial cleaning of the insulator surface, coating and curing procedure and packing, storage and transport. The surface shall be prepared prior to applying any coating as it is of critical importance for the overall quality and life performance. Modified standard cleaning processes shall be carried out. That process should be adapted from the suppliers'

standard practice and recommendations. Relevant optimum solvents for cleaning shall be applied. The coating shall be applied by spraying the compound in multiple steps to achieve the correct thickness which shall be more than 300µm.The spraying parameters shall be a function of the type of silicone, viscosity etc. The optimal spraying process shall be carried out to minimize the quantity of silicone that will not reach the surface of the insulator. Therefore, this process shall be moved progressively from manual operation to semi-automatic sprays.

Curing process shall be carried out according to the conditions recommended by silicone suppliers. Curing temperature, humidity, time and drying conditions shall be evolved in the process based on experience and quality inspection on coated products. The manufacturer of RTV coated insulators shall have more than 5 years of proven industrial experiences in the same field with relevant conditions and standards.

4.3.5. POLLUTION LEVEL

The specific creepage distance to be adopted for this Project is related to the highest phase-to-phase voltage for equipment (Um) which corresponds to pollution level mentioned in IEC 60815.

4.3.6. INSULATOR UNITS AND INSULATOR STRING SETS

4.3.6.1. INSULATOR UNITS

Disc Insulators shall be of the Cap and Pin type with Ball and Socket Couplings. Cap and pin insulators shall be provided with ball and socket fittings in accordance with IEC 60120 and split-pin locking devices for the insulator units themselves, in accordance with IEC 60372.

The locking devices shall be so formed that when set and under any conditions there shall be no risk of the locking device being displaced accidentally and that nothing but extreme deformation of the locking device shall allow separation of the insulator units or fittings. Locking device design shall be such as to allow easy removal or replacement of the insulator units or fittings under live line conditions. Locking devices when in position shall be independent of rotation, and the efficiency of the locking shall be independent of the degree of opening applied to the locking device after insertion. The locking device shall be of austenitic stainless steel or phosphor bronze and of the same design for all the complete insulator sets.

Cap and pin insulators shall be provided with a pure zinc anti-corrosion sleeve, bonded to the surface of the pin and extending at least 12 mm on either side of the interface between pin and internal cement. The material of the sleeve shall be pure zinc, with impurities not exceeding 0.3 percent. The zinc sleeve shall not be porous. A suitable metallurgical bond is required between sleeve and pin; the fused area between them shall be in excess of 80 percent of the total interfacial area between the sleeve and the pin. The insulator head shall be so designed to have straight headed.

The electrical and mechanical characteristics for each type of insulator units shall be as mentioned in the below tables;

Table 4.1: Type of insulators for 132 kV Line and 220 kV Lines

DESCRIPTION	UNIT	Normal Suspension Insulators	Normal Tension Insulators	Jumper Suspension Insulators
IEC Designation	-	U120B	U160BS	U70BL
Electro-mechanical Failing Load	kN	120	160	70
Maximum Nominal Diameter of Disc	mm	255	280	255
Nominal Spacing	mm	146	146	146
Minimum Nominal Creepage Distance*	mm	320	380	320
Dry Lightning Impulse withstand voltage	kV	100	110	100
Wet power frequency withstand voltage	kV	40	40	40
Puncture Voltage	kV	130	130	130
Ball and Socket Coupling	-	16	20	16

4.3.6.2. INSULATOR SETS

All insulator sets including their clamps and fittings shall be in fair weather free from visible corona discharges. In particularly, the live part of all insulator sets shall be

conceived and shielded in a way to avoid visible corona under fair weather condition. The freedom from corona shall be proven by design tests in the workshop or laboratories in accordance with the tests recommended in Chapter 10 of this specification.

The upper and lower arcing horns shall be installed on the insulator assemblies as recommended by the fittings manufacturer and confirmed by electrical tests.

Locking devices for the insulator units themselves and for associated ball and socket fittings shall be of stainless steel and shall comply with IEC 60372. The design shall be such as to allow easy removal for replacing of insulator units or fittings without the necessity to remove the insulator set from the crossarms. Locking devices shall be incapable of rotating when in position.

The insulator string shall be of sufficient length to provide the required electrical performance as regards the specific leakage path and minimum required withstand voltages.

This has to be determined as per catalogue data, but has to be finally proven by tests on complete sets.

The following insulator string types will be required and details of each type shall be entered in Employer's Requirements.

Based on design requirements, the number of insulators in the string could be increased during design review stage.

Table 4.3: No of insulator discs per unit and strings per set

	132 kV		220 kV	
	String per set	**Units per string**	**String per set**	**Units per string**
Normal Suspension Set	1	11	1	16
Heavy Suspension Set	2	11	2	16
Jumper Suspension Set	1	11	1	16
Normal Tension Set	1	12	2	16
Light Duty Tension Set	1	12	1	16

Heavy suspension insulator sets are intended for use on TD1 type tower at suspension positions and shall be capable of carrying the maximum wind and weight spans specified for heavy suspension towers with the specified factor of safety. In addition, heavy suspension insulator string is to be used at the spans crossing major roads, railways, rivers or other important structures as instructed by the Employer.

Insulator strings complete with all fittings shall be designed to have the following characteristics.

Table 4.4: Mechanical and Electrical characteristics of insulator strings

		Unit	132 kV Single	132 kV Twin	220 kV
Highest voltage for equipment (Um) according to IEC 60071-1		kV	145	145	245
(a)	Minimum Impulse withstand Voltage, wet	kV(*)	800	800	1050
(b)	Switching Impulse withstand Voltage	kV(*)	–		–
(c)	Power Frequency withstand Voltage, wet	kV(*)	300	300	395
(a)	Normal suspension string set	kN	120	120	120
(b)	Heavy suspension string set	kN	120 × 2	120 × 2	120 × 2
(c)	Jumper suspension string set	kN	70	70	70
(d)	Normal tension string set	kN	160	160 × 2	160 × 2
(c)	Light duty tension string set	kN	70	70	70

Note (*) Light duty tension set complete with adjustable arc gaps need not meet this requirement.

Retaining pin or locking devices for the insulator units shall be of phosphor bronze or stainless steel, the composition of which shall comply with BS EN 12163, BS EN 12164 and BS EN 12167 and IEC 60372. They shall be so made and shaped that when set and under any condition of handling and service nothing but extreme deformation of the retaining pin or locking devices shall allow separation of the insulator units or fittings or shall cause any risk of the retaining pins at locking devices being displaced accidentally. The design shall be such as to allow easy removal for line working without the necessity to remove the insulator string from the cross-arms. Retaining pins or locking devices shall be incapable of rotation when in position.

4.3.7. SUSPENSION INSULATOR SETS

The suspension insulator shall comply with clause 4.3.6 and shall consists of disc insulator units complete with necessary hardware including armour rods as per Employer's Requirements and drawings.

The suspension towers will be equipped with "I" (vertical) suspension insulator sets.

The normal "I" suspension insulator set shall be used as standard set on normal suspension towers.

The double "I" suspension insulator set shall be used for crossings of rivers, main roads, village roads, overhead transmission lines ≥ 110 kV and railways. Double suspension insulator sets shall have the two strings in a plane parallel to the line and shall be fixed in two points to the crossarm.

On heavy suspension towers, double "I" suspension set shall be used. Single "I" suspension insulator set shall be used as jumper suspension set (pilot) on the angle-tension and terminal towers, where clearance requirements so demand.

4.3.8. TENSION INSULATOR SETS

The Tension Insulator sets shall comply with clause 4.3.5. It shall be ball and socket coupling as specified in clause above and as per Employer's Requirements complete with Ball Eye, Bow Shackle, Cotter pin etc.. Compression type Conductor Tension Clamps shall be made out of Aluminum Alloy/ Steel or other suitable material as specified in clause 2.8 & 4.3.9, for attaching conductors as specified in the Employer's Requirements. Where extension links are used, they shall be adjustable.

The tension towers (angle-tension and dead-end towers) shall be equipped with tension insulator sets and pilot suspension sets as required.

Single tension sets shall be used as standard on all tension towers for 132 kV lines (angle-tension and dead-end towers).

Double tension sets shall be used as standard on all tension towers for 220 kV lines (angle-tension and dead-end towers).

Spacing between double parallel strings shall be sufficient to assure good behavior of insulators and good performance of guarding rings.

The tension insulator sets attachment to the tower crossarms is of special importance. Attachments to the tower are to be of secure connection such as with swivels. Hooks are not acceptable.

Between the terminal towers and gantries (in the slack span), low duty tension sets shall be installed in conductor direction and down droppers.

Gantries will be equipped with inverted low duty double tension insulator sets and pilot suspension sets if required.

4.3.9. FITTINGS

Fittings shall comply with BS 3288: Part 1 and shall be suitable for maintenance using hot line tools already owned by the employer. Suspension Clamps shall be made of aluminum alloy, and shall be free to pivot in the vertical plane containing the conductor and shall permit the complete conductor to slip at a load lower than the breaking load of the conductor. The conductor supporting grooves shall be curved at its ends in the vertical plane to a radius of 150 mm and for a sufficient distance to allow for the conductor leaving the clamp at the maximum angle of inclination obtained in service. The mouth of the supporting groove shall be slightly flared in plan. The grooves in the clamping piece or pieces shall be bell - mouthed at each end and all conductor grooves bell - mouths shall be smooth and free from waves, ridges or other irregularities. Particular attention shall be paid to the elimination or corona emission from all parts of suspension clamps.

Suspension clamp except jumper suspension set shall have a suitable dimension for clamping the conductor with preformed armour rods.

Hardware accessories/ Fittings used for insulator strings shall match with the required capacity of the insulator discs mentioned in the above tables.

Tension clamps in which the conductor is necessarily cut shall comply in all respects with the provisions of clause 2.8 where these are applicable. The mechanical efficiency of tension clamps shall not be affected by methods of erection involving the use of "come-along" or similar clamps before, during or after assembly and erection of the tension clamps itself.

Adequate bearing area between fittings shall be provided and "point" and "line" contacts shall be avoided. Split pins for securing attachment of fittings of insulator set shall be of stainless steel and shall be backed by washers of approved size and gauge. All insulator strings shall be attached to cross-arms by means of shackles. Hooks shall not be used.

Light duty tension sets at the lower ends of slack spans shall be provided with turnbuckle adjusters.

In case where insulator strings are uplifted in strain towers, terminal towers or gantries inverted type insulator strings shall be provided accordingly with necessary hardware fittings.

Tension insulator sets shall be equipped with sag-adjusting devices to provide a total range of longitudinal adjustment for each separate conductor from plus to minus 150 mm in steps not greater than 25 mm. Insulator sets shall be fitted with shouldered extension links, at each end of the insulator strings, suitable for standard strain carrier yokes of live line maintenance equipment and for bundled line conductor, an attachment plate behind the tension clamp to enable the load on the tension set to be relieved when making adjustment to the sag-adjusting links.

4.3.10. ARCING HORNS

All insulators sets shall be fitted with line and earth end arc horns. Arc horns shall be made of galvanized steel. Where tube is used, the wall thickness shall be approved by the Employer and both inner and outer surfaces shall be galvanized. The parts of horns where arcs are expected to make contact shall be solid.

The design of the arcing horns shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and arcing horns themselves under all flashover conditions.

The upper and lower arcing horns/rings shall be installed on the insulator assemblies as recommended by the fittings manufacturer and confirmed by electrical tests.

The design of arc horns shall be such as to obviate damage to clamps and conductors, and shall prevent cascading over the line end insulator units when flashover occurs. They shall be suitable for use with hot line tools. The amount of lift and general shape shall at the same time given maximum values of power frequency and impulse flashover voltage consistent with the above provisions. In particular the lift of line end horns shall be such that their points extend beyond the disc of the line end unit, as shown on drawings.

Arcing horns shall not be attached to insulator pins or caps.

Any special tests considered necessary to prove the correct setting of arcing fittings shall be carried out at the manufacture's works without extra cost.

Details of the arcing horns shall be in accordance with the following: -

(a) Normal and Heavy Suspension Insulators: Double point horns shall be arranged in the vertical plane containing the conductors. The lower arcing horns shall be strong enough to support a man weighing 90 kg standing on the horizontal portion with adequate security.

(b) Tension Insulators: Single point arc horns shall be fitted so as to provide a horizontal arc path above the insulator string.

(c) Light Duty Tension Insulators: Light duty tension insulators for use at the upper end and lower end of the slack spans shall be fitted with arc horns at both line and earth end.

Line end horn shall be fixed and the earth end horns shall be adjustable.

4.4. ADDITIONAL REQUIREMENTS

4.4.1. IDENTIFICATION

Identification details as indicated below shall be provided on the insulator and shall be weatherproof and corrosion proof.

(a) Manufacturer's identification

(b) Minimum failing load kN

(c) Year of manufacture

Each insulator shall have marked on it the manufacture's name or trademark. Tension and suspension insulators shall also be marked with the guaranteed electro-mechanical strength. Marks shall be visible after assembly of fittings and shall be imprinted and not impressed. For porcelain insulators, the marks shall be imprinted before firing and shall be clearly legible after firing and glazing.

When a batch of insulators bearing a certain identification, mark has been rejected no further insulators bearing this mark shall be submitted. The Contractor shall satisfy the Employer that adequate steps will be taken to mark or segregate the insulators constituting the rejected batch in such a way that there is no possibility of the insulators being subsequently resubmitted for tests or supplied for the Purchaser's use.

4.5. ADDITIONAL INFORMATION TO BE SUPPLIED WITH THE OFFER

Other than what is mentioned in the Clause 1.44 in Chapter 1, following information shall be submitted along with the bid;

a) Complete dimensional drawings with cross section of insulator discs

b) Evidential documents which shall state that the manufacturer of insulator discs guarantees that the failure rate shall not exceed one (1) per Hundred Thousand (100,000) per year in case of Porcelain insulators or the shatter rate shall not exceed one (1) per Ten Thousand (10,000) per year in case of Glass insulators. It shall be attached with certificates issued by at least two different utilities outside the manufacturer's country.

c) It is required to include a list of names and addresses of fifteen (15) leading purchasers other than the country of origin (of similar items only) giving times of delivery and quantities supplied during the past ten (10) years.

Failure to furnish these particulars may result in the manufacturer being rejected.

CHAPTER 5 –SUPPORTS

CONTENTS

5. SUPPORTS

This specification covers the design, detailing, manufacture, pre-assembly, fabrication, inspection and packing of self-supporting steel lattice towers.

5.1. APPLICABLE STANDARDS

The equipment or components supplied shall be in accordance with the standards specified below or later editions and/or amendments thereof.

Offers of Items manufactured to any other internationally recognized standards or specifications, provided they are not less rigid shall accompany an English version of such standards.

BS EN 50341-1	-	Overhead electrical lines exceeding AC 45 kV – Part 1: General Requirements Common Specifications
ANSI/ASCE10-97	-	Design of latticed steel transmission structures
ASCE/SEI 48-05	-	Design of steel transmission pole structures
IEC 60826	-	Design criteria of overhead lines
IEC 60652	-	Loading tests on overhead line structures
ISO 1459	-	Metallic coatings - Protection against corrosion by Hot Dip Galvanizing
ISO 1461	-	Hot dip galvanised coatings on fabricated iron and steel articles
ISO 12944	-	Paint coatings, corrosion protection, and structural steelwork
ISO 898-1	-	Mechanical properties of fasteners. Part 1-Bolts, Screws and studs
ISO 657	-	Hot rolled structural steel plates tolerances on dimensions and shape
ISO 7411	-	Hexagon Bolts for high strength structural bolting with large width across flats
ISO 657-5	-	Hot rolled Structural Steel Sections equal and unequal leg angles

ISO 7452	-	Hot rolled structural steel plates tolerances on dimensions and shape
BS 8004	-	Code of Practice for Foundations
BS 8110	-	Structural use of concrete
BS EN 10025 (2004)	-	Hot rolled products of structural steels
EN 10029	-	Hot rolled steel plates 3 mm thick and above
EN 10056	-	Structural steel equal and unequal leg angles - Part 1: Dimensions, Part 2: Tolerances"
BS 5950:2000	-	Structural use of steelwork in building

5.2. TOWER OUTLINES

Towers shall be of self-supporting lattice steel construction. They shall be designed to carry the line conductors with the necessary insulator sets, earthwires and all fittings under the condition specified. Towers shall be of double circuit/ four circuit with one or two earthwires as specified in the Scope of Work.

Conductors and earth wire/ OPGW for each circuit of double circuit towers shall be arranged in vertical formation. The clearances from conductor, arcing-horns, jumper loops and all live metal to the tower steelwork shall be not less than those specified in Clause 5.4 under still air conditions and at assumed maximum swing conditions. Where uplift occurs at tension tower positions the minimum clearance between any arcing horn and jumper loop or phase immediately above it shall not be less than the minimum still air clearance from live to earth metal as specified in Clause 5.4.

The dimensions of tension towers cross arms shall be so dimensioned that the horizontal spacing between adjacent circuits will be maintained throughout the line to ensure erection of intermediate suspension towers, both before and after the angle, without any conductor counterweights to maintain conductor alignment vis–a–vis verticality of insulator strings. In this respect, the dimensions of the cross arms of the angle-tension towers shall be such to ensure that horizontal spacing between conductors in a plan normal to the conductors are not less than that at normal suspension towers.

The earth wire support positions must also ensure the corresponding spacing between earth wires as well as the assumed shielding angle.

For all angle towers carrying line deviation angles up to 30°, cross arms shall generally be so proportioned that live metal clearances are maintained under all conditions without the use of jumper suspension insulators. Jumper suspension insulators shall be used on all angle towers for line angles deviations bigger than 30° and on terminal towers, as required.

Allowance shall be made for increasing or decreasing the length and varying the arrangement of all terminal cross arms to enable down lead span connections to be made in any desired phase sequence with keeping the required electrical clearances between live parts and towers earthed parts, as specified in Clause 5.4.

The method of attachment of the earthwires to the towers shall be by means of suspension clamps at tangent suspension towers and by means of tension anchor clamps at angle tension towers. Tension towers shall be capable of accommodating OPGW joint box.

Conductor and earth wire/ OPGW tensions shall be so selected that the sag of the steel earth wire/ OPGW at mid span under minimum temperature basic span is less than the sag of the line conductor by 10%.

The positioning of the conductors and of the earthwires on the tower shall be determined considering the following clearances:

a) The clearances between the conductors and between conductors and earthwires in mid span and still air (according to Clause 5.3);

b) The clearances between towers live parts (conductors, jumpers, arcing horns) and earthed parts (according to Clause 5.4);

c) Clearances to ground and obstacles (according to Clause 5.5);

d) The earthwire's shielding angle: 0° to top phase conductors and not more than 5° to middle and bottom phases.

5.3. CLEARANCE BETWEEN THE CONDUCTORS AND BETWEEN CONDUCTORS AND EARTHWIRES IN MIDSPAN AND STILL AIR

The minimum mid span clearances (meters) between phase conductors and between phase conductors and earth wire OPGW (considered at maximum conductor temperature, still air) shall be as following:

- Phase to phase distance:

$$\sqrt{c} = k \cdot f_{\max} + l_i + 0.75 \cdot D_{pp} + D_b$$

- Phase to OPGW / earthwire distance:

$$c = k \cdot \sqrt{f_{\max} + l_i} + 0.75 \cdot D_{el}$$

where:

k: factor according to EN 50341-1:
k = 0.75 for vertical distance
k = 0.62 for horizontal distance

l_i length of swinging suspension insulator set (m)

f_{max} maximum sag of the longest span [m] at 40°C, no wind.

D_{pp} min. phase-phase clearance

D_{el} min. phase-earth clearance

D_b sub-conductor spacing in bundle

Table 5.1- Minimum clearances between conductors and earthwires

	132 kV	**220 kV**
D_{pp}	1.4 m	2.0 m
D_{el}	1.2 m	1.7 m

The phase-to-phase and phase-to-earth wire mid span distances determine the maximum span (or phase span) of the respective tower.

5.4. CLEARANCES BETWEEN LIVE PARTS AND EARTHED PARTS OF TOWERS

Table 5.2- Clearance to supports for 220 kV and 132 kV

Description	Unit	132 kV	220 kV
Minimum clearance from live metal to earthed metal for Suspension towers			
(a) From still air to 10° swing of insulator	mm	1650	2200
(b) From 10° to 40° swing of insulator	mm	1550	2050
Minimum clearance from live metal to earthed metal at Tension towers			
(a) Jumper loops from still air to 10° swing	mm	1650	2200
(b) Jumper loops from 10° to 40° swing	mm	1550	2050
(c) Minimum plan clearance from arc horn tip to tower steelwork	mm	1650	2200

Assumed maximum transverses wing from vertical of (a) Jumper loops (b) Jumper suspension insulator strings at tension towers	 deg deg	 40° 20°	 40° 20°
Minimum separation between phases in down leads	mm	2500	3500

5.5. LINE CLEARANCES TO GROUND AND OBSTACLES

The minimum clearance between line conductors and ground or other objects shall be as specified in the following tables. These clearances shall be obtained under conditions corresponding to the final (after long term creep) still air sag of the line conductors at their maximum operating temperature and with any angle of swing of the conductors from the vertical between 0° and 45°.

An additional clearance of 0.3 m is required to allow survey and sagging errors and shall be considered in the calculation of tower heights.

Table 5.5- Minimum required clearances

Description of Clearance	Minimum Clearance (m)	
	132 kV	220 kV
To normal ground	6.7	7.0
To normal road crossings	6.7	7.4
To main roads / highway crossings	7.5	8.5
To railway crossings	8.0	8.2
To home gardens	NA	NA
To cradle guards	4.0	4.0
To road surface where cradle guards can be used (Note 1)	8.8	9.8
Between conductors of power line crossings or situated in close proximity (Note 2)	2.7	3.7
To any object on which a person may stand including ladders, access platforms etc. (Note 3)	3.6	4.6
To any object to which access is not required and on which a person cannot stand or lean a ladder (Note 3)	1.4	2.4

Between tower supports of upper line and any conductor of lower line situated in the close proximity		15.0	15.0
Survey and sagging error (Note 4)		0.3	0.3
(i)	Unable to support ladders/ climber	1.4	2.4
(ii)	Capable of supporting ladder/ climber	3.6	4.6
(iii)	Trees falling towards line with line conductors hanging vertically only	1.4	2.4
To rivers, non-navigable		10	10
To rivers, navigable		15	15

Notes:

1 These clearances are possible for situations where sky cradle can be used for conductor erection and maintenance. These clearances allow for the positioning of Sky cradle and erection of temporary scaffoldings under a live circuit.

2 Clearances shall be defined in a way that the upper conductor at its maximum temperature and coincides with the lower conductor, which at its minimum temperature and deflected by an angle of 45 degrees.

3 Clearances shall be defined with the conductor at its specified maximum temperature and deflected by any angle up to 45 degrees.

4 To account for minor variations in ground topography and foundation installation, the transmission line profile shall be plotted with an additional clearance of 0.3 m over those specified in the above table.

Note: The clearances for 33 kV lines are the minimum clearances between live conductor and other objects, which correspond to the condition of maximum sag of conductor and conductors hanging vertically or deflected up at any angle up to 40° from vertical. Telecommunication lines and Cradle Guards over railway are to be considered as power line at 33 kV or less.

5.6. WIND PRESSURE AND TEMPERATURES

Wind forces acting on different overhead line components (conductors, earthwires, insulators, towers) shall be considered according to BS EN 50341-1, and to below specification.

Table 5.7- Peak wind pressures to be applied for tower/pole design

ITEM	UNIT	VALUE
Peak Wind Pressure on Conductors and Earthwires	N/m^2	970
Peak Wind Pressure on Insulators	N/m^2	1170
Peak Wind Pressure on Lattice Steel Supports	N/m^2	1640
Peak Wind Pressure on poles (16 sided pole)	N/m^2	1170

Note: Above wind pressures shall be used for the design of towers irrespective of the actual conductor drag coefficients.

Table 5.8- Transmission Line Design Temperatures

ITEM	UNIT	VALUE
Minimum Temperature	^0C	7
Everyday Temperature	^0C	32
Temperature with maximum wind	^0C	7
Maximum Operating Temperature, ACSR	^0C	75
Maximum Operating Temperature, LL-ACSR	^0C	75

5.7. TYPES OF SUPPORTS

5.7.1. STEEL TOWERS

The standard types of structures shall be designated as follows;

Table 5.9- Tower Types and Designations

1	Suspension Tower (0°- 2°)	TDL
2	0° - 10° Line Deviation Tower	TD1*
	0° Section Tower	

	2° Heavy Suspension Tower	
3	10° - 30° Line Deviation Tower	TD3
4	30° - 60° Line Deviation Tower	TD6
5	60° - 90° Line Deviation and Terminal Tower (0°- 45° in line side & 0°- 90° in slack span)	TD9/TDT

*TD1 tower shall be designed for following three (03) applications;

(i) Angle tower for 0° - 10° deviation angle

(ii) Section tower of 0° angle with longitudinal load of 15% of the maximum working tensions of all conductors and earthwires on one side

(iii) Heavy Suspension tower of 2° deviation angle

(Tower type in profile drawing and line schedule "TD1S" is applied in order to distinguish from tension tower)

For Four circuit towers, the letter "F" shall be used instead of letter "D" to denote particular tower type.

E.g. TFL shall be used for four circuit suspension (Line) towers

The height of the bottom cross arm of TD1 shall be designed without taking the Vertical Height of the suspension insulator set.

Towers shall be provided with body extension of -3 m, +3 m, +6 m, +9 m, +12 m +15 m and +18 m. TD9/TDT towers shall have up to +15 m body extension. Each type designation will carry the construction type (i.e. TDL +3)

Leg extensions of -3 m, -2 m, -1 m, +1 m, +2 m, +3 m, +4 m and +6 m shall be provided wherever necessary.

5.7.2. STEEL POLES

The poles shall be telescopic steel self-supported double circuit monopoles with 16 sided uniformly tapered.

Following poles structures shall be used in locations specified in the scope of work. The standard types of tubular steel poles shall be designated as follows;

Table 5.10- Pole Types and Designations

1)	Suspension Pole	PDL
2)	0° - 10° Line Deviation Pole	PD1*

	0° Section Pole	
	2° Heavy Suspension Pole	
3)	10° - 30° line deviation Pole	PD3
4)	30° - 60° line deviation Pole	PD6
5)	60° - 90° line deviation & terminal Pole (0°- 45° in line side & 0°- 90° in slack span)	PD9/PDT

*PD1 pole shall be designed for following three (03) applications;

(i) Angle pole for 0° - 10° deviation angle

(ii) Section pole of 0° angle with longitudinal load of 15% of the maximum working tensions of all conductors and earthwires on one side

(iii) Heavy Suspension pole of 2° deviation angle

(Tower type in profile drawing and line schedule "PD1S" is applied in order to distinguish from tension pole)

Weight of lineman with tools 1600 N

Design spans for 132 kV poles shall be the same as for 132 kV Towers, as stated in Clause 5.8

Poles shall be provided with body extension of +3 m, +6 m, +9 m, +12 m +15 m and +18 m. Each type designation will carry the construction type (i.e. PDL+3)

The cross arms of double circuit poles shall be configured to support the line conductors in a vertical formation with one earthwire and one OPGW above the top conductors to provide a 5° lightning shield angle.

Heaviest section of the poles should be limited within the normal lifting capability of the proposed erection equipment and possible to facilitate transport.

5.7.2.1. POLES/SUPPORT STRUCTURES STEELWORK

The Contractor shall ensure that the Poles structure steelwork consists of steel tubes sections (shafts) made of special high steel grade S500MC according to EN 10025 or equivalent. The crossarms base plates and connection plates shall be made of steel grade S355JO according to EN 10025.

The ultimate design load (working load multiplied by factor of safety) in tensile loading cases shall not exceed the elastic limit strength of the material.

Steel shall be free from blisters, scale or other defects.

The cross arm ends of tension poles shall be so arranged that two holes for the attachment of conductor erection and maintenance shackle be provided adjacent to each hole for tension set shackles. It shall be possible to apply full conductor tension safely to either additional attachment point.

Poles shall be capable of accommodating OPGW joint box including spare wire length where required. A Suitable arrangement shall be made for OPGW connection from tower top to joint box.

All Pole members shall be stamped with distinguishing numbers and/or letters corresponding to those on the approved drawings or material lists. These erection marks shall be impressed prior to galvanizing and shall be clearly readable.

The pole top shall be capped. Poles shall have an arrangement to prevent if rain water is trapped in any part of the structure.

Minor modifications may be made to standard Pole designs where the Employer directs that such be required to suit special loading conditions.

Each bolt shall be supplied with: one plain washer, one spring washer and 2 Standard Nuts. Nuts and heads of all bolts shall be of the hexagonal type.

Use only one bolt diameter per Pole unless otherwise agreed by the Employer.

The type of the tower shall be marked with permanent paint on the pole. All male sections of the poles shall be marked with permanent horizontal line at the respective overlapping length.

Attachment holes for the ground earthing conductor shall be provided on pole cap and base plate. The cost of required earthing materials shall be included in the price of poles. During assembling the sections of poles, if galvanizing on mating surface is damaged it shall be repaired.

Welding shall be carried out according to the relevant standards. All welding shall be continuous, parallel to the longitudinal axis of the pole and shall be capable of developing the full strength of the parent material. All welding shall be carried out at manufacturer's plant. Welding at site is not permitted.

All drilling punching cutting shaping and welding of parts shall be completed and burrs shall be removed before the galvanizing.

All steelwork shall be hot dip galvanised according to BS EN ISO 1461 consisting of minimum zinc coating 610g/m^2 (or equivalent 0.086 mm, as thickness). The preparation for galvanizing and galvanizing itself shall not distort or adversary affects the mechanical properties of the material. The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

5.7.2.2. POLE/SUPPORT STRUCTURE ACCESSORIES

STEP BOLTS

Each Pole shall be provided with galvanized step-bolts of an approved type and fixed on the pole trunk at not more than 400 mm centres starting immediately above the foundation cap and continuing up to the earth wire.

The step bolt shall with- stand load of at least 1330 N.

ANTI-CLIMBING DEVICES

Spiked type anti-climbing device shall be provided where access for personnel is required. The height of the anti-climbing device shall be designed within the limits of 3 m and 4.5 m from the ground on any type of pole. It shall be provided with a hinged section with a padlock.

POLES EARTHING

Each pole shall be provided with 4 short tails of earthing conductor of 7/4.00mm stranded galvanized steel wire, connected to the pole above ground level to the special provided earthing angles and protruding from the foundation concrete sufficiently to allow subsequent connection to be made to the counterpoise earthing system.

LOADS ON FOUNDATIONS (In addition to Chapter 6: Foundations)

The foundations shall be designed to withstand the reactions at Pole base considering appropriate factors of safety specified for the design. The above base reactions with appropriate factors of safety shall further be multiplied by a factor 1.10 for the check against over-turning, sliding and uplift.

Whenever wire slings or ropes are liable to be used, the pole shall be suitably protected by heavy Hessian bags or strips, or by some other approved method.

The Contractor shall make use of temporary struts on poles shafts prior to lifting, if in the opinion of the Employer, there is a likelihood of damage occurring to that shaft during lifting.

Where derricks are used for lifting, they shall be securely guyed.

All Poles shall be vertical under the stresses set up by the completed overhead line to the satisfaction of the Employer. The maximum acceptable deviation from vertical shall normally be 1%.

Proper precautions shall be taken to ensure that no parts of the Poles are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.

The poles shall be stored off the ground. Handling and erection of all pole structure shall be done carefully to avoid bending or damage to galvanizing. When stacking wood blocks shall be used underneath to support the steel poles. Similar protection shall be used on the decks of wagons, lorries, trucks, ships etc. during transportation.

Throwing of Pole steel into piles on conveyances or from conveyances onto the ground is totally prohibited. The Pole steel shall be laid out in neat rows, in complete Pole lots and shall be labelled with respective type, height and Pole number.

Suitable ladders shall be used whenever necessary during erection, but such ladders and removable step bolts shall be removed when erection work is not in progress.

After erection all poles shall be cleaned of all foreign matter.

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads.

The Contractor must ensure that poles erection procedures and equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as members of the public.

Damage to the galvanized surfaces of the poles steelwork and the bolts shall be repaired using approved zinc rich paint or similar and the cost of such repair is deemed to be included in the appropriate rates.

TESTING

Testing will be carried out as per the recommended international standards.

5.7.3. GANTRY AND DETAILS

Gantry structures shall be of self-supporting lattice steel construction and shall consist of three lattice columns and two lattice beams in each gantry structure. Gantries shall be constructed at some places where it is required to cross existing

transmission lines including 33kV lines. Two gantry structures shall be required at a single crossing point of an existing transmission line. Each gantry structure shall comprise of three peaks to connect earth wires (one for OPGW and other two for GSW). Gantry structures shall be designed to withstand wind loads on the structure and horizontal & vertical loads coming from conductors with necessary insulator sets, earth wires and all fittings due to weight, tension and wind under the conditions specified.

5.8. DESIGN SPANS

The design of all structures shall provide for the following basic, wind and weight spans.

Table 5.11- BASIC SPAN

	132 kV	**220 kV**
BASIC SPAN	300 m	350 m

Table 5.12- WIND SPAN

Tower Type	**Condition**	**132 kV**	**220 kV**
All Towers	Normal Working (NW)	360 m	420 m
	Broken Wire (BW)	270 m	315 m

Table 5.13- WEIGHT SPAN

Tower Type	**Condition**	**132 kV**		**220 kV**	
		Max. (m)	**Min. (m)**	**Max. (m)**	**Min. (m)**
TDL	NW	600	*	700	*
	BW	450	*	525	*
TD1S	NW	1220	NA	1220	*
	BW	915	NA	920	*
TD1 [Section Tower]	NW	1220	-600	1220	-600
	BW	915	-450	920	-450
	NW	900	-300	1050	-300

TD1 as an [Angle Tower]	BW		675	-200	790	-200
TD3 & TD6	NW		900	-300	1050	-300
	BW		675	-200	790	-200
TD9/TDT	NW	TD9	900	-300	1050	-300
	BW	TD9	675	-200	790	-200
	TDT NW	Line Side	250	-200	300	-200
		Slack Span	75	0	75	0
	TDT BW	Line Side	50	0	70	0
		Slack Span	NA	NA	NA	NA

*Minimum weight span for suspension towers shall be according to wind span/ weight span application chart.

Design spans for gantries shall be decided based on-site conditions by the Contractor and approved by the Engineer.

Design Criteria for Four Circuit Towers:

- For 220/ 132 kV – 220 kV Basic Span, wind span, weight span shall be used
- For 132/ 33 kV – 132 kV Basic Span, wind span, weight span shall be used

Spans for broken wire condition apply only for the conductors or earth wire considered broken - loading for the intact conductors shall be based on Normal Working Spans.

The term basic span shall mean the horizontal distance between the centers of adjacent supports on level ground from which height of normal supports is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term wind span shall mean half the sum of adjacent horizontal spans lengths supported on any one tower.

The term weight span shall mean the equivalent length of the weight of conductor supported at any one tower at minimum temperature in still air. At suspension positions the minimum weight of conductor, inclusive of weights where used, is not to be less than 25%, of the total weight of conductor in the two adjacent spans.

In steeply sloping areas where the gradient between adjacent supports exceeds 15° to the horizontal, special consideration shall be given to the vertical loading on towers.

Four circuit towers shall be designed in a way that any one circuit of the line could be maintained under hot condition while other circuits are in normal operation. Therefore, required clearance for live working shall be kept between the set of cross arms of different voltages, enabling linesman to work using standard hotline tools.

5.9. ASSUMED WORKING LOADINGS

For all tower types and gantries, the calculation of design stresses for the steel members under normal or broken wire loadings shall be considered for the worst loading combinations from the range of loading cases which are considered.

All towers shall be designed taking into consideration any combination of minimum and maximum tower body extensions.

5.9.1. NORMAL CONDITION

The assumed maximum simultaneous working loading on towers and gantries shall be as follows;

(A) Suspension Towers (TDL)

(i) Vertical Loading (Maximum, minimum)

For the maximum weight condition, the weight of the insulators and all other fittings and the actual dead weight of specified span lengths of phase conductors and earthwires.

For the minimum weight condition, the weight of the phase conductors and earthwires shall be considered to be zero. The weight of the insulators shall be ignored.

(ii) Transverse Loading from Wind

A wind pressure of 970 N/m^2 at right angles to the lines on the whole projected areas of the conductors and earth wires. 1170 N/m^2 on insulators and in addition a wind pressure of 1640 N/m^2 on 1.5 times the projected area of the members of one face of the tower.

Suitable allowance shall be made for the projected area of cross arms, earthwire peaks, any fibre optic transmission system equipment

mounted on the tower and any aircraft warning marker (AWM).

(iii) Transverse loading from conductors and earthwire maximum working tensions

The transverse horizontal component of the maximum working tensions of the conductor and earth wire, shall be considered for the 2° maximum line angle deviation, as specified.

(B) Angle Towers (TD3, TD6 & TD9 function of TD9/TDT tower)

Maximum vertical and transverse loading as described above plus the transverse horizontal components of the maximum working tensions of the conductor and earth wire, corresponding for the maximum angle of deviation.

For the minimum weight condition, the actual dead weight of specified minimum (uplift) span lengths of phase conductors and earthwires shall be considered.

The full wind span shall be taken regardless of the angle of line deviation. The transverse components of phase conductors and earthwire tensions shall be computed for the full range of specified angles of deviation.

Where cross arms are not pointed in the plan at the outer ends, the design shall allow for the entire vertical loading to be applied to a single outer corner of each cross arm.

The Bidder shall indicate the variation of wind spans with the angle of deviation for the towers under this condition and also indicate the maximum negative weight span (i.e. uplift force).

(C) Section and 10° Angle Tower (TD1)

The loading for these towers shall be any one of the following three conditions, which shall in all cases include for transverse loading as applied to straight line supports;

(i) 0° - 10° Angle as per angle tower loading.

(ii) Section loading nil angle of deviation Weight span 1220 m. Unbalanced longitudinal loading of 15% maximum working tension shall apply for all conductor and earth wire points.

(iii) Uplift loading as per condition (ii) but weight span to be minus 600 m, (i.e. upward force).

(iv) Heavy suspension tower in special positions the tower strength capacity derived from loading (i) and (ii) may be utilized in positions of extra-long wind and weight spans, using double suspension insulator sets. The tower shall be so arranged that electrical clearances are maintained either tension insulators or with double suspension insulators, in accordance with Clause 5.4

The Bidder shall indicate the maximum wind spans available for the towers under this condition. The lowering in conductor attachment level when suspension sets are fitted shall be taken into account when plotting profile and need not be allowed for in calculating height above ground to lowest cross arm.

(D) Terminal Tower (TDT function of TD9/TDT tower)

Loading for terminal towers shall be the vertical and transverse loading as described in Section (A) of this clause using the design spans for terminal towers, together with the full maximum longitudinal conductor and earthwire tensions derived from the Technical Particulars of Employer's Requirements and considered for a plan angle of entry of 00 up to 45° on the line side. In addition, the terminal towers shall be designed to accommodate slack span conductors to the substation gantry at any angle of exit from 0°- 90° to the tower and from the horizontal to the vertical plane. All terminal towers shall also be designed for up to 4 slack spans of earthwires (2 per arm) to connect to the substation earth masts.

Slack Span Tension per Wire

Conductors	6660 N
Earth wires	4500 N

Where necessary auxiliary conductor and earth wire cross arms shall be used, at the schedule extra rate, for a large angle of deviation into the substation. Auxiliary conductor and earth wire cross arms shall be designed to carry the slack span tensions mentioned above, together with the relevant weights of insulators, etc.

(E) Gantry

Loading for gantry structures shall be the vertical and transverse loading as described in the sections (A) and (B) of this clause using design spans for

gantries together with the full maximum longitudinal conductor and earthwire tensions derived from the technical particulars of Employer's requirements and considered for an angle of entry on the horizontal plane available at the site. In between the two gantry structures at a gantry location, slackspan shall be considered, and slackspan tension of conductors and earth wires shall be as specified in the section (D) of this clause.

5.9.2. BROKEN WIRE CONDITION

Suspension structures shall be designed for the reduced vertical and transverse loading derived for Clause 5.8 plus the unbalanced longitudinal force at maximum working tension due to the breakage of one phase conductor or one earthwire. In case of a bundled phase conductors (twin or more), breakage of all sub-conductors in the same phase or breakage of one earthwire shall be considered.

In the case of a conductor breakage the pull on a suspension tower may be assumed to be reduced to 70% of the specified maximum working tension. This reduction shall not be assumed in the case of an earth wire breakage. The Bidder shall indicate the maximum negative weight spans (i.e. uplift force) available for the intact (unbroken) phase conductor or earthwire under this condition.

Tension Towers and gantries shall be designed for vertical & transverse loading plus the full unbalanced longitudinal forces at maximum working tension due to the simultaneous breakage of two adjacent phase conductors on the same side of the tower/gantry structure, or of one earthwire and one phase conductor In case of a bundled phase conductor (twin or more sub-conductors), the term phase conductor will mean all sub-conductors of the same phase.

For TD1 towers, the design shall take account of the possibility that the unbalanced tensions referred to in Clause 5.9.1(C) (ii) and (iii) may act either in the same direction as broken wire forces, or in the opposite direction, applying increased torsion moments to the tower body.

5.9.3. STRINGING CONDITION

Under stringing condition, weight and wind span and factor of safety relevant for normal condition shall be considered irrespective of whether they are in strung or stringing state.

(A) Eccentric Loading

This loading case will be considered under Every Day Stress condition (EDS) still air (no wind).

Vertical load caused by one circuit conductors and earthwires strung on tower shall be considered in the design.

Transverse horizontal components of the EDS tensions of conductors and earthwires corresponding to the maximum angle of deviation shall be applied

For terminal towers, torsion loads caused by the unbalanced longitudinal working tension due to one circuit conductors and earthwires strung shall be considered at EDS tensions.

Eccentric loading shall not be critical in designing gantry structures

(B) Tensioning Loadings

All earthwires and conductors are installed on towers for which corresponding vertical and transverse loads shall be applied. In addition, longitudinal loads of every two earthwires, top two phases, middle two phases or bottom two phases of conductors as well as vertical loading derived from guy wires installed for back tension shall be applied. The conductor and earthwire tensions for calculation of transverse and longitudinal loads shall be based on reduced 10% and 50% of maximum working tensions for suspension towers and tension towers respectively.

Tensioning loadings shall not be critical in designing gantry structures

The Contractor shall ensure that all towers and gantries can safely withstand any other loading condition which may occur during construction operations with the minimum factor of safety as recommended by IEC 60826.

5.10. FACTORS OF SAFETY

The design philosophy shall be based on deterministic concept applied in conjunction with the safety factors method.

Each type of tower and gantry structures shall be so designed that no failure or permanent distortion shall occur in any part of the tower/gantry structure when tested with applied forces equivalent to the specified maximum or minimum applied loads and the specified maximum simultaneous unbalanced loadings with the following factors of safety:

Table 5.14- Minimum safety factors

Description	Factor of Safety
Conductors, Earthwires and OPGW at Maximum Working Tension based on Ultimate Strength	2.5
Conductors and Earthwires at Everyday Temperature (EDS) still Air Tension, based on Ultimate Strength	4.5
Tension Clamps and Mid-span Joints, based on Ultimate Strength of Conductor and Earthwire	0.95
Insulator Strings and Fittings at Maximum Working Tension based on Failing Load	3.0
Suspension Towers under Normal Working Condition	2.0
Angle, Section, Terminal Towers and Gantry under Normal Working Condition	2.5
All Towers and Gantry under Broken Wire Condition	1.25
Cross arms of Suspension Towers under Broken Wire Condition	2.0
Cross arms of angle, section and terminal Towers under Broken Wire Condition	2.5
Foundations of Suspension Towers under Normal Working Condition	2.0
Foundations of angle, section, terminal towers and gantries under Normal Working Condition	2.5
All Foundations under Broken Wire Condition	1.5

All towers and gantries shall be designed as self-supporting structures, conforming to the loadings and duties as specified and including all loadings resulting from the Contractor's erection and stringing methods, as well as for:

- Simplicity and ease of erection,
- Sub-assembly of panels on the ground,
- Erection of panels by gin pole/derrick.

5.11. DESIGN AND DETAILING OF SUPPORT STEEL WORK

The Contractor has to use the three-dimensional indeterminate stiffness method of checking for tower design. The computer program to be used shall be developed or tested by a recognized institute, acceptable to the Employer.

All materials shall be brand-new and of the best quality for use in the conditions and the variations in temperature and pressure that will be encountered in service without undue distortion or deterioration or the setting up of undue strains in any part that might affect the efficiency and reliability of the plant. Any steel member with traces of hole filling shall not be used.

Special attention shall be paid to eliminating the possibility of corrosion resulting from galvanic electrochemical effects. Design, selection of materials and all methods of erection shall be such as to keep these effects to a minimum.

Materials used for the design and construction of the steelwork shall comply with the codes and standards listed below.

The materials for steel tower construction shall be as follows:

a) Rolled shapes and plates

All materials shall be hot-rolled of mild steel and /or high-tensile steel and shall conform to the steel qualities S275JO and S355JO respectively according to EN 10025 or equivalent standards.

The chemical composition and mechanical properties of the grades of steel used shall correspond to the EN 10025 and be suitable for working in the project area.

b) Connection bolts, nuts and washers

All metal parts shall be secured by means of bolts and nuts provided with plain washers and spring washers.

For structural connections, one bolt size is preferred. The minimum diameter and number of bolts at each connection for stressed member shall be as follows:

Diameter:	16 mm
Number of bolts:	2

For 132 kV and 220 kV, the number of bolts for connecting redundant members shall be used as per the detailed design submitted for approval.

All tower steel connection bolts, nuts and washers shall comply with ISO 898-1, BS 4190, BS EN 20898 or other approved standard and screw threads shall be to metric standards. Bolts and nuts shall be of steel, with hexagonal heads. Screw threads shall not form part of the shearing plane between members, any thread in the bearing plane shall be to the approval of the Employer. Bolts of any given diameter shall be of one grade of steel and marked for identification.

The quality of bolts shall be not less than 5.6 according to BS EN 20898 or equivalent.

Bolt spacing and edge distance shall be according to ASCE 10/97 for members in towers and BS 5950:Part1:2000 for members in gantries.

The nuts of all bolts for attaching to the tower: plates, brackets or angles supporting insulator sets or earthwire fittings shall be locked by means of locknuts.

All bolts and screwed rods shall be galvanised, including the threaded portions; all nuts shall be galvanised with the exception of the threads, which shall be oiled. Galvanising shall be in accordance with Clause 1.33 of this Specification.

There shall be no excess of galvanizing at the root of the thread and nuts shall turn easily on the complete bolts without excessive looseness.

Bolts will be rejected if they are considered by the Employer to have an excessive loose or tight fit.

When in position all bolts or screwed rods shall project through the corresponding nuts, for a minimum of two full turns but such projection shall not exceed 10 mm.

All bolts and nuts below the anti-climb device to be special vandal-proof bolts from ground level.

c) Locking devices

All tower bolt connections shall be provided with one flat washer and one spring washer.

d) Tower signs (plates)

Tower plates, consisting of aerial patrol, phasing, circuit name, danger plate and tower number shall be made of anti-corrosive materials: mild steel covered with enamel on either sides, or aluminium. The thickness shall not be less than 2 mm.

High strength steel, when stored in the fabricator's stockyard prior to fabrication and galvanizing, shall be marked continuously throughout its length with a light blue water paint line. In addition, the grade number of the steel shall be painted on and ringed round with paint.

Steel shall be free from blisters, scale or other defects and shall be smooth on surface finish.

The minimum thickness of steel members of towers and gantries shall be as follows:

- Leg, stub and main compression members in cross arm 6 mm
- All other members having computed stresses 5 mm
- Redundant members without computed stresses 5 mm
- Gusset plates 6 mm

The minimum angle section permitted shall be 45 mm × 45 mm × 5 mm. Unequal angle sections shall not be used in any case.

The sections used in the design of the structures shall be of equal angle profiles and readily available from standard sources of supply.

All structures and their components shall be designed to withstand without failure the stresses resulting from the design loading combinations, inclusive of the specified factors of safety.

All cross arm and bridge chord members shall be capable of supporting an ultimate vertical ladder load at any position within 1 m of each phase centre line of 4450 N. The ladder load shall be applied as two 2225 N point loads 0.3 m apart.

The redundant members shall be designed to carry 2.5 percent of the axial load of the members they restrain in addition to the vertical load of 1.8 kN described above.

Bolt-holes shall not be more than 1.5 mm larger in diameter than the corresponding bolt diameter. The design shall be such as to keep the number of different parts as small as possible, and shall facilitate transport, erection and inspection.

Bracing shall be symmetrical in each face.

The ultimate design stress in tensile members shall not exceed the elastic limit strength of the material. The ultimate stress in the compression members shall not exceed a figure obtained from an approved formula to be entered in Technical Particulars of Employer's Requirements based on the elastic limit strength.

For maintenance purpose, each suspension cross arm tip shall incorporate two attachment points of equal strength at approved positions: one for the suspension insulator set and the other for maintenance equipment.

The crossarm tips of tension towers shall be so arranged that two holes for the attachment of conductor erection and maintenance tackle are provided adjacent to each hole for tension set shackles. It shall be possible to apply full conductor tension safely to either additional attachment point.

All joints shall be such that eccentricities are kept as small as practicable. Spaces between members at the connection points, created by the arrangement of members in the tower/gantry structure, shall be completely filled by the use of fillers with proper thickness. Gusset plates, where used, shall be designed by the Contractor and shall be in accordance with relevant standards.

Attachment devices shall be suitably furnished on all cross arms or gantry beams to suspend and to terminate insulator or earth wire assemblies. The devices shall have minimum ultimate tensile strength equal to that of the hardware.

Stubs shall be provided with suitable holes for connection to the standard grounding system and the counterpoise. The lowest bolt hole in the stub for connection of the main bracing member shall be 50 mm above the foundation concrete level.

All designs and details of towers and gantries shall conform to the requirements of the ANSI/ASCE Manual – 10-97 "Design of Latticed Steel Transmission Structures" (latest edition) and BS 5950: Part1:2000 "Structural Use of Steelworks in Building" respectively

The towers shall be designed taking into consideration any combination of minimum and maximum tower body extensions.

The design drawings and calculations shall show the following data and information:

- Scaled line diagram of the tower/gantry showing all redundant, bracing members and their sizes completely dimensioned and proved in compliance with all clearance requirements.

- All loads and their manners of application including the determination of wind load on tower/gantry. Wind load on towers shall be applied at each panel point along the height of the towers.
- Tables showing:

(i) Total stresses in each member for each load case and the critical case.

(ii) The effective slenderness ratio, calculated capacity and ratio of maximum total stress to calculated capacity for each member and connection.

(iii) Size and type of steel for each member and number of bolts required for its connection.

(iv) The calculated weight of the complete galvanized tower.

(v) The compression and uplift reactions and corresponding horizontal shears at each leg of all towers for all loading cases.

The maximum allowable effective slenderness ratio (KL/R) for various classes of member shall not exceed the values given in the next table.

Table 5.15- Maximum allowable effective slenderness ratios

	Members	**KL/R**
(a)	Main members in the cross arm in compression and legs	120
(b)	Bracing carrying computed Stresses	200
(c)	Redundant	250
(d)	Bracing loaded in tension only	350

The determination of effective slenderness ratios of any member of a tower shall strictly conform to the requirements in ASCE, Guide for the Design for Latticed Steel Transmission Structures.

Plan bracing of towers at the levels of cross arms shall be such a type to prevent the cross section of the towers from deforming from the original form under torsional loading.

The angle included between any two connecting stressed members shall not be less than 15 degrees.

The angle included between diagonal members and main members for the Heavy Angle and for the Dead-end towers shall not be less than 25 degrees.

Detailed drawings shall be complete with sizes and detailed dimensions of all members. At each joint, there shall be the number, size and length of bolts, number and size of fillers and detailed dimensions of gusset plate, if any.

All members and plates shall be designed on drawings, the Contractor shall endeavor to use as few designations as possible, and each member of identical size and detail shall have the same designation, regardless of its position in the structure.

The member and plate designation shall be successively grouped on individual drawing. The groups of designations shall be indicated on the drawings.

A proper cross-index shall be furnished, correlating the tower part numbers with the tower types and drawing number.

A bill of materials shall be submitted containing the size, length and galvanized weight of each member and the total weights of body, body extension and foundation stub conforming to the detailed drawings approved. It shall also include the number of bolts, nuts, washers and attachment devices per structure.

At locations with steeply sloping ground one or more of the tower legs shall be extended or reduced in lattice steel framework, in 1 metre intervals in an approved manner to give minimum interference with standard or extended body design. Independent single leg extensions shall be designed and provided where necessary for both standard and extended towers. Attention is drawn to Clause 8.10 in respect of the limitation on extra payments where sloping ground is encountered.

Minor modification may be made to standard tower design where the Employer directs that such are required to suit special loading conditions.

Where no specific rate is included in Schedules, payment for special extensions, cross arms, body extensions or other extra steelwork will be made at the variation rates of galvanized steelwork entered in Schedules. For special extensions, the weight paid for will be the difference between the weight of the tower actually installed (i.e. with hillside extensions) and the weight of the tower would have been required to give the same height from center peg on level ground (with normal extension if appropriate), Based on the detailed Bill of materials for both towers approved by the Employer.

5.12. ANTI-CLIMBING DEVICE, BIRD GUARDS, ANTI-THEFT BOLTS AND STEP BOLTS

a) Anti-climbing devices

Each tower shall be fitted with an approved spiked rod type anticlimbing device generally as indicated in drawings of this bidding document. Spikes shall be of a solid design, have a sharp end, a minimum length of 250 mm and shall be pointed downwards. The maximum distance between the strings of barbed wire shall not be more than 100 mm. The horizontal separation of the strings of barbed wire shall be maintained by the provision of spacers at a maximum distance of not more than 2 m. The mounting of the anti-climbing device may be either separately or on members forming an integral part of the tower and designed within the limits of 3m and 4.5 m from the ground on any type of tower. Where the support or tower is erected on sloping ground the height should be measured for the foot of the support from the highest ground point.

b) Bird guards

Tower members positioned above insulator strings/solar (if applicable) shall be fitted with stainless steel needle strips, effectively preventing birds from sitting in these locations. The strips shall extend sufficiently, horizontally beyond the protected location and shall be applied to all surfaces a bird can sit on. Where needles are projecting from cross arm contour towards live parts, the tower clearance diagram shall consider the height of the needles.

c) Step bolts and anti-theft bolts

Each tower shall be provided with step bolts of an approved type on diagonally opposite legs at not more than 380 mm centers starting immediately above the anti- climbing device and continuing to the earth wires. No step bolt shall be assumed to contribute to the strength of a structural joint. The minimum diameter of the step bolts shall be 16 mm. Step bolts shall not be used as connection bolts.

Holes for removable step bolts below the anti-climbing guards shall be provided at no more than 380 mm centers on the legs to which the permanent step bolts are fitted.

To prevent theft of tower members, special measures shall be taken and special bolts connections shall be installed for the connection of all diagonal members and secondary bracing members below the anti-climbing device.

The cost of anti-climbing devices, bird guards, step bolts and anti-theft bolts shall be deemed to be included in the price of the towers.

5.13. DANGER, NUMBER, PHASE PLATES AND COLOUR CODES

The Contractor shall furnish and fix in approved positions on towers all materials for tower signs as shown on the drawings including all bolts, nuts, washers, brass eyelets fitted with the holes and supporting structures for attaching the signs to the structures.

The colors of figures and background shall be as generally shown in the drawings, described below or as it will be indicated later by the Employer and shall be of corrosion resistant aluminium with embossed letters and painted, or of enameled mild steel.

The Contractor is required to make provision in the tower members for attaching signs at the locations described hereunder.

a) Number and circuit designation plate

The tower number and circuit designation plate shall show the tower number and each circuit abbreviation and number in Red letters, on a white background. The figures height shall be 150 mm.

The plate shall be provided at every tower and shall be installed about three meters from ground level and above anti-climbing guards. Termination gantries shall be equipped with circuit plates showing the circuit name in full length.

b) Phase plates

Phase color plates of approved types of corrosion free material for indicating the line phasing sequence, shall be provided at all structures. Phase plates shall show the English letters "R", "Y" and "B", in black color, on red, resp. yellow, resp. blue background. Phase plates shall be secured to number plates with stainless steel bolts and should be detachable.

c) Airborne observation plates

On each tension and every tenth suspension tower an airborne observation number plate shall be provided. The tower number shall be cut from the sheet metal, with a letter height of min. 500 mm. The plate background shall be white and the engraved numbers, red. The plates shall be installed, either on the top cross arm or on the earthwire peak, in a position that is easily recognizable from the air.

d) Danger plates

Danger plates (2 Nos.) shall feature red symbols on a white background. They shall comprise three lightning arrows as shown in the drawings and the text "DANGER" which shall be boldly written in Sinhala, Tamil and English languages. The voltage shall be shown as well.

Danger plates shall be attached about three meters from ground level and above anti-climbing guards and shall be provided at every tower.

All plates shall be of anti-corrosive material. If enameled iron plates are used, the whole surface of each plate including the back and edges shall be properly covered and resistant to corrosion. On all plates the colors shall be permanent and free from fading. With enameled plates, washers of approved material shall be provided back and front of the stainless-steel securing bolts.

The cost for danger, number and phase plates shall be deemed to be included in the price of each tower.

5.14. FABRICATION

Fabrication shall not commence until approval of drawings and completion of successful tower tests, unless otherwise directed by the Employer.

5.14.1. WORKMANSHIP

Workmanship shall be first class throughout. All pieces shall be straight, true to detailed drawings and free from lamination flaws and other defects. All clipping, back-cuts, grindings, bends etc. must be true to the detailed drawings.

All identical pieces bearing the same erection number must be exactly interchangeable with each other and interchangeable in their relative position in all structures of which they form a part.

The Contractor shall be responsible for the correct fitting of all parts. He shall replace, free of charge, any defective material discovered during erection, and pay all costs of field corrections for such replacement.

All parts of the structure shall be neatly finished and free from kinks, twists or bends. The fabrication shall be in strict accordance with the shop drawings prepared by the Contractor and approved by the Employer.

5.14.2. SHEARING AND CUTTING

Materials may be sheared to length, but the ends must be square with length and free of burrs so that difficulty of assembly caused by interference of end section with other members at the time of assembling the steel tower may not occur.

5.14.3. PUNCHING AND DRILLING

All bolts holes in steel members shall be punched, sub punched, reamed or drilled before galvanizing. Holes for conductor attachment shall not be punched but only drilled. All members shall be cut to jig and all holes shall be punched or drilled to jig.

Holes are to be punched with racks and jigs employed to ensure accuracy throughout. The punches and dies for this work must be maintained sufficiently sharp so as to produce clean round holes normal to the plane of material. Holes shall be free of burrs, folds and depressed, upset, or ragged edges.

Bolt holes shall be drilled full size and at right angles to the surface of the steel, accurately spaced and true to line, pitch gauge and edge distance. Any member having holes or cut more than 0.8 mm from correct position will be subject to rejection. No welding, filling or plugging will be permitted unless otherwise approved by the Employer.

Holes may be punched subject to the following limitations. In the cases listed below, holes shall be drilled full size or sub-punched to a diameter of not less than 4 mm smaller than the required diameter and reamed to the required diameter:

- Structural steel more or equal to 16 mm thick;
- High strength structural steel more or equal to 12 mm thick;
- Holes in the vicinity of bends in members or gusset plates;
- Holes in cross arm members normally loaded in tension for both steel qualities S275JO and S355JO according to EN-10025 European Norms or equivalent

Holes which are elongated or otherwise distorted by bending will not be accepted.

The diameter of bolt holes shall be 17.5, 21.5 and 26 mm for 16, 20 and 24 mm bolt diameter respectively, or for larger sizes not greater than 2.0mm greater than the bolt diameter.

All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite each other before being bolted up. Drifting of holes will not be allowed.

All matching holes for bolts shall pass freely through the assembled members in a direction at right angles to such members.

5.14.4. BENDING

All bending of high-strength structural steel must be done hot. Bends of a difficult nature on structural steel must be done hot, but otherwise cold bending can be employed.

Members bent hot shall be heated in a non-oxidizing flame over a sufficient area to prevent excessive deformation.

Hot bends shall be left for slow cooling in air. Where bends are near splices, the upset metal shall be forged smoothly for full bearing on the contact surface.

A member bent in error with respect to the location of a bend line shall be rejected.

5.14.5. WELDING

No field welding will be allowed unless otherwise approved by the Employer.

All welding shall be performed in accordance with the Standard Qualification Procedure of the AWS (American Welding Society). A shielded arc-welding process shall be used. All welds shall be made in such a manner that residual shrinkage stresses will be reduced to a minimum. If not previously qualified, the welding process and the welders employed in performing the work covered by the Contract Documents shall be qualified in accordance with the requirements of the mentioned AWS. The structural steel, the welding process, electrodes and treatment shall be such as to avoid embrittlement of the steel and safe operation shall be assured at low temperatures.

5.14.6. TOLERANCES

Tolerances of finished members shall be as follows:

Finished members shall not have lateral variations greater than 1/1000 of the actual length between points of lateral supports.

Finished members without ends finished for contact bearing shall have a tolerance +1.5 mm for members up to 3 m in length. For members over 3 m long, an additional 1 mm for every 3 m length may be allowed, but in no case will a tolerance more than 3 mm allowed for any member.

5.14.7. MARKING

All individual pieces shall be marked with the correct designations shown on the detailed drawings approved and shall indicate the type of towers also. Markings shall be done by stamping the marks into the metal before galvanizing and details shall be clearly legible after galvanizing. The figures and letters shall be minimum of 12 mm in height.

Marking of bolts shall be made on bolt heads to identify manufacturer, grade, size and length. Markings may be raised or depressed.

5.14.8. CLEANING AND GALVANIZATION

a) Cleaning

After fabrication has been completed and accepted, all materials shall be clear of rust, loose scale, dirt, oil, grease and other foreign substances that may affect the uniformity of the coating.

b) Galvanizing

Galvanizing work shall conform to requirements of Clause 1.33 and as following specified.

It is essential that the shape of steel members and assemblies which are to be hot dip galvanized shall conform to the requirements of the process.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed. All drilling, cutting, welding, forming and final fabrication of unit members and assemblies shall be completed before the structures are galvanized. The surface of the steelworks to be galvanized shall be free from paint, oil, grease and similar contaminants.

The minimum average coating weight shall be as specified in Table 1 of B.S. 729 or equivalent. Structural steel items shall be initially grit blasted to B.S. 4232, second quality, (Sa 2 ½) or by pickling in a bath and the minimum average coating

weight on steel sections 4 mm thick and over shall be 700 g/m^2. However, in case the particular tower and fittings specifications are more severe - those provisions should be observed.

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high tensile friction grip bolts shall be roughened before assembly so that the required slip factor (defined in B.S. 3294, Part 1 and B.S. 4604, Part 1) is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high tensile friction grip bolts (referred to in B.S. 3139 and B.S. 4395, Part 1) shall be hot dip galvanized and subsequently centrifuged. Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger turned on the bolt for the full depth of the nut. No lubricant, applied to the projecting threads of a galvanized high tensile friction grip bolt after the bolt has been inserted through the steelworks, must be allowed to come into contact with the mating faces of the steelworks.

Protected slings shall be used for off-loading and erection. Galvanized work which is to be stored at the works or on site shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining (white rust).

Small areas of the galvanized coating damaged in any way shall be restored by:

- Cleaning the area of any weld slag and thorough wire brushing to give a metallic clean surface.
- The application of two coats of zinc powder rich paint, or the application of a low melting point zinc alloy repair rod or powder to the damaged area, which is heated to 300^{o}C.

  After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Connections between galvanized surfaces and copper, copper alloy or aluminum surfaces shall be protected by suitable tape wrappings.

All materials for towers shall be hot-dip galvanized after fabrication and cleaning.

All steelwork shall be hot dip galvanized in accordance with internationally recognized standards such as EN ISO 1461, ASTM A-123, ASTM A-153 or

equivalent, providing a smooth, clean and uniform zinc coating of min 700 g/sqm (100 micrometers) thickness for bars and plates and 500 g/sqm (70 micrometers) for bolts, including the threaded portion. All nuts shall be equally hot dip galvanized except the threaded portion which will be greased.

Excess spelter shall be removed by appropriate means acceptable to the Employer.

Nuts and locknuts shall be galvanized after threading. Retapping of nuts and locknuts after galvanizing, if required to ensure free running of nut on bolt, shall be such that sufficient protective zinc or tapping oil will remain on threads in nuts and locknuts.

Finished materials shall be dipped into a solution of dichromate or be otherwise treated after galvanizing for white rust protection during sea transportation and storage.

c) Uniformity of coating

A test on the uniformity of the zinc coating shall be made in accordance with ASTM A-239. The minimum number of one-minute dips in uniformity test shall be as follows:

Steel shapes and plates: 6

Bolts, nuts and similar hardware except threaded parts: 4

d) Minor repair

Materials on which galvanizing has been damaged shall be re-dipped unless in the opinion of the Employer, the damage is local and can be repaired by applying a coating of galvanizing repair paint.

Where such repair is authorized, the damaged area shall be cleaned by wiping with clean rags saturated with mineral spirits of xylene, followed by wire brushing. After wire brushing, the area shall be re-cleaned with solvent to remove residue, and shall be given one heavy brush coat of galvanizing repair paint. The percentage of pure zinc by weight in dry film of galvanizing repair paint shall not be less than 85.

5.15. QUALITY ASSURANCE TESTING

The Contractor shall supply a detailed Quality Assurance Procedure, and shall be responsible for performing all tests and inspections required during the production of the towers.

The Contractor shall identify all materials, including bolts and nuts used in the project on the appropriate mill test reports and/or material certificates, and shall furnish the mill test reports and/or certificates to the Employer.

The Contractor shall make dimensional checks of all materials for conformity to the relevant material standard. The Contractor shall make a visual inspection of all materials before and after galvanizing. Embrittlement tests shall be made in accordance with ASTM A-143. Uniformity of coating tests and thickness of coating tests shall be in accordance with the appropriate ASTM. Size of test "lot" and number of tests shall be in accordance with appropriate standards.

In addition to the above inspection and tests, the Contractor is required to perform the following tests at his own expense on samples selected at random by and in the presence of the Employer.

a) Physical tests on samples of structural steel sections
The tests to be carried out shall include yield strength, ultimate tensile strength and percentage elongation. One set of tests shall be carried out for each 50 tons of steel passing through the fabrication plant.

b) Galvanizing tests on samples of structural steel sections
The tests to be carried out shall include determination of weight of zinc coating, adherence of zinc coating and uniformity of zinc coating. One set of tests shall be carried out for each 50 tons of steel passing through the fabrication plant.

c) Mechanical and galvanizing tests on bolts and nuts
Mechanical property and galvanizing tests on samples of bolts and nuts shall be carried out in accordance with the requirements.

If the towers are fabricated or galvanized by Sub-Contractors, the Contractor shall, if required by the Employer, provide a resident inspector at the works of each Sub Contractor during the time that the bulk of the steel work is being fabricated or galvanized.

5.16. PACKING

The whole of the goods shall be packed where necessary in non-returnable cases or on non-returnable drums or otherwise prepared for overseas shipment to a tropical country in a manner suitable to withstand rough handling without sustaining damage. All packing materials shall remain the property of the Owner.

Bundles of steel angle sections shall be properly tied together by an approved method and care taken to ensure that they are robust and not of excessive length

for handling during shipment. All labels shall be of stamped metal. Unless the Contractor can bid an equally acceptable method, bundles of angles shall be arranged in rectangular formation with notched outer stout wooden battens to locate the angles, the battens being compressed on the bundles by outside tie bolts - the above binders being located at sufficiently close intervals to form a strong and homogeneous element. Provision shall be made for the circulation of air between angles to minimize white rust formation.

Bundles shall be as large as practicable to provide stiffness and resistance to careless handling.

Packing cases where used shall be strongly constructed and in no case is timber less than 25 mm in thickness to be used. The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens. Cross battens supporting weight in any direction shall not rely for their support on nails or screws driven lengthwise into the grain of the wood, but shall be supported by cleats secured from the inside.

Bolts and nuts shall be crated in an oil bath for shipment. Crating together of components of dissimilar metals is unacceptable.

Particular attention shall be given to strutting before packing cases are fastened down. Cases shall be up-ended after packing to prove that there is no movement of the contents.

Timber wedges or chocks shall be firmly fastened in place to prevent their displacement when the timber shrinks.

If light parts are fastened to the sides of a case, hoop iron straps secured by screws shall be used for the purpose. Nails driven in and bent over shall not be permitted.

Where bolts are used, large washers shall be fitted under the head and nut to distribute the pressure and the timber shall be strengthened by means of a pad.

The Contractor's attention is drawn to the provisions for galvanizing wherein the Contractor shall be required to protect all steelwork before shipment to prevent damage by white rust to galvanized surfaces.

All stencil marks on the outside of casings shall be either of a waterproof material or protected by shellac or varnish to prevent obliteration in transit.

The use of excelsior as a packing material shall be avoided at all times.

Waterproof paper and felt linings shall overlap at seams at least 13 mm and the seams secured together in an approved manner, but the enclosure shall be provided with screened openings to obtain ventilation.

Each crate or package shall contain a packing list in a waterproof envelope and copies in triplicate shall be forwarded to the Employer prior to dispatch. All items of material shall be clearly marked for easy identification against the packing list.

All cases, packages, etc., shall be clearly marked on the outside to indicate the total weight, to show where the weight is bearing and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

The Owner / Employer may require to inspect and approve the packing before the items are dispatched but the Contractor is to be entirely responsible for ensuring that the packing is suitable for transit and such inspection shall not exonerate the Contractor from any loss or damage due to faulty packing.

5.17. AUTHORITY TO USE DESIGNS

A written authority on all designs of foundations and structures, which are used for this project shall be provided to the Employer for the reuse in other transmission lines.

5.18. ADDITIONAL INFORMATION TO BE SUPPLIED WITH THE OFFER

Other than what is mentioned in the Clause 1.44 in Chapter 1, following information shall be submitted along with the bid;

a) Complete dimensional drawings of supporting structures.

b) Names and addresses of seven (7) purchasers for the particular item with the same or higher quantity, other than the country of origin. The list shall comprise the purchased quantity and the date of purchase.

   For the items that had already been used successfully by the Employer from the particular manufacturer, the bidder only needs to provide the details of the supply to the Employer of identical item.

CHAPTER 6 – FOUNDATIONS

CONTENT

6. CHAPTER 06 – FOUNDATIONS

6.1. APPLICABLE STANDARDS

The equipment or components supplied shall be in accordance with the standards specified below or later editions and/ or amendments thereof.

Offers of items manufactured to any other internationally recognized standards or specifications, provided they are not less rigid shall accompany an English version of such standards.

BS 8004	-	Code of Practice for Foundations
BS 8110	-	Structural use of concrete
BS 4449	-	Carbon steel bars for the reinforcement of concrete
BS 12	-	Specification for Portland cements
BS 812	-	Testing aggregate
BS 1881	-	Testing concrete (All parts 109 to 125 and 201 to 206)
BS 4449	-	Specification for carbon steel bars for the reinforcement of concrete
BS 4466	-	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
BS 8666	-	Specification for scheduling, dimensioning, bending and cutting of steel reinforcement for concrete
ICTAD	-	Specification for Bored & cast In-Situ reinforced concrete piles

6.2. FOUNDATION TYPES

Soil types to be applied for foundation design are classified as shown below;

Table 6.1- Foundation Types

Soil Type	Particular of Soil
S1	Homogeneous Rock
S2	Fractured Rock/ Dense sand and Gravel
S3	Medium Dense Gravel/ Medium Dense Gravel with Sand/ Compact Sand/ Very Stiff to Stiff Clay/ Hard Clay

S3A	Medium Dense Gravel/ Medium Dense Gravel with Sand/ Compact Sand/ Very Stiff to Stiff Clay/ Hard Clay (Water Logged)
S4	Loose Sand and Gravel/ Medium Dense Sand/ Stiff Clay/ Firm Clay
S4A	Loose Sand and Gravel/ Medium Dense Sand/ Stiff Clay/ Firm Clay (Water Logged)
S5	Soft Clay, Silt, / Loose Sand
S5A	Soft Clay, Silt, / Loose Sand (Water Logged)
S6	Very Soft Clays and Silt/ Peat and Organic Soil
S7	Alternative

The foundations for the towers shall be of the types stated above and shall be designed in accordance with the particulars given in the same table.

Table 6.2- Foundation Requirements

Foundation Type		Soil Classification	Presumed allowable Bearing value kN/m^2	Design Uplift Frustum Angle	Level of Water Table	Concrete Density kg/m^3	Solid Density kg/m^3
1	Rock Anchor		> 1000	45		2240/ 1200[2)]	2000/ 1000[2)]
2	Concrete Pad & Chimney	S2	> 500	30	Below Datum level[1)]	2240[2)]	1800
3	Concrete Pad & Chimney	S3	> 200	20	Below Datum level[1)]	2240[2)]	1600
3A	Concrete Pad & Chimney	S3A	> 200	20	Above Datum level[1)]	2240/ 1200[2)]	1600/ 1000[2)]
4	Concrete Pad & Chimney	S4	> 100	10	Below Datum level[1)]	2240[2)]	1500
4A	Concrete Pad & Chimney	S4A	> 100	10	Above Datum level[1)]	2240/ 1200[2)]	1500/ 1000[2)]

5	Concrete Pad & Chimney	S5	> 50	0	Below Datum level[1)]	2240[2)]	1400
5A	Concrete Pad & Chimney	S5A	> 50	0	Above Datum level[1)]	2240/ 1200[2)]	1400/ 960[2)]
6	Piling	S6	Subject to soil investigation	0	Above Datum level[1)]	2240/ 1200[2)]	Subject to soil investigation
7	Any other special	S7	Subject to detailed soil investigation	0	Above Datum level[1)]	2240/ 1200[2)]	Subject to detailed soil investigation

Note 1) Datum level is 0.5 m below the level of the bottom of the pad

2) Submerged Density

6.3. FOUNDATION DESIGN

All types of foundations shall be designed to withstand uplift, settlement, overturning and sliding when subjected to the specified conditions of tower loading. Allowance shall be made in foundation design for hydrostatic pressure where this may occur and the effects of seasonal rains, drying out, cyclic loading and wind induced vibration of tower members.

Foundations shall be designed considering maximum forces (compression, uplift, transverse and longitudinal) acting on the foundations due to various loading conditions. Those forces shall not necessarily be induced due to a single load case.

Subject to the agreement of the Employer, concrete pad and chimney foundations as defined under 6.3.1 of this clause may be employed with undercut excavations. At tower sites where the soils are stiff or dense and are free from standing water and will permit a satisfactory undercut without risk of collapse, the base of the excavation walls shall be so undercut.

For the standard towers other than TDL, TD1, TD3, TD6, TD9/TDT, the design of the footings for the compression legs may differ in an approved manner from those for the tension legs.

As far as practicable, for any one standard tower type, the foundation stub joint and also the dimensions of each standard foundation shall be identical for standard

towers and extended towers and leg extensions and comply with the requirements of the Specification on construction.

All steelwork below ground except reinforcement bars, whether part of the tower or part of the foundation shall be galvanized and completely covered with encasing concrete not less than 75 mm thick from a point 300 mm above ground down to the main foundation block or, for rock foundations, down to the rock. Where necessary, the encasing concrete shall be keyed to the steelwork or to the main foundation in an approved manner. Cover over the reinforcement bars shall not be less than 50 mm.

As an addition to the main quotation which shall be completed in full and shall be based on the foundation types specified, alternative types of foundation differing from those specified may be considered subject to the approval by the Employer of design principles, parameters, and all relevant factors affecting the performance of the proposed foundations over the service life of the transmission line.

6.3.1. FOUNDATION TYPES

The foundations for the towers shall be of the following types and shall be designed in accordance with the particulars given in Schedules of foundation design particulars (Employer's Requirements).

Suspension or Tension towers;

a. Concrete pad and chimney
b. Rock anchor
c. Special foundations rafts and pile foundations.

Single footings of each standard class of tower foundation designed in accordance with the Technical particulars given in Employer's Requirements, any special foundations when instructed by the Employer shall be tested in accordance with Chapter 10.

Concrete shall be reinforced and designed, detailed and constructed in accordance with BS 8110 and the minimum grade of structural concrete shall be C20/25 (Grade 25). Compressive strength to be checked in accordance with British Standard. While the cement content shall be not less than 330 kg/cubic meter of concrete and maximum water cement ratio of 0.55. In case of aggressive soil and ground water condition with high Sulphur content (greater than its limit), the minimum cement

content, maximum free water/cement ratio and type of cement to be used should be decided as per BS 8500.

Test cubes shall be provided whenever requested and appropriate to the foundation type, method of production and volume of concrete.

The type of foundation to be used at each tower position shall be subject to approval and shall normally be decided on the most economical solution.

Foundations shall conform to the following general requirements: -

(A) CONCRETE PAD AND CHIMNEY FOUNDATON

The main concrete block shall be pyramidal or spread type (stepped) in shape. The tower stub shall extend into the main concrete block. Stubs shall be provided with bolt-on cleats as approved, to provide embedment to the concrete. The gantry shall be connected with base plate and anchor bolts. To provide for soils with reduced bearing and/ or uplift resistance the base of the pyramid may be extended by means of a single reinforced concrete pad. All steel work below ground level (except concrete reinforcement bars) shall be completely galvanized and firmly keyed and, grouted and designed to withstand the load due to the specified conditions in accordance with the particulars given in the Schedules. Stubs shall be provided with bolt-on cleats which shall comply with the requirements of the Schedules.

Where the soils are stiff or dense and are free from standing water and will permit a satisfactory undercut without risk of collapse, concrete pad and chimney foundations may be employed with undercut excavations subject to approval of Employer. The undercut shall extend to a minimum of 300 mm outside the walls of the excavation, which shall be vertical. The outer edge of the undercut shall also be vertical for a minimum of 100 mm and the upper surface sloped to an angle of 50° from the horizontal. All undercutting of excavations for foundations as defined under this clause shall be carried out by hand tools and use of excavators will not be permitted. Care shall be taken to ensure inclusions of foreign matter do not occur during concreting and the sides of the 'undercut' shall be lined with waterproof paper or similar material to prevent migration of fine aggregate and cement.

Undercut concrete pad and chimney foundations shall be dimensioned according to the assumed parameters for the foundations Class 2 and 3 given in Schedule of foundation design particulars. In order to distinguish the

standard concrete pad and chimney foundation combined with an undercut excavation the word 'undercut' shall be appended to the foundation description.

(B) ROCK FOUNDATION

Rock anchor foundations comprise of rock anchors and are in forced concrete block of at least 1.5m depth directly cast against rock for soil class 1. The length of the anchor bolts or anchor profiles shall be calculated with the consideration of the following mechanical characteristics;

1) The bearing capacity of the anchoring bolts or profiles
2) The rupture of the adhesive power between the steel anchor and grouting material
3) The rupture of the adhesive power between the grout and rock
4) The failure-rupture of the rock due to shear forces.
5) In all cases the length of anchors shall be at least 1.2 m or 50 × d (d equals the diameter of the anchor bars.)

The holes for stubs shall be made in such a manner to eliminate the possibility of serious cracking of the rock. The dimensions of hole shall be approved and shall ensure the stubs are firmly keyed and grouted and in no case shall the stub be embedded less than 1 meter into the rock. The stubs shall be galvanized, except that it shall be permissible to cut off, on Site, lengths at the bottom ends of the stubs when the upper surface of the rock is at or near ground level. The stubs shall be encased as for other types of foundation with the exception that the encasing concrete shall extend down to the upper surface of the rock.

Where the use of embedded stubs is not economical, other types of rock foundation consisting of grouted anchors may be used. The construction methods and design detail for grouted anchors shall be proposed by the Contractor and approved by the Employer.

For foundation type A and B, sufficient spacing between the individual foundation edges shall be maintained to avoid superposition of the spread stress to the adjacent foundation(s).

In addition to the standard foundations where the investigation of subsoil according to the Specification have indicated ground of very low bearing capacity and/or high-water table in granular soils or other special circumstances, special foundations are to be provided. These foundations shall be designed in accordance with established principles of soil mechanics and shall be of one of the following types: - either concrete pad or chimney with enlarged pad, concrete raft or deep reinforced concrete piles (bored or driven) with reinforced concrete cap. AN-steel and wooden piles are not accepted.

To enable the type and size of a special foundation to be determined the Employer may require a special soil investigation to be undertaken and a report and recommendation submitted. The report shall include soil cohesion and/or friction values obtained by means of tri-axial compression tests from undisturbed bore hole samples together with other complementary laboratory test results.

The static analysis and pile design shall normally be in accordance with BS 8004, BS 8110 and/ or equivalent as approved by the Employer.

Subject to the approval of the Employer, where other towers adjacent to the bore hole are deemed to require special foundations, additional tests shall be undertaken to correlate the soils test data. These tests shall include, but not necessarily be confined to, use of the standard penetrometer, the shear vane, the penevane or the Dutch Cone (static penetration test) and bearing test plates.

Pile foundations shall comprise reinforced concrete piles bored or driven to a depth determined by the Site soil investigation. Driven reinforced concrete piles will normally be preferred if access costs are not prohibitive. Unless otherwise agreed with the Employer where bored piles are employed a minimum of two piles shall be constructed for each tower leg footing. The diameter to length ratio of any bored pile shall not exceed 1:50. Where the subsoil conditions dictate, steel casings may be left in the bore as a precaution against the formation of voids. Wherever possible bores terminating in stiff clay or other suitable strata are to be provided with a bulb end or undercut. Piles may be raked or vertical. To resist horizontal shear forces piles shall normally be connected by collar beams extending between the tower legs at the surface of the ground. The tower stub or anchor plate shall be grouted into

a concrete block extending over the pile group and the whole shall be properly reinforced to ensure no rupture of the concrete when subjected to simultaneous ultimate applied loading.

Bearing for pile foundations shall be the sum of pile end bearing and shear resistance of the soils developed over the effective surface area of the piles. The under-surface of the pile cap shall be considered as not contributing to the bearing surface of the foundation.

The pile foundation resistance to uplift shall be the sum of the shear resistance of the soils developed over the effective surface area of the piles and the weight of the concrete piles including the pile cap. The minimum weight of any pile cap shall not be less than the uplift developed under the conditions of "everyday" temperature and zero wind. Due allowance shall be made in all calculations for hydrostatic pressure where the water table occurs above the base of the piles. The loading capacity of a pile group shall be reduced by a factor appropriate to the configuration of the group. The soil sub-grade reaction to horizontal forces shall also be evaluated and the pile and/or collar beams reinforced as found necessary.

To allow for shrinkage due to seasonal changes in soil water content it shall be assumed that a minimum of the top 3 meters of each pile has no contact with surrounding soils. The effective surface area of the pile shall be calculated accordingly.

Subject to the approval of the Employer, additional piles may be installed at a tower site for the purpose of tests to confirm the uplift and/or bearing capacity of the installed piles. Where possible such tests shall be carried out before concreting of the pile caps for the tower foundations thus allowing for additional piles to be installed if necessary. Piles shall be excavated to a minimum of 3 meters or suitably sleeved during construction to ensure no soil adhesion during testing.

The pile shall have the minimum dimensions of 300 mm x 300 mm for square cross section or 300mm in diameter for circular cross section in case of driven reinforced concrete piles, or 460mm in diameter for bored piles.

The piling system proposed should be provided for convenient adjustment of depth over a wide range but for the purposes of tendering, basic designs should be submitted and prices entered using the following assumptions:

- Depth shall be 20 m from ground to the bottom of piles
- The bidder shall state kind, size and number of piles per leg for each tower type.
- Minimum number of piles is 3 per leg in case of driven piles and 2 for bored piles.
- For pile lengths more than 20 m shall be paid as per the per meter rate in the schedule of prices.
- The material used for pile joint bolts shall be stainless steel.

All special foundations shall be designed in accordance with the requirements of Schedule of foundation design particulars.

The cost for the special foundation in category 7 will be paid for, on basis of Schedule variation rates for concrete, steel and excavations, which shall apply throughout irrespective of special conditions.

6.4. SUPPORT STRUCTURE EARTHING

6.4.1. EARTHING ANGLE SET

Each leg of foundations shall be earthed by earthing angle. A set of earthing angle consists of a galvanized steel angle of 45 mm wide and 5 mm thick and 1 m long, stranded copper conductor of 38 mm^2 and compression terminals at both ends. The steel angle shall be driven into ground underneath the concrete block before concreting and electrically connected to tower stub member or cleat by means of copper conductor. The price for a set of earthing angle for one leg including copper conductor, bi-metallic compression terminals and the required bolts and nuts shall be entered in the Schedules of rates and Prices. The installation cost of earthing angle set and measuring of footing resistance shall be deemed to be included in the rates of foundation works.

6.4.2. COUNTERPOISE

Counterpoise shall be 7/4 mm stranded galvanize steel wire. It shall be electro-galvanised to provide a coating of at least 580 grams of Zinc per square metre of surface. The Zinc shall be smooth, clean, of uniform thickness and free from defects and shall withstand to the test set out in BS EN 10244.

Prices shall be entered against the appropriate item in Schedules for the supply and installation of counterpoise earth systems including compression lugs and normally

comprising one 60 m lengths of 7/4.00 mm stranded galvanized conductor per set, and connected to individual leg members in an approved manner. The earth counterpoise shall be buried not less than 600 mm in the ground. Normally two counterpoise sets will be installed per tower connecting to individual leg members in an approved manner and shall run an opposite direction each other underneath the lines where possible.

The electrical resistant to earth of all structures shall be measure as described in Chapter 10.2.3

Individual tower footing resistance shall be reduced to a value not exceeding 10 Ω (ohms) or as agreed by the Employer following resistance measurements.

6.5. AUTHORITY TO USE DESIGNS

A written authority on all designs of foundations and structures, which are used for this project, shall be approved to the Employer for reusing in other transmission projects.

CHAPTER 7 – ACCESS, CLEARING AND SURVEY

CONTENTS

7. CHAPTER 07- ACCESS, CLEARING AND SURVEY

7.1. ACCESS TO SITE

The Employer will provide the following facilities free of charge to the Contractor.

(A) Such right of access along the line routes as the Employer agrees that it is necessary to enable the Contractor to proceed with setting out, preliminary and profile survey and the investigation of foundation conditions. Any necessary clearance of trees and shrubs along the line trace will be the responsibility of the Employer.

(B) The right to construct and make use of a reasonable width of track along the line routes for the transport of stores and material and the carrying out of erection operations, except where the route crosses building, tea plantation, orchards, gardens or any other ground over which the Employer decides that such a track is not reasonably practicable.

(C) The right to transport material to the lines and to carry out erection operations using points of access and working areas agreed in advance by the Employer and the Contractor.

Provision of the above-mentioned facilities is subject to the official procedure and is depend of survey progress. Details are given in Clause 7.5 -Wayleaves. The Employer does not bind himself to provide the facilities in such a manner as would enable the Contractor to work continuously from one end of the line to the other end (though efforts will be made to do so wherever feasible) and the Contractor shall make appropriate allowance in his program.

The Contractor shall examine the line routes, prepare access maps showing his proposed entry routes to all parts of the lines and the type of plant or transport intended to traverse the routes. The maps shall indicate the places where it is proposed to use existing roads or to construct new tracks. New tracks shall be located as far as possible within the width of the route, and the number of new tracks between existing roads and the width of the line route shall be kept to a minimum. Where it is agreed that vehicular access tracks will be provided those shall be 2.5m wide unless otherwise specified by the Employer. The access maps shall be submitted to the Employer who will arrange for the proposed routes to be examined jointly with the Employer and the Contractor in order to establish feasibility and to agree any necessary adjustments, following which the access maps will be approved.

Once the access maps have been approved, the Contractor shall not make use of any other entry routes without the prior approval of the Employer.

It is emphasized that the procedure of negotiating with landowners, etc. May be lengthy, and the Contractor must submit Access Maps as early as possible to avoid delay. The approved maps shall finally be submitted to the Employer for information and record purposes.

Where the Contractor has approval to use existing roads which are not maintained by government or other statutory authorities, he shall at his own expense either;

(a) Negotiate and pay a toll to the persons or organization normally responsible for maintaining the road to compensate for additional wear and tear during line construction,

Or

(b) Undertake to maintain the road himself during line construction to such a standard that its use by the customary traffic is not impeded in any way and then restore the road to a condition at least equal to that existing before the start of line construction. Such restoration shall be completed before the issue of the Taking Over Certificate.

The Employer will assist the Contractor in negotiating with the persons or organizations normally responsible for maintaining the road.

The Contractor is obliged to undertake a condition survey of all roads, to verify and document the condition prior to the project. For the avoidance of doubt, the Contractor is obliged for necessary rehabilitation of roads utilized during the course of the project.

Where the Contractor has approval to construct new tracks they shall be located in accordance with the approved access maps and in such a manner that the security of supports and foundations is not jeopardized, and shall be adequate for use by such construction vehicles as are agreed by the Employer to be necessary. The new tracks shall be designed and made in such a way as to minimize damage to property, land, crops and vegetation; shall be adequately drained to prevent washouts or soil erosion; and shall be provided at low points with bridges or culverts sufficient to prevent retention of flood waters upstream of the track.

Permanent culverts and bridges where approved by the Employer shall also be required to replace the existing structures as required by the Employer. The culvert

shall be of different sizes and of reinforced concrete pipe sufficient to prevent retention of flood waters upstream of the access. The types of culverts and bridges proposed by the Contractor shall be approved by the Employer.

The Contractor is not required to maintain the surface of new access tracks continuously in a good condition. If the Employer requires improvement of any or all such tracks for his own use in future, the Employer shall direct the Contractor to undertake such works as are necessary for the improvement at rates to be agreed. Notwithstanding the foregoing, if, in the opinion of the Employer, use by the Contractor of the tracks is unreasonably damaging property, the Contractor shall forthwith and at his own expense restore the tracks and fillings to original state to remedy such damage. Junctions between new tracks and existing roads shall not impede or damage neither the latter nor any associated drainage channels etc.

Where such new tracks are located outside the reasonable width of the line route (normally of 13.5 m and 17.5 m width from both side of the center line of the route, the total width is 27 m and 35 m for 132 kV and 220 / 400 kV in turn), the contractor shall be responsible for obtaining in his own expense any permit from the land owner for the use of land during construction period.

The Contractor shall avoid using private access belonging to individual house owners to gain access to the site. Any damages to their lands and properties must be repaired to the satisfaction of the house owners.

The Contractor shall arrange for his own store yard for storing of materials and equipment. The Contractor shall arrange with the landowners for using their lands as store yards.

Responsibility for damage, compensation etc., is defined in Clause 7.6. All other costs of providing and maintaining entry routes for line construction shall be borne by the Contractor. Should it be necessary to manhandle materials and equipment to erection points, or should the Contractor opt to use helicopters for this purpose, the costs shall be deemed to have been allowed for within the several rates entered in the Schedule and the Contractor shall not be entitled to extra payment for such manhandling or use of helicopters. The Contractor shall be responsible for obtaining at his own expense any permits necessary for the use of helicopters.

Permission to use helicopters shall be obtained if required. It must be clearly understood that the Employer will not, under any circumstances, reimburse the

Contractor for any extra costs occasioned by such forms of transport to deliver materials or labour to tower sites.

7.2. ROUTE CLEARING

The Employer will clear the line route of all trees and tall scrub to such an extent as will permit erection of the lines and their subsequent operation.

In order to enable identification of the trees etc. to be cleared, the Contractor shall provide for the Employer one copy of each profile sheet showing support and conductor positions as soon as it has been approved.

Certain valuable trees (e.g. fruit and spices) will not be cleared and the contractor shall be responsible for any arrangements necessary to avoid damage to them.

Clearing will be carried out after wayleaves have been obtained.

7.3. PRELIMINARY SURVEY

The line survey shall be performed by qualified and experienced surveyors. Not less than 15 days prior to the commencement of the work, the Contractor shall submit qualification records of the proposed personnel, the work program and a list of survey equipment for approval by the Employer.

The Contractor shall, as soon as the Contract is awarded, make immediate arrangements to set out angle and terminal supports positions. He shall then establish preliminary lines alignments by instrument survey between angle and terminal points with an adequate number of intermediate line pegs and including the minimum clearing of vegetation necessary to obtain lines of sight.

The Contractor shall record the positions of angle and terminal pegs on sketches related to existing permanent features nearby or to additional pegs placed off line, in such a way that the angle and terminal pegs can be conveniently and accurately replaced in event of loss.

The preliminary route shall then be offered for inspection by the Employer. If the Employer decides that it is necessary to change the route, the Contractor shall set out new angle points as directed by the Employer and shall establish new preliminary lines alignments between them until approval is obtained.

The Contract rates for preliminary survey shall be deemed to include for setting out angle points etc., establishing lines alignments and clearing all as described above

as well as replacement of lost pegs as necessary, all at an average rate per kilometer aligned only for the route approved by the Employer.

Where the Employer directs the Contractor to modify the preliminary line, payment shall be made for repeated survey at the contract rates for the distances concerned, except where in the Employer opinion the repeated survey is necessitated by lack of care on the Contractor's part in which case the Contractor shall bear the additional cost.

Employer will accompany Contractor's staff during preliminary survey. Details are given in Clause 7.5.

Preliminary survey shall be deemed complete and the Contractor shall be entitled to claim payment for it, only when the Employer has approved the preliminary line route.

For special cases, e.g. line crossings, arrangements, routes down steep escarpments etc., the preliminary survey shall include a full profile survey in order to establish the feasibility of the chosen route to confirm that all required clearances can be obtained using the range of towers provided for in the Specification.

7.4. PROFILE SURVEY AND SETTING OUT

The following details and information are to be included on the profile drawings:

(i) At each angle position a 'tie-in' sketch shall be provided on the profile sheet. This sketch shall show clearly the location of the support, using as reference, points which can be located on the ground. The direction of the line and angle of deviation are to be show stating also whether the deviation is left or right.

(ii) Where ground slope across the line route exceeds 1 in 25 the level of the ground left and right of the centre line shall be recorded at an off-set distance of 10 m. The off -set levels shall be indicated on the profile as broken and /or chain dotted lines and the distance off-line stated. All obstructions and features within this 20 m band shall be shown.

(iii) The profile shall show all changes of level of 300 mm or more along the route center line and along the off-set lines. All features such as hedges, fences, ditches, roads, railways, rivers, canals, buildings, telegraph, power and pipelines shall be shown. Route numbers of roads shall be stated or, if unclassified, the destination, similarly for railways.

(iv) The chainage, is to be shown at each 300 m and at every geographical feature or obstruction. Chainage shall also be given at pegs on line sited close to hedges, boundaries, etc.

(v) Ordnance datum stating the basic for all levels shall be shown at 10m vertical intervals at the beginning and end of each section and profile sheet. Levels shall be shown at each peg on line and at every obstruction or geographical feature.

(vi) The visual nature of the ground shall be noted, whether arable, pasture, etc., with special reference to paddy fields, marshy, soft ground or rock and other relevant information such as soil instability, avalanche paths and seismic disturbance.

(vii) All buildings or high obstructions within 30 m of the center line shall be shown dotted at their measured height with the distance. Left or right of line indicated.

After obtaining the Employer approval for the preliminary line routes the Contractor will proceed to peg out the center line and carry out profile survey which shall proceed in convenient sections and shall not await completion of the entire preliminary survey.

It is the responsibility of the Contractor to center peg the line in a manner not easily removable. As a safeguard, it may be necessary to locate and tie in permanent features near to the line which will enable the speedy reinstatement of both angle and intermediate points in the event of unauthorized removal of any pegs.

The rates given in schedules shall be deemed to include any necessary clearing of vegetation and also replacement of any lost pegs.

Strip plans and longitudinal sections shall be prepared by the Contractor for each complete line at scales of 1:2000 horizontal and 1:200 vertical. In hilly terrain a scale of 1:400 vertical can be used but mixing vertical scales on a line is to be avoided. A typical profile indicating format required is shown in the tender drawings.

The Contractor shall plot thereon the proposed support positions and submit the profile for approval. When plotting towers on the profile drawings, their base level (i.e. design ground level) is plotted at 300 mm below the actual ground level shown on the profile. This "sinkage" is to allow for small inaccuracies in the plotted ground line and therefore is not be added to the design height of towers. Actual tower setting

levels on site shall be related to the site ground levels. Supports shall be so located that the wind and weight span loading specified in clause 5.8 are not infringed.

It will be the Contractor's responsibility that the final tower positions within the line sections will be correctly aligned, that the spans and relative levels of all proposed tower center pegs correspond with the profile that the ground line is such that clearances to conductors are maintained in accordance with the profile drawings.

During the survey, the Contractor shall also check the presence of electrical signal lines or telecommunication antennas within the vicinity of the line and to ensure that there are no hazardous, induced voltages or any other interference.

The profile drawings are to include the following features: -

Continuous longitudinal section chainage between angle points, positions of pegs on line, ground line salient levels related to local datum levels, ground line, ground clearance line, line of lowest conductor at maximum sag, indication of side slopes where these affect ground clearances below the outer conductor phases, (due account being taken of swing of conductor under wind loading and clearance of conductor to vertical or other steep slopes and obstructions), walls, fences, hedges, building, streams and rivers, road and railways, power and telecommunication lines to be crossed or to be deviated, pipelines., sections unsuitable for support positions, vegetation, and any other features affecting the line construction.

Along the bottom of the profile plan, a strip plan of the line route, extending 20m beyond the corridor limits, to either side of centerline, shall be shown. The strip plan shall detail all relevant information regarding obstructions, services, vegetation, terrain type, land use etc.

Horizontal and vertical coordinates of all features affecting the line construction shall be indicated on the profile plan. Crossings of existing overhead lines shall be documented with measured elevations and locations of their top and bottom conductors, at centerline and side profile limits, together with the air temperature at the time of measurement. All qualified crossings and approximations shall be covered by individual clearance calculations, to be shown on the profile plan.

High voltage power line crossings shall be surveyed and drawn in sufficient detail to show that all required clearances are obtained. If necessary, separate plan and elevation scale sketches shall be given.

Once profile is approved, the Contractor shall lose no time in center pegging the supports for inspection by the Employer.

The Contractor shall confirm all towers at the positions shown on the plan and profile drawings. If the site of any tower as spotted in the plan and profile drawings is not suitable by reasons of topographical, geological or any other affecting conditions, the Contractor shall be required to recommend alternative locations of the towers to the Employer for consideration. The Contractor shall carry out the work in accordance with the Employer decision.

Quantities given in the Price Schedules are provisional only and the Contractor shall lose no time in starting survey work at the commencement of the Contract in order to establish final quantities for the line at an early stage in the manufacturing program. Delay in survey work shall not be held as a valid reason for lack of progress in manufacture and the Contractor shall be expected to commence manufacture on a provisional basis even though final quantities are not known until a later stage. Attention is drawn to the urgency of having tower stubs and templates on site in order that foundation work can proceed with a minimum of delay once way leaves have been obtained.

A plan and cross-section shall be surveyed for each tower locations. The plan of tower locations shall include contours with intervals of 0.5m and the cross sections shall show ground levels on eight lines radiating from the tower center peg, four lines in transverse and longitudinal directions of tower and the other four lines in a direction of four tower legs. The plan and the cross section shall be prepared by the contractor at the scale of 1:100 horizontal and vertical. The contractor shall indicate on the drawings, his proposed setting levels, leg extensions etc. for approval by the Employer.

The Contractor shall set out excavations etc. from the support center pegs and before commencing construction shall be given the Employer lists of sites set out and available for inspection (not less than seven days' notice).

If during the construction, tower sites have to be relocated and the line route realigned, the Contractor shall carry out the tower site realignment survey, which shall be considered as included in the Contract price. The tower site survey shall include the survey for the centre peg, left and right reference pegs and diagonal levels.

For line route modifications agreed with the Employer, the Contractor shall carry out a complete line survey, elaboration of the longitudinal profile drawings including the necessary uphill side slope information, plotting of the towers, pegging the tower positions in site and surveying diagonal profiles for determination of disleveled legs - complete as required for the project.

7.5. WAYLEAVES

Wayleaves shall be provided by the Employer to enable the Contractor to carry out the Works. In order to provide wayleaves the Employer has to obtain approvals from Government and other Statutory Authorities, and also consents from owners and occupiers of property, which will be affected by the lines.

The procedure for obtaining approvals and consents is dependent on preliminary and final profile survey, as described below.

(i) Employer will accompany Contractors staff during preliminary survey. The Employer will issue notices to and liaise with landowners and occupiers in order to establish rights of entry for survey and agreement to limited cutting of vegetation as specified.

(ii) Upon approval by the Employer of preliminary survey the Employer will initiate procedures for obtaining wayleaves, and when necessary approvals and consents have been granted the Employer will arrange for trees etc. to be cleared from the line trace as specified.

(iii) Upon approval by the Employer of support center pegs the Contractor shall submit access maps as specified and the Employer will obtain the necessary rights of construction access for the Contractor.

(iv) Wayleave procedures as described above will take place concurrently with preliminary survey, approval of center pegs etc. The Contractor shall allow in his program for a period of up to 4 months from approval of preliminary lines to the grant of right of access for its construction. As the Employer has to obtain approval from the government and other statutory authorities to clear wayleaves the contractor shall keep provision in his program for a delay in right of access for its construction due to a delay in obtaining above approvals.

(v) When, in the opinion of the Employer, right of access has been granted for a sufficient proportion of any line route he shall notify the Contractor to that effect and the Contractor shall forthwith commence preparation for erection of the

line. Should the Employer not so notify the Contractor by the date indicated in the approved program then the Contractor shall rearrange the program to the Employer satisfaction and in such a manner that erection is commenced instead on another section of line route where the notification has been given.

(vi) The contractor shall ascertain the period of notice to be given to landowners and occupiers before entry for erection of the lines, and shall make appropriate allowance in his program. Before commencing work on any property the Contractor shall be responsible for obtaining from the Employer a Wayleave Schedule giving details of any special requirements, and shall give landowners and/or occupiers the necessary notice prior to entering.

7.6. DAMAGE TO CROP AND PROPERTY

The Contractor shall take all precautions to avoid damage to land, property, crops, etc., and shall ensure that the work is adequately supervised so that damage is reduced to the minimum. All surplus material shall be removed after erection and the site shall be left in a clean and tidy condition, to the satisfaction of the Employer.

Where the Contractor considers that damage cannot be avoided if the work is to proceed normally he shall notify the Employer accordingly. If the Employer confirms that such unavoidable damage will occur then the Employer will be responsible for compensation in respect of it and the Contractor shall proceed with the Works within the limits indicated by the Employer. In the event of such notification not being received within four days from the date when the damage is caused, the Employer may at his discretion refuse to consider any subsequent claims by the Contractor for compensation resulting therefrom.

Where the Contractor causes damage beyond the indicated limits or to a degree which the Employer considers excessive then the Contractor shall be responsible for reinstatement and/or compensation. If in such circumstances the Contractor shall fail to settle compensation to the extent that in the Employer opinion, the progress of the Works is likely to suffer, then the Employer shall negotiate and settle the matter and the cost shall be deducted from moneys due to the Contractor.

7.7. REMOVAL OF OBSTRUCTIONS

Where it is agreed that obstructions such as telecommunication line, power lines or pipes are to be permanently removed or relocated to allow erection of the lines, the Employer will initiate procedures to obtain necessary consents and secure removal

upon receipt of sufficient notice through the Employer from the Contractor of his planned date for commencing work at the places affected. The Contractor shall be responsible for ascertaining the periods of notice required and shall make appropriate allowance in his program.

Immediately after completion of profile survey the Contractor shall provide sketches showing the relative positions of the lines and the obstructions.

Where temporary removal of bunt, wall or similar obstacle is necessary for the purpose of foundation installation or support erection, the cost of removal and subsequent reinstatement shall be deemed included in the Contract rates for foundations and support erection.

7.8. CROSSINGS OF PUBLIC SERVICES

Where public services are not to be permanently removed, the Employer will obtain necessary approvals for crossings on the basis of sketches to be provided by the Contractor immediately after finalization of the profile showing the relative position of the lines and the services.

Where the Contractor is about to erect conductors along or across power lines, telecommunication lines, railways, public roads or waterways he shall be responsible for ascertaining and giving requisite notice to the appropriate authorities of the date and time at which the work is to be carried out.

For all national expressway crossings, Angle towers with Heavy suspension (in case of 0° line angles)/ double Tension insulator strings, adjacent to expressway at either side of the expressway shall be used and the crossing span shall not exceed 250 m. It is desirable to cross expressways at 90° and in any case not less than 60°.

Existing LV lines (400/230 V) will generally be switched off during working (daylight) hours while conductor erection is in progress at crossing points. The Contractor shall provide scaffolds to protect the existing lines from physical damage and to maintain adequate clearance against accidental contact with lines when energized outside working hours. Especially rigid scaffolding (steel) should be used over any power line crossing

For existing lines at voltages exceeding 400/ 230 V, extended outages will not be possible, and the Contractor shall provide live line scaffolds such that conductor erection can proceed in safety over energized lines. The Employer will arrange outages for erection and removal of live line scaffolds upon receipt from the

Contractor of requisite notice (which the Contractor shall ascertain and allow for in his program), but the duration of such outages will be the minimum necessary for the work to be completed. Where essential supplies are affected it may be possible to provide outages only at weekends or public holidays. The Employer shall inform the Contractor which existing lines are subject to such restriction and the Contractor shall arrange his program accordingly.

Where it is necessary to provide scaffolding over roads, or telecommunication lines in order not to interfere with the passage of traffic, etc., this shall be carried out by the Contractor at such times as may be convenient to the Authority concerned. Flagmen and approved types of danger or warning notices shall be provided by the Contractor to ensure safety of the public.

Scaffolding and decking shall be erected in a safe manner to the approval of the Employer and the time taken to effect the crossing and remove the temporary work shall be kept to a minimum. The Contractor shall provide with his tender drawings showing his scaffolding proposals.

The cost of all scaffolding (including live line scaffolds for power lines up to 33 kV) warning signs, notices and other necessary precautions shall be deemed to be included in the Contract rates for stringing.

7.9. OTHER CROSSINGS

The Contractor shall, at his own expense, make the necessary arrangements and take any necessary precautions where the route crosses other obstacles or ground over which erection cannot be carried out in the normal manner.

7.10. PROTECTION OF REAL ESTATE AND LIVESTOCK

The Contractor shall limit the movement of his crew and equipment on the right of way and on approved access routes, so as to minimize damage to crops, orchards, or property and shall endeavor to avoid marring the lands. Ruts and scars shall be obliterated, damage to ditches, terraces, roads and other features of the land shall be corrected, and the land shall be restored its original condition.

The Contractor shall be responsible for any excessive or unnecessary damage to crops or lands resulting from his operations, whether on right-of-way, on lands adjacent thereto, or on approved access roads.

The Contractor shall be responsible to the occupants of the land which are crossed by the transmission line for any damage to personal property resulting from his fault

or negligence and he shall make prompt settlement of damages to personal property resulting from his negligence.

Adequate provision shall be made by the Contractor to prevent the straying of or damage to livestock during the execution of the Contract Works and until the permanent reinstatement of fences, walls, hedges, gates and the like is completed, the Contractor shall be held responsible for any loss or damage to livestock due to failure to comply with the above requirements.

7.11. FOUNDATIONS

7.11.1. GENERAL

The Contractor shall be responsible for ascertaining that the sub soil is suitable for the type of foundation used and shall provide details of site investigations and relevant tests carried out for the Employer. The Contractor shall examine the soil investigation results and submit for the Employer approval, a schedule showing the type of foundation proposed at each support. The Employer's decision as to which type of foundation shall be employed at any given location shall be final. The Contractor shall be responsible for any subsidence or failure due, in the opinion of the Employer, to insufficient care having been taken either in the preliminary examination of ground conditions or in the choice of installation of the foundations.

Where, in the opinion of the Employer, after examination of the Contractor's soil investigation data, the nature of the ground warrants special investigation and tests the Contractor shall carry these out to the instructions of the Employer until satisfactory information is obtained on the ground bearing properties. The cost of such tests shall be included in the foundation rates.

Consideration shall be given to offsetting the center pegs of angle towers to ensure that the conductors are located equi-distance either side of the route center line.

If anything with archaeological value is found during the implementation of the project, it should be immediately informed to the Employer and all construction work shall be curtailed until the approval of the Employer to do so.

7.11.2. EXCAVATION

Before excavations are commenced the Contractor shall submit his proposals with regard thereto for the Employer's approval. Excavations shall be close timbered or sheeted, planked and strutted as and when necessary and kept free of water by pumping or other means during the course of the work and shall ensure the safety

of personnel working within them. The sides of excavations shall normally be vertical unless otherwise specifically agreed with the Employer.

In designing and constructing the foundation works the Contractor shall ensure that no damage is caused to adjacent buildings, boundary walls, roads, pavement and/or any other existing services either by any vibration caused, by any settlement of the ground or due to any other cause. Special precautionary measures shall be adopted when excavation is performed to avoid damage.

Although a mechanical excavator may be used in many parts of the lines, the Employer reserves the right to instruct the Contractor to excavate certain sites by hand (particularly on steep slopes or in marshy ground), and the normal rates shall be deemed to include for this activity.

In general, for steeply sloping hillsides the foundation of a level tower platform by digging the high side and using the soil to fill the low side will not be accepted.

When constructing foundations in the paddy field or on wetland, the excavated soil from the top layer, which is tended to be loose soil, should be kept separated from the rest of excavated soil. After the completion of tower foundations, the soil from the top of the layer should be used for backfilling the top layer of the tower foundation and should not be used for backfilling the bottom of the foundation.

When foundation site is in steep slopes, the method such as constructing retain wall, stone terracing or installing gabions shall be applied in order to avoid soil erosion.

During excavation, the Contractor shall take adequate precautions to prevent earth disturbances which Might affect the safety of personnel, property and the Site Works.

The Contractor shall ensure that excavations are made to the correct depth and width. If excavations are taken too deep, the excess depth shall be backfilled with concrete at the Contractor's expense. If excavations are made too wide, such modifications to the design as the Employer may require shall be made at the Contractor's expense.

Blasting for foundation pits of the line can only be made upon prior approval of the Authorities and the Employer. Written approval shall be obtained from the Employer before explosives are used for excavating foundations in rock. The Contractor shall be responsible for complying with local regulations concerning the use of explosives and for the safe-keeping and handling of explosives. During operations involving the handling or use of explosives, the Contractor shall be responsible for the safety of

personnel, Site Works and people or properties in the vicinity of the Site. The Contractor shall make good at his own expense any damage caused by the use or mishandling of explosives. Blasting shall not be permitted in the location when concreting started in any leg. If no blasting is allowed, other methods have to be approved by the contractor without any extra payment.

Construction site shall be properly barricaded to control access of neighboring people and to avoid entering fauna to the site, in order to avoid accidents. Suitable sign boards shall be erected to make people aware about potential construction hazards at construction site.

In the case the surface water paths are to be obstructed by constructing foundations, alternative paths should be facilitated to ensure the water movements.

Dewatering shall be provided by maintaining water pumps and wells etc. in operation. The equipment for this purpose shall have sufficient capacity to keep excavations free of all water down to 0.5 to 1 m below deepest excavation level during concreting refilled or the structure attain their sufficient strength and water uplift resistance. Discontinuous pumping shall be subject to the approval of the Employer. The dewatering measures as described are to be included in the foundation rates entered in the schedules of rates and prices.

7.11.3. STUB SETTING

Stubs for tower foundations may only be installed with the use of templates approved by the Employer or by using the lower sections of the support with suitable temporary bracing to ensure correct spacing. The method selected shall be such that all four stubs are supported and interconnected by a rigid steel framework. The main members of templates must be in the form of trussed beams. The stubs shall be held in correct position by the template while the concrete is placed. The templates are not to be struck until at least 48 hours after the foundations have been completed and backfilled.

Stub setting templates shall be of approved type with sufficient rigidity to ensure correct setting of the stubs.

They shall be manufactured from mild steel angle or channel or a combination of both, of approved and adequate cross section, and shall be equipped with central alignment notches or holes, corner braces, riser braces, and stub angle bolting legs to permit the accurate setting of stub angles in respect of the following requirements;

(i) Route longitudinal center line
(ii) Tower lateral center line
(iii) Stub elevations (with reference to datum)
(iv) Stub leveling
(v) Stub rake
(vi) Stub hip bevels
(vii) Stub angle spacing

No concreting shall be commenced before the stub settings are approved by the Employer inspector.

7.11.4. REINFORCEMENT

All steel rod reinforcement shall be clean and free from loose mill scale, loose rust, oil and grease or other harmful matter and except at bends shall be truly straight before being surrounded with concrete. Evidence of steel quality shall be provided. The numbers, lengths, diameters, forms and positions of all reinforcing bars shall be in accordance with approved drawings. Reinforcement shall be readily identifiable as to grade and origin.

The Contractor shall provide copies of the Manufacturer's test certificates required by the relevant British Standards for the steel reinforcing material. Alternatively, the Contractor shall carryout tests to check the mechanical properties of steel as directed by the Employer at a laboratory approved by the Employer. The standard proving tests for steel reinforcing bars and wire as set out in the applicable specifications. Copies of the test results shall be available to the Employer for approval. The cost of such tests shall be borne by the contractor.

The steel reinforcement shall be so connected as to form a rigid cage or mat. To prevent displacement before or during concreting, the bars shall be tied one to the other with 18-gauge soft iron wire. Sufficient pre-cast rings or cover blocks shall be used between the reinforcement and the bottom and sides of the excavations to ensure the correct cover of concrete around the bars. The cover blocks shall be made of concrete of not less strength than that of the concrete in which they occur. Reinforcement bars shall be carefully bonded to the tower steelwork with soft iron wire before concreting.

Steel rod reinforcement shall be bent cold in a manner which will not injure the material.

Cutting and bending of reinforcement shall conform to approved Standard. Bending schedules should be prepared by the Contractor and submitted to the Engineer for approval.

Reinforcement shall not be welded except where shown on the construction drawings or as requested by the Contractor and approved by the Engineer.

7.11.5. CONCRETING

Concrete foundations shall extend to at least 300 mm above ground and shall be sloped off around the steel leg section and smoothly finished to ensure drainage away from the steelwork.

In areas subject to the flooding the encasing concrete shall be extended up the tower members as directed by the Employer. Extended foundations shall be provided in paddy fields and marshy areas and the cost shall be deemed to be included in the normal foundation cost.

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

Towers shall not be erected until fourteen days after completing the foundation concrete work. At the discretion of the Employer, for the emergency condition duration could be changed. However, in any case towers shall not be erected before back filling is completed.

Alternative methods of concreting foundations which do not involve formwork are to be first agreed in detail with the Employer before employment at site.

The backfill of all types of foundations shall be thoroughly rammed, the ramming to be carried out at intervals of not greater than 300 mm to ensure thorough consolidation of the backfill as the Employer requires. Compaction ratio above 95% shall be achieved. In no circumstances, shall peat or equivalent material be used as backfill for foundations. Where necessary excavations in peaty material shall be backfilled in an approved manner with suitable soil or hard-core from an approved source at rates agreed by the Employer.

7.12. FOUNDATION INSTALLATION

7.12.1. STUB SETTING

Stubs for tower foundations shall be carefully adjusted to template (which may be the bottom tower section itself for grillage foundations only) or any other method approved by the Employer and shall be held in the correct position while the concrete for the foundation structure is placed. The templates shall not be struck until at least 24 hours after foundations have been completed. The spacing and levels of the stubs after the templates have been struck shall be such as to ensure correct alignment of the towers without forcing of members during erection.

7.12.2. MATERIAL

All cement used shall be of Portland or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS 12. Where Portland cement concrete may be liable to chemical attack sulphate resistant cement to BS 4027 may be used where approved. Cement shall be stored in an approved manner.

In certain areas of the line route, sulfate-resisting cement may be necessary and the cost of this is deemed to have been allowed for in the several rates entered in the Schedules. Sulfate resisting Portland cement shall be in accordance with British Standard 4027; Sulfate Resisting Portland Cement, obtained from a source approved by the Employer.

The Contractor shall certify that the proposed cement is of the required quality regarding resistance to corrosion due to sulfates. Methods of testing this quality shall be included in Tender. The use of Aluminium cements will not be permitted. Cement shall be of recent manufacture and shall be used within a period of 3 months from production. All cement shall be obtained from the same source for any particular part of a structure.

All aggregates shall be obtained from sources approved by the Employer and shall be clean and free of clay, earth, organic matter, salt or other impurities. The aggregate shall comply generally with the requirements of BS 882. The Engineer shall have the right to request the Contractor, at any time, to draw samples of aggregates from stockpiles on the Site or any other location to be indicated by the Engineer. All sampling and testing shall be in accordance with BS standards. The cost of such tests shall be borne by the Contractor.

a. **Coarse aggregate** shall be broken stone of angular shape, of approved grading according to BS 882 (Latest).

b. **Fine aggregate** shall, unless otherwise approved by the Employer, be sand, well graded from 4 mm gauge downwards. No seashore sand shall be used, and unwashed pit or river sand shall not be used unless approved by the Employer.

c. Water shall be obtained only from sources approved by the Employer. It shall be clean, free from deleterious materials and chemically neutral. The water should comply with the requirements of SLS.

7.12.3. FORMWORK

Formworks shall normally be employed to produce the correct foundation shape and ensure no loss of aggregate or cement. All formers shall be sufficiently strong to withstand the pressure arising from the concrete during compaction and shall be capable of removal without undue disturbance to the concrete. Formworks shall not be removed before the concrete has sufficiently hardened and in no case less than 48 hours after pouring. Concrete that is damaged or honeycombed must be removed by chipping to sound concrete and replaced with mortar or concrete.

7.12.4. CONCRETING

All concrete shall be thoroughly mixed & vibrated by machine, with only sufficient water to ensure a workable mix. Where grillage or other types of steel foundation may be used, the Contractor shall be -responsible for ascertaining that the sub-soil is not of a nature such as to cause corrosion of buried steelwork.

Unless otherwise approved, towers with concrete foundations shall not be erected until the foundations have had fourteen days in which to set, or such longer or shorter time as may be approved, depending on the type of cement used and on local conditions.

Foundation setting level diagrams shall be provided to show the foundation and stubs, tower body and leg extensions and concrete leg extensions proposed. The diagram shall be to a scale of 1:100 and extend beyond the limits of the foundation design frustum by 1 meter.

The cost of the extra work and materials arising from the provision of each 0.75 m stub and foundation extensions but not including the raising of the soil mounds shall be paid for at the prices given in the Price Schedules.

Cement shall be measured by weight, either by use of one or more complete bags or by weighing on site. Other ingredients shall be measured by weight or by volume, and concrete shall be mixed in batches using one or more complete bags of cement.

Only in exceptional circumstances shall a bag of cement be divided. When mixing by volume is adopted, suitable batch boxes of approved dimensions shall be made and used for the measurement of coarse and fine aggregates. A suitable container for the measurement of water shall also be used.

In the event that the Contractor proposes to use ready mixed concrete for foundation work, approval must first be obtained from the Employer, who will inspect the batching plant and sand, cement and broken stone used in the making of concrete at the works. No ready mixed concrete shall be used in foundation work if it has been mixed in the lorry during its journey to site for more than 45 minutes. At the discretion of the Employer, ready mixed concrete may be used in foundations if the journey to site is in excess of 45 minutes.

No concreting may start without the presence of the Employer if not directed otherwise.

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

The concrete shall be thoroughly compacted by vibration during the operation of placing and shall be free from honeycombing and other defects.

Consistency tests shall be made when required by the Employer: the slump in a truncated cone 300 mm high and of standard dimensions shall be tested to confirm it within the range as directed by the Employer.

Freshly placed concrete shall be properly protected against the weather.

Joints in the concrete foundations are to be avoided as much as possible. Where the construction of the foundation is such that joints are unavoidable adequate bond between the old and new concrete shall be ensured by chipping the old concrete to a rough, clean surface free from loose particles. Immediately before placing the new concrete, this cleaned surface shall be primed with a layer approximately 15 mm thick of a wet mix of cement and fine sand in equal proportions.

The muff (upper surface of the concrete foundation) shall be constructed by a continuous pour of the chimney concrete. The upper surface of the concrete for all types of foundations shall be sloped in an approved manner to prevent accumulation

of water and the whole exposed surface shall be rendered with mortar composed of one part of cement to two parts of sand.

Concrete foundations shall extend to at least 300 mm above ground. Extended foundations up to 500 mm above ground shall be provided in paddy fields and marshy areas and the cost shall be deemed to be included in the normal foundation list.

Unless otherwise approved, towers shall not be erected until fourteen days after completing the foundation concrete work.

The Contractor shall give sufficient notice and, in any case, not less than 24 hours to the Engineer of the placing of any concrete.

The Contractor shall not place any concrete until forms or excavations and reinforcing steel and embedded items have been checked, approved by the Engineer.

7.12.4.1. Acceptance of Concrete

Hardened Concrete shall be liable to rejection if any of the following defects occur.

a. It is porous, segregated or honeycombed.

b. The construction tolerances have not been met.

c. The reinforcing steel has been displaced from its correct location.

d. The required surface finish has not been achieved.

The Cost of further checking, testing or remedial work shall be borne by the Contractor.

7.12.4.2. Concrete Curing and Protection

Freshly cast concrete shall be protected from premature drying and excessively hot or cold temperature. In windy conditions breaks shall be erected to shield the concrete surfaces during and after placement. The concrete shall be maintained at a reasonable constant temperature with minimum moisture loss for the curing period.

The concrete shall be protected from damage due to load over-stresses, heavy shocks and excessive vibrations, particularly during the curing period.

7.12.5. BACKFILLING

For tower foundations where excavations are to be backfilled immediately following the striking of shutters, the concrete shall be thoroughly wetted before backfilling

commences. Where shutters are to be struck and backfilling of the excavation is not be take place immediately, the concrete shall be covered by hessian sacking and shall be kept continuously moist to avoid rapid drying of the concrete until backfilling, or as otherwise directed by the Employer.

Proper precautions shall be taken to ensure that all backfilling and compaction of earth is done thoroughly and evenly round all parts of each separate foundation block or structure. The backfill shall be placed in layers not exceeding 200 mm in thickness and compaction shall be carried out as instructed by the Employer. Backfilling from one side or corner only, of an excavation hole shall not be allowed. In wet or flooded situations adequate provision shall be made to ensure the excavation is kept free from water whilst work is carried out. No backfilling is permitted until the foundations are approved by the Employer.

Organic matter and silt shall not be used as backfill material. All temporary timbering, shuttering, etc and all decomposable or perishable material shall be removed from the excavations prior to backfilling.

Backfill shall be such that the original ground contours are restored as nearly as possible and any subsidence of backfill shall be made good before the issue of the Taking over Certificate. In places where settlement is observed during construction works or Defect Liability Period the Contractor shall restore original level with additional fill at no extra cost.

Should any of the civil works undertaken interfere with either natural or man-made drainage or be susceptible to erosion by the flow of water the Contractor shall be responsible for constructing suitable alternative drainage and protecting the works against erosion.

7.12.6. COATING

The chimney above the ground and the sloping top surface of the concrete and the tower steelwork for a minimum distance of 150 mm above the concrete shall coated with two coats of approved bitumen-based point. No paint may be applied to concrete until at least 48 hours after shutters have been struck and the second coat of paint may not be applied until 24 hours after the first coat. All surfaces to be painted must be dry, clean and free of oil, grease or other contaminants.

Paint of tower steel works up to 2 m with two coats of epoxy water resistant paint shall be applied for the towers located in paddy fields and marshy areas and the cost deemed to be included in the relevant foundation cost.

7.13. PILING WORK

7.13.1. General

Items not covered in this specification shall be referred to "Specification for Bored and cast in Situ Reinforced Concrete Piles" (Ref No: CIDA/SP/101), published by the Construction Industry Development Authority (CIDA) Sri Lanka.

This Article applies to the foundation design/static analysis in view of necessary piling works. Piling works shall be based on the findings of the soil investigations and/or information given in writing by Employer. Piles shall be designed for the required design loading (uplift, compression and horizontal loads) in line with the approved foundation design.

Earthwork as well as all concrete and reinforced concrete work shall be as specified under the relevant items.

The static analysis/pile design shall normally be in accordance with BS 8004, BS 8110 and/or equivalent as approved by the Employer.

7.13.1.1. Cast In-Situ Pile

Material

All materials to be used for the piling works shall meet the requirements as specified in standards. Cement to be used for concrete piles shall be selected according to the recommendations of the soil investigations report. Sulphate resistant Type Cement (SRC), or under certain conditions, 'Moderately Sulphate Resistant Cement' (MSRC-type II to ASTM-C150) based on the recommendations of the Geotechnical Engineer and approved by the Employer, shall be used. All cements are to be in accordance with either BS or equivalent, as approved by the Employer.

Reinforcement

Only deformed high tensile steel shall be applied.

Execution of Work

Where required, temporary casing pipes shall penetrate ahead of the removal of soil, likewise during drilling above the ground-water table. In the vicinity of underground water, additional water has to be filled up during the drilling. The hydro-static head pressure shall be at least 1.0 m above the ground water table when filled boring tools are extracted.

Casing shall extend to a sufficient depth below the stiff/solid strata to adequately seal off the unstable soil material. Casing pipes shall not be deepened by means of jetting.

Immediately after the drilling, the reinforcement has to be placed, providing a concrete cover of 75 mm, and the pile has to be cast. Temporary casing shall be removed by vibration method. Other methods of casing removal shall not be permitted, except in some cases/piles, where casing removal by vibrator will affect the existing services/buildings. In such cases, the Employer may approve the rotation method for casing removal.

Concreting is to be done through tremie-pipes or equivalent devices to prevent segregation. Concreting of each pile shall be a continuous operation and no (cold) joints shall be permitted. The continuous flow of concrete shall be ensured by using pumps or other suitable means to be approved by Employer.

Each pile shall be installed to the correct lengths as shown on the drawings or when the pile reaches the socket in the recommended bearing strata. Piles shall be installed accurately in their required locations. In vertical direction, piles shall not vary more than one (1) percent from the perpendicular. In plan, pile shall not deviate more than 75mm in any direction at piling platform level.

The Contractor shall submit to the Employer before start of piling works, a detailed description of the equipment, materials and procedures that will be used for the piling work. The description shall include equipment specifications, including catalogue data manufacturer's published specifications, loading capacities, protective devices, and test apparatus, detailed installation procedures test procedures, as well as references concerning previously completed piling work.

Installation procedures shall be such that adjacent piles shall not heave or move laterally. All installation procedures shall be subject to Employer's approval. Permanently installed shells shall be cut off at the pile cut-off level.

Daily records of each pile shall be produced by the Contractor. The records shall give detailed information on the type, diameter, length, location, penetration into bearing strata, piling platform level related to zero level, date driven, date of casting volume of concrete consumed, depth from piling plat form level to toe, cut off level, top concrete level, length of temporary casing, length of permanent casing and details of any obstructions encountered. Records shall be submitted in duplicate to the Employer every following working day by 09 00 HRS.

Each cast-in-situ pile shall be filled with quality concrete up to at least 60 cm above the cut-off level of the pile to allow for complete removal of slush and other foreign matters etc. from the main pile and thus obtain sound and uniform concrete. Pouring concrete into the pile shall be carried out using the tremie pipe method as well as the concrete pump. Pouring concrete into pile shall only be stopped once complete removal of slush and other foreign matter has been ensured, or as directed by the Employer.

The heads of concrete piles shall be incorporated with in-situ concrete pile caps, etc. and the concrete in the head of the pile shall be carefully broken away from the reinforcement which shall then be cleaned and straighten as shown on the Drawings or as directed. The pile shall be cut off at the specified level and the concrete surface must be horizontal, plane and free from all loose aggregate.

The top portion of the pile reinforcement shall be protected with PVC pipes, polythene sheet wrapping or equivalent means to prevent damages to the epoxy coating of the reinforcement when trimming the pile heads.

Permanent Casings

For soils in areas classified as category 5 according to BRE Digest 363, permanent casings shall be provided. The permanent casing length shall be 2.0 m below ground surface. Should the ground water table be at 2.5 m below ground level, casing will be extended to become 3.0 m below finished ground surface. This procedure shall be applicable for areas not affected by tidal effects. For areas affected by tidal effects, casings shall project 0.5 m below the lowest water level anticipated.

7.13.1.2. Pre-Cast Driven Piles

Driven piles shall be executed as per BS. Pile driving will not be allowed before the Employer receives from the Bidder/Contractor the following reports and calculations for approval:

- Calculation of refusal
- Proposal for the minimum penetrated depth of the piles through the ground
- Complete information about the driving and the hammers to be used.

Piles shall not be driven until the excavation has been completed to the grade required for footings or pile caps. Piles shall be driven in the exact locations shown on the drawings to be submitted by the Bidder/Contractor and approved by the Employer or as may be directed by the Employer.

The Contractor shall be responsible for the accuracy of location of each pile and the grade of the off-cut. Driving shall be done with fixed leads, which will hold the pile firmly in position and in axial alignment with the hammer. Driving tolerances shall not be more than one per cent out of plump and not more than 5 cm out of place. Driving of each pile shall be continuous without intermission until the pile has been driven to refusal or to total penetration for the last ten blows not exceeding the design penetration unless otherwise approved by Employer. Any piles that are split, warped, buckled, damaged or imperfect in any way shall be removed and discarded. If any driven pile shall have been raised by the subsequent driving of any adjacent pile or by any cause, the raised pile shall be re-driven to its original penetration and resistance. The refusal shall be with HILEY formula or any other dynamic formula subject to the approval of Employer.

Debris from pile cut-offs and damaged piles shall not be buried in required fill under slabs at grade or in required embankments, but shall be disposed by the Bidder/Contractor off the Site of the work.

A record of the driving of all piles shall be kept by the Contractor, and a signed copy submitted to the Employer daily. The records shall show the pile type, length, location, penetration for driving stages and the results of any tests.

After driving, the concrete heads of the piles are to be stripped off, to the elevation required, the binders removed, and the main reinforcement bent to form an anchorage into the concrete of the pile cap. Care must be taken in breaking out concrete that no damage is done to the lower section Driven Cast-In-Situ Piles.

Driven Cast-In-Situ Piles are created by driving a temporary tubular steel casing, closed by a removable steel shoe at its bottom end, to the required depth into the ground. The soil is thus both displaced and compacted and the void for the pile created. Reinforcing and concreting for the pile shall be done in line with the guidelines for cast in situ bored piles and the casing shall eventually be withdrawn.

Casings shall be free from distortion and shall be strong enough to be driven without damage. Shoes to be used (and later remaining in the ground) shall be made from sufficiently strong and durable material. The shoe shall provide a watertight joint with the casing during driving.

Casings shall be driven at adequate spacing to prevent damages to piles, which have recently been cast and thus still contain un-set concrete. The length of driven

piles shall be at least as per the design schedule. Any change in pile lengths shall immediately be brought to Employer's attention.

Driving of each casing shall be a continuous, not interrupted operation. After unavoidable interruptions during driving, it has to be ensured that the casing is finally driven to the specified design depth and driving resistance. Sufficient information shall be provided on the efficiency and energy of the driving equipment. Dynamic evaluation and analysis shall be provided where requested by Employer.

Weight and fall of the hammer/ram and the number of blows for each 25 mm of penetration shall be recorded, as well as the "Set".

Hammer blows shall only be applied along the line of the pile axis and the impact surface shall be perpendicular to the pile axis.

Set limits shall be defined based on the working load, factor of safety soil condition and driving equipment. During measurement of the "set", exposed parts of the casing shall not be damaged or deformed and the dolly, helmet, etc., shall be in good condition. Set, i.e. the achieved penetration during driving and the temporary compression after completion of driving shall be measured and recorded for each pile. The set shall be recorded either as the number of blows resulting in a penetration of 25 mm or the penetration in millimeters achieved by imposing 10 blows.

The sequence of pile driving shall minimize any possible detrimental effect on other piles in the vicinity. The permissible uplift of any pile due to the driving of other piles shall be limited to 3 mm.

Regular measurements (at least in weekly intervals) shall ensure that no adjacent piles have been effected detrimentally during piling work. If any pile has been displaced or indicates a higher than permissible uplift, load tests have to prove the design capacity of such piles. If the design capacity cannot be reached, the Contractor shall propose remedial actions or design adjustments accordingly.

CHAPTER 8 – ERECTION

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8. CHAPTER 08 – ERECTION

8.1. GENERAL

All transmission tower steelwork stored at site shall be kept clear of the ground. Contact with brackish water or other substances likely to attack galvanizing shall be avoided and all tower members shall be kept in a clean and tidy condition.

8.2. ERECTION OF SUPPORTS

The Contractor shall erect the towers for the transmission line in accordance with the erection diagrams, construction lists and other drawings and instructions.

The Contractor shall submit erection procedure for approval at least one month before structure erection is scheduled.

The Contractor shall ensure that all concrete foundations have cured for the minimum period specified and that all backfill is compacted and approved by the Employer before placing or erecting tower steel on foundations. The minimum period between concreting and the commencement of the tower erection is fourteen (14) days.

In general, support structures shall be assembled and erected with bolts finger tight only. Final tightening of bolts shall only take place when all members are in place. When in position, all bolts shall project completely through the corresponding nuts, but such projections shall not exceed 10 mm.

All members shall have their joints cleaned when bolted up. As far as possible, bolts shall be inserted with the nuts facing outwards or downwards. Whenever wire slings or ropes are liable to abrade a support member, the member shall be suitably protected by heavy hessian bags or strips, or by some other approved method.

The method of assembling and erecting a tower shall be such that during erection no member shall be subjected to any stress in excess of that for which it was designed.

If erected by assembling in sections, the initial tightening of bolts shall be adequate for dead load, live load and direction stresses, but shall not be so strong as to prevent aligning and fitting adjacent sections or members. The assembled sections shall be adequately supported during erection.

Misalignment or misfit of adjacent sections or members attributable to the adopted method of erection shall be corrected by changing erection methods as necessary to eliminate the trouble.

The Contractor shall make use of temporary struts on panels prior to lifting, if in the opinion of the Employer, there is a likelihood of damage occurring to that panel during lifting. All towers assembled on the ground shall be kept off the ground with wood so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure.

Where derricks are used for lifting panels, they shall be securely guyed and shall be supported only at approved locations on the legs.

All towers shall be vertical under the stresses set up by the completed overhead line to the satisfaction of the Employer. The maximum acceptable deviation from vertical shall be 0.3% of the tower height before conductor erection.

Proper precautions shall be taken to ensure that no parts of the towers or supports are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.

Where tower members arrive on Site with slight distortions due to handling in transit, they shall seek the Employer agreement to attempt to affect a repair by an approved means. Straightening shall be done only by the use of methods that will not damage the zinc coating. Tolerances for lateral variations of straightened members shall be as follows:

Member Type	Tolerances
Compression Members	± 2 mm/1000 mm
Tension-only Members	± 6 mm/1000 mm

The agreement to the attempt to repair shall not bind the Employer to accept the repaired part when it is offered for inspection prior to erection. Members that are damaged in a manner causing reduction in their strength shall be replaced at the Contractor's expense.

Tower members arriving on site with damaged galvanizing due to mishandling or formation of white rust shall be repaired by an approved means and submitted to the Employer for approval before erection commences. Members rejected by the Employer shall be reworked until the Employer is satisfied that the repaired coating will provide protection to the member similar to an undamaged galvanized coating.

If any shop errors in the steel are discovered, the Contractor shall notify the Employer who will decide whether the error shall be corrected on site or the members shall be replaced. All exposed steel surfaces around the holes or on cuts on which such corrective work is permitted shall be given sufficient coats of a zinc rich paint to provide sufficient protection to the steel and shall be to the approval of the Employer.

Suitable ladders shall be used whenever necessary during erection, but such ladders and removable step bolts shall be removed when erection work is not in progress.

Before assembly of members, joints shall be free of all earth, or any other substance which might prevent the correct alignment of members.

After erection all supports shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the hexagon to avoid damaging nuts and bolt heads. The Contractor must ensure that support erection and steel handling procedures and equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as members of the public.

After erection, all bolts from ground level up to and including anti-climbing guard components shall be tack welded at the protruding threads. All bolts between the anti-climbing guard and the bottom cross-arm shall have the threads punched in an approved manner to prevent unauthorized removal. Each tower shall be thoroughly inspected by a special crew to check the condition of the section surfaces and the correct tightness of the nuts on the bolts. The final tightening of the nuts shall be carried out using torque wrenches and the nuts shall be torqued to the values proposed by the Contractor and approved by the Employer.

Damage to the galvanized surfaces of bolts or support steelwork caused by tack welding or thread punching of bolts shall be repaired using Galvafroid or similar and the cost of such repair is deemed to be included in the appropriate rates.

All foreign matter and surplus materials shall be removed from the towers and from the site upon completion of erection.

Materials used for the towers grounding system shall comply with Clause 6.4. The Contractor shall measure the electrical footing resistance to earth of each tower

before the earthwires are erected. These measurements shall be recorded by the Contractor in the form of a tower footing earth resistance profile of an approved type.

Individual tower footing resistance shall be reduced to a value not exceeding 10Ω (ohms) or as agreed by the Employer following resistance measurements.

8.3. ERECTION OF PHASE AND EARTH CONDUCTORS

Stringing of phase conductors and earthwires shall not be performed until 28 days after foundation concrete has been placed or such other time approved by the Employer depending upon the type of concrete used and local conditions and not until assembly and tightening of bolts of structures have been completed and inspected by the Employer.

The earthwires shall be strung prior to stringing of the conductors. The earthwires shall also be sagged prior to sagging of the conductors.

The fullest possible use shall be made of the maximum conductor lengths in order to reduce the number of joints to the minimum. The number and location of line and earth conductor tensions joints shall be approved. Mid span joints shall not be less than 30 m from the nearest conductor clamp. There shall be not more than one joint per conductor in any span.

Unless the Employer agrees to the contrary mid span joints shall not be used;

(A) at locations which would allow less than 2 clear spans between mid-span joints on a given conductor. (This means 2 clear spans irrespective of the support types used).

(B) in spans crossing power lines, telecommunication lines, public roads or building, railways and navigable water ways.

(C) In single span sections.

(D) Maximum of two joints are allowed in the same span of either circuits.

The Contractor shall measure by means of approved micro-ohm meter equipment the electrical resistance of all joints after completion and before erection. The resistance of the joint shall in no case be greater than 75 percent of the resistance of the equivalent length of conductor. Where the joint includes bolted parts, the resistance to be measured is that of the complete assembly. The values of resistance measured shall be recorded on a schedule which shall be submitted to

the Employer as part of the final records. Any faulty joint shall be cut out and replaced at the Contractor's expense.

All current carrying surfaces of bolted connections shall be coated, prior to erection, with an approved conducting compound in an approved manner.

In case of local damage to isolated strands of a conductor during erection the use of repair sleeves of approved type may, in exceptional circumstances, be permitted upon application to and at the discretion of the Employer who will regard repair sleeves as joints in respect of permitted locations. Any use of repair sleeves shall not incur additional cost. The following general rules shall be observed:

a) For damage which reduces the strength of the outer layer of the conductor by an amount equivalent to one strand but not more than three strands, the use of a compression repair sleeve may be allowed. Repair sleeves shall not be allowed within a distance of 3 m from the suspension clamps.

b) For damage in excess of three broken strands or any damage to the strands of an inner layer, the damage shall be replaced with new conductor and compression joints used.

c) Any strand which has lost 50 percent or more of its cross-sectional area shall be considered as having lost all of its strength.

Conductor repair sleeves shall not be used without the permission of the Employer, which will be granted only in exceptional circumstances.

Conductor and earthwire stringing shall be carried out entirely by tension stringing methods and the Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment he intends to use. Comprehensive details including manufacturers safety factors and calculated applied loads of all equipment used such as come-along clamps, pulleys, hooks, tensioners, winches pilot and sling wires should be provided for approval prior to the stringing operations.

Tools and equipment shall conform to IEEE Standard 524, Guide to the installation of Overhead Transmission Line Conductors and as following specified:

a) Snatch Block

Snatch-blocks shall be designed especially for stringing the conductors and shall have grooves of a shape and size in accordance with the requirements of IEEE

Standard 524. The sheaves shall be equipped with high quality ball or roller bearings. The sheaves shall be lined with bonded neoprene or equivalent rubber material approved by the Employer. The sheaves used for installation of galvanized steel stranded overhead ground wire may be unlined. Unlined sheaves, if employed, shall be made of aluminum magnesium alloy, and the grooves shall have a smooth, polished finish. The sheaves shall have free and easy movement in the blocks and shall cause no damage to the conductor contact surface. Sheaves which do not run freely or which hinder the stringing operation shall be immediately replaced.

b) Reel Stands

Reel stands shall be strongly constructed and reel brakes shall be provided. Braking of the conductor and OPGW reels during stringing shall be positively controlled and shall be applied in a manner which will avoid damage to the conductor or OPGW or to the reels.

c) Pilot Wire

Pilot wires shall be made of non-twist steel wire. The pilot wire shall be strong enough for stringing work. The Contractor shall be responsible for clearing a narrow path (about 2 m wide) along the center line of the line route for paying out the pilot wire manually.

d) Powered Puller

The powered puller shall have a capacity of not less than the maximum stringing tension of the phase conductor and OPGW. The puller system shall have a powered winch with transmission gears for changing speed during stringing work.

e) Tension stringing equipment

Tension stringing equipment shall be of neoprene or Teflon lined bull wheel-type. The bull wheel brake or brake control shall be designed such that when the maximum working tension is obtained, the tension will be held constant so long as the brakes are left at this setting. The bull wheel diameter and lining material shall be approved by the Employer. A neoprene or Teflon lining material at least 6 mm thick would be acceptable

f) Come-along

Come-alongs shall be of the type that can be installed anywhere on the conductor and grips it more firmly as the tension of the conductor increases. Any other type of come-along, if employed, shall be subject to approval by the Employer.

g) Compressors for Joints and Dead End Connector Assemblies

Suitable hydraulic compressors equipped with pressure gauges and dies or other approved types shall be used for tension joints and compression dead-end connections. This shall thoroughly satisfy the requirements for jointing of the conductor.

h) Length meter

A length meter for measuring the conductor or OPGW during stringing shall be provided and may be part of either the powered puller or the tension stringing equipment.

During stringing operations, a method should be available to continuously monitor the tension of the conductors, earthwires or pilot wires and to automatically stop pulling if the tension exceeds a predetermined value. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required to install all conductors and earthwires shall be continuously controlled.

The conductor and earthwire tension during stringing operations shall be kept as low as possible, consistent with keeping the conductor clear of the ground at all times whilst in motion. At no times will the tensions be allowed to exceed 75% of the final tension. All sub-conductors forming the bundle of each phase shall be installed at the same time and shall be maintained at the same tensions throughout the operation.

The Contractor shall make any necessary special arrangements for running out and sagging the conductors where the route crosses buildings, orchards, plantations, gardens, or other ground over which erection cannot be carried out in the normal manner. No extra charge for man-handling of material or for any special precautions or methods necessary at such positions shall be allowed.

The Contractor shall also make such special arrangements as the Employer may approve where power lines are to be crossed. Where the conductors have to be erected whilst the power line to be crossed is energized, no additional payment to

the prices stated in the Schedules shall be made for any special scaffolding or equipment required.

Scaffolding shall be used to prevent the conductor and OPGW from coming within 5 meters of roads and 1.5 meters from telecommunication lines and power lines of 220 kV or lower voltages during unreeling. The scaffolding itself shall also have the aforementioned clearances. Efficient temporary grounding shall be installed in case metal scaffoldings are used for power line crossings. The scaffoldings shall be sufficiently long to cater for any conductor side-swing which may occur during stringing and shall be of sufficient strength to withstand wind pressure, vertical loads and all other loads which may be anticipated. The cost of all scaffolding shall be included in the stringing price.

All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded. Conductor drums shall be securely anchored during stringing operations and drum jacks shall be of the self-braking type to prevent conductor over run. Conductor and earthwire pulling equipment are to be such as shall ensure a continuous steady pull. Every precaution is to be taken to prevent damage to the conductor. Clamps and other devices used for handling conductor during erection shall be of approved design and shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductors. Conductor grooves in sheaves and tensioner shall be lined with neoprene or rubber. Sheaves shall have an electrical conducting path between their suspension points and the conductor supported within them and shall run with minimum friction.

Conductors shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

At least three months before stringing commences the Contractor shall give due consideration to all the factors involved and submit to the Employer for approval a fully detailed stringing schedule stating location of conductor drums for stringing and the proposed position of mid span joints, together with temporary staying of supports and all other relevant information. Particular attention shall be paid to the adequate anchorage of back stays in paddy field or swamp areas, bearing in mind that the strength properties of these types of soil are very poor.

Conductor and earth wire drums shall be closely examined before conductor pulling commences and all nails and other things which could damage the conductor shall be removed. During stringing, the conductor and earthwire drums are to be

supervised at all times and the conductor and earthwire shall be inspected for defects whilst it is being pulled off the drum.

Any damage caused to conductor or earthwires shall immediately be reported to the Employer whose decision to replace or repair will be final.

Conductors shall be carefully regulated to the correct pre-stress (if required) and initial tensions by optical measurement of sag. Ambient temperature shall be measured by thermometer inserted in a length of conductor and suspended on the support at the sag measurement position. Marking for and application of anchor clamps shall follow regulation to initial tension without delay. Conductors shall be clamped in, vibration dampers and spacers shall be erected, as soon as practicable but in any case, within 48 hours after having been tensioned to the correct sag.

Immediately after regulation and clamping in has been completed in a section, the sag of conductors shall not depart from the correct value by more than ±1.5%. Suspension insulator sets shall be installed so that clamps are within 20 mm of their correct position on the conductors.

Where required by the Employer, the Contractor shall check prior to the issue of the Taking over Certificate that the sags of conductors and earthwire in selected spans are within the specified tolerance, and shall make any adjustments necessary to ensure compliance.

Joints, clamps etc. shall be applied using the approved tools and in such a manner that no bird caging, over tensioning of individual wires or layers or other deformation or damage to the conductor occurs. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands.

Compression fittings shall be applied only by linesmen approved by the Employer, using approved methods. The outer surfaces of conductors and the interiors of compression sleeves shall be scratch brushed through grease immediately before assembly. The resistance of each compression fitting shall be measured after assembly.

The Contractor shall keep a record of each compression fitting showings its location, date of assembly, resistance and the name of the linesman responsible for the assembly. Where records of the joints made by a particular linesman show a repeated performance below the required standard the Contractor shall, at the request of the Employer, cease to employ the linesman on jointing operation and immediately replace him with other qualified personnel.

After conductors have been made off and landed, stringing sheaves shall be removed and suspension clamps and vibration dampers shall be fitted with minimum delay. Suspension clamps and Armour-rods shall be fitted with due regard to offsets where appropriate, and the conductor shall be cleaned before the clamp is assembled. Vibration dampers shall be erected on each conductor in accordance with the number required as specified in Chapter 02.

At the end of the maintenance period stated in the Conditions of Contract, the line conductor sag adjusting devices for bundled sub conductors shall be finally not more than 75 mm plus or minus, from their median position, unless otherwise approved.

The Contractor shall provide suitable dynamometers, thermometers, sighting rods and other approved apparatus necessary for the proper checking of the work. Dynamometers, if used, shall read in Kilograms or Newton, and where required by the Employer, shall be tested and, if necessary, recalibrated.

The Contractor shall keep a record schedule of all sagging, showing details of the section, the sagging and checking spans, ambient temperature, pre-stress (where appropriate), initial and final sags, the date of sagging and clipping in offsets if any. This record schedule along with the record of compression fittings shall form part of the final records for the line and shall be handed over to the Employer prior to the issue of the Taking over Certificate. The records shall be available for inspection at any time.

8.4. ERECTION OF OPGW EARTHWIRES

The OPGW shall be strung prior to stringing of the phase conductors. The OPGW shall also be sagged prior to sagging of the conductors.

The OPGW shall be strung for the whole line, without joints. The tools and equipment used shall be earthed.

The fullest use shall be made of the maximum lengths of conductor to reduce the number of joints to a minimum. The locations for joints shall be approved by the Employer.

The conductors and clamps shall be assembled using approved tools and shall be erected in such a manner that no bird-caging, over-tensioning of individual wires or layers, over-tensioning or stressing of optical fibre elements, or any other deformation or damage to the conductors shall occur.

During the installation of the OPGW in sections cable rotation shall be avoided. During the installation of the OPGW through the tower, cable rotation as caused by stretching out of the OPGW and kinking shall be avoided.

The conductors shall not at any time during erection come into contact with the ground or with any obstacle, including walls, fences and buildings. The relevant clauses related to erection of line and earthwires shall apply also for OPGW earthwires. The erection of OPGW is to be effected in such a manner that neither torsion nor bending stresses on the conductor during erection, sagging, jointing or landing shall cause any damage or deterioration to the optical fibre system. Suitable precautions shall be taken, using for example torsionally stable pulling ropes, suitable running-boards, counterweights and running blocks. Special attention shall be paid to ensure that the conductor at no time is subjected to bending in excess of that permitted by the minimum bending radius specified by the manufacturer. Running-out blocks shall be sized to conform to the minimum bending radius specified by the OPGW manufacturer.

The Contractor shall carry out tests to confirm the satisfactory condition of optical fibres prior to erection.

Once installation of OPGW earthwire is complete a series of tests to be agreed with the Employer shall be carried out to ensure the satisfactory operation of the cable. The tests shall be carried out in both directions.

The tests shall include but not be limited to:

(a) Optical attenuation on OPGW earthwire terminated with connectors carried out in both directions at 1310/ 1550 nm.

(b) Loss distribution to measure the uniformity of loss in the optical fibres and joint losses in the OPGW earthwire using an optical time domain reflectometer (OTDR).

(c) On completion of the tests three copies of the test report shall be supplied to the Employer.

Optical attenuation of the OPGW earthwire terminated with connectors shall be measured and recorded at the end of the guarantee period and it shall not be more than 102 per cent of the reading at commissioning.

The contractor shall submit his proposals for erection and test regimes to the Employer for approval prior to field work commencing.

8.5. EARTHING OF CONDUCTORS, EARTHWIRES AND OPGW

Conductors, earthwires and OPGW shall be effectively earthed in an approved manner during running out at all places where men are working on them. Sufficient earth to maintain safety shall be kept until the time of taking over. The position of each earth shall be recorded by the Contractor.

Conductor sheaves lined with neoprene or rubber shall have an electrical conducting path between their suspension points and the conductor or OPGW supported within them and shall run with minimum friction.

When stringing operations are being carried out in close proximity to or crossing energized lines, the Contractor shall take all precautions necessary to prevent accidents and injuries to persons and property due to induction or physical contact.

8.6. ERECTION OF INSULATORS AND LINE HARDWARE

Insulators, insulator fittings and line hardware shall be assembled and installed by the Contractor as per the approved drawings, and in accordance with the recommendations of the manufacturers. Insulators shall be cleaned and inspected before assembly. All insulators shall be handled carefully during transportation, assembly and installation on the tower to avoid chipping or damage and shall be cleaned when installed using techniques which cause no damage to the surface of the insulator. Any defective insulators shall be removed from site forthwith.

Proper precautions shall be taken to ensure that insulators and fittings are not strained or damaged during erection of the insulator sets, and during the pulling out and erection of conductors.

Insulators when completely assembled shall have all security clips, cotter pins and other locking devices fully in place, and shall be erected in a manner avoiding damage to the discs, fittings or locking devices. Where possible, the split pin end of bolts or other locking devices shall be installed so as to be visible from the structure body. Insulator strings are not to be used as ladders and the Contractor shall provide suitable ladders for access to the conductor end of insulator sets.

The Contractor shall take adequate precautions to ensure that dust and dirt are excluded from insulator ball and socket joints. When all work on the insulator assemblies at a tower has been completed, insulators shall be given a final clean with a soft cloth.

Vibration Dampers shall be accurately placed according to the manufacturer's recommendations. In case of Vibration Dampers installed on OPGW, the fastening clamp has to be adapted precisely to the OPGW diameter including armour protection rods.

Spacer-dampers for bundled conductors shall be installed in accordance with Manufacturer 's recommendation. They shall be efficiently distributed along the spans at unequal intervals, but at minimum 2.0m away from any mid span joint, repair sleeve or any other fitting attachment to the conductor.

8.7. SAGS AND TENSIONS

The conductors and OPGWs shall be sagged in accordance with tension/sag tables calculated by the Contractor and approved by the Employer.

The assumed minimum every day and maximum temperatures of conductors and earthwires are as stated in Employer's Requirements.

The conductors and earthwires shall be erected with such sags that at everyday temperatures in still air the final tensions shall provide a factor of safety on the ultimate tensile strength of the conductor of not less than that stated in Employer's Requirements.

Additionally, at "Minimum Temperature" in still air and for the basic span, the earthwire and OPGW sag shall be approximately 10% less than the phase conductor sag.

In case of OPGW, the maximum permissible installation tension shall be lower than the value provided and guaranteed by the OPGW manufacturer. Moreover, the OPGW installation shall be supervised by the fibre optic cable manufacturer.

The term "final tension" shall mean the tension existing in a line or earth conductor, for any given condition of loading, after sufficient period in service to allow of "bedding down" stretch and creep to take place. For purposes of calculating creep allowance this shall be taken as 10 years from erection.

"Initial Tension" shall mean the horizontal tension in a conductor at the time of sagging regulation and marking for making off, under a given loading and temperature condition, with allowance where appropriate for the conductor being supported in sheaves rather than in clamps.

"Pre-stress Tension" where applicable shall mean the horizontal tension maintained in a conductor for some stipulated period prior to regulation to initial tension as above, for the purpose of temporarily stabilizing the conductor during regulation and for partial compensation of creep.

In calculating tensions and sags the "equivalent span" method shall generally be used; i.e. the tension in any section length is that which would apply to a single span equal to the square root of the figure arrived at by dividing the sum of the cubes of the individual span lengths in the section considered by their sum.

$$\text{Ruling span length} = \sqrt{\frac{L_1^{\,3} + L_2^{\,3} + \ldots\ldots\ldots L_n^{\,3}}{L_1 + L_2 + \ldots\ldots\ldots L_n}}$$

where L_1, L_2, .., L_n are individual span lengths within a ruling span section

The following sagging tolerances against the specified sag for the conductors in all spans shall be observed:

a. no sag decrease shall be allowed in any conductor,

b. the maximum sag increase over the specified sag given on the sag data sheets shall be 150 mm,

Employing the approved design sags and tensions as the basis the Contractor shall submit, for approval, calculations for the initial sags and tensions to be employed during stringing activities. These calculations shall take into consideration the effects of creep for each of the phase and earth wires and also that, for instance, Aircraft Warning Markers will not be installed at the time of sagging. For sections where Aircraft Warning Markers are to be installed additional initial sag and tension data shall be provided.

For portions of the line in hilly terrain, the contractor shall where directed by the Employer adopt the more rigorous method of analysis taking account of the influence of differences in support level, swing of insulators with conductors in sheaves etc. and showing insulator offsets for clipping in.

The contractor shall at an early stage submit for the Employer approval his proposals for a system of initial tensioning (with or without pre-stressing as desired) which shall ensure that the conductors are so erected as to arrive at the required final tensions after 10 years of service. The system shall be such that other components of the line are not overloaded during the stringing operations as well as conductors during and

following erection. Creep compensation shall be calculated by the 'temperature difference' method.

The length of conductors, earthwires or OPGW sagged in one operation shall be limited to that length which will permit obtaining of the correct sag.

The spans used for determining the correct sag shall be, where possible, the longest level spans in the section of line being sagged. When sagging lengths covering more than six spans, the sag shall be determined not less frequently than at 1500 meter intervals. In unusual situations, additional determinations may be required.

After being pulled into the sheaves, the conductors, earthwires / OPGW shall not be allowed to hang in the stringing blocks for more than 48 hours before being pulled to the specified sag.

The correct sag shall be determined by accurate sighting in the selected span or, in cases where sighting is considered unsatisfactory by the Employer, another method approved by the Employer shall be used. The Contractor shall provide and use a reliable radio communication system to assist in the control of conductors and earthwires/OPGW tensioning operation.

All conductor and earthwire/OPGW sagging shall be performed during daylight hours. Sagging operations shall not be permitted during high wind, or other adverse weather conditions which would impair the accuracy of the sagging.

The pulling and adjusting of the conductor or OPGW to the final sag position shall be done by means of a hand or power operated hoist and not by pulling directly with trucks or tractors. The Contractor shall not apply final tension to any conductor or OPGW nor make off any conductor or OPGW except in the presence of the Employer. Complete responsibility for ensuring correct tensions will, nevertheless, rest with the Contractor.

All conductors and OPGW shall be accurately marked and clipped-in on the same day following final sagging. Clipping-in offsets shall be calculated by the Contractor and marked using a method approved by the Employer that will not damage the conductors and OPGW.

Preformed armour rods shall be installed at all points of conductor and OPGW suspension. Armour rods shall be carefully centered in the suspension clamp. Suspension clamps shall be installed and adjusted such that the insulator string in its final position hangs in a vertical plane through the axis of the structure.

If it becomes necessary to change the point of attachment of the suspension clamp by more than 7 cm either way from the midpoint of the armour rods after they are installed, the rods shall be removed and reinstalled so as to center on the point of attachment. Under such circumstances the armour rods may be reused if not damaged. The Contractor will not be allowed any additional compensation for such removal, re-installation, or replacement of armour rods where required.

A sag tolerance (in meters) = 0.01 sag (in meters), but not exceeding 0.15 meter will be permitted provided all conductors in the span assume the same sag and the necessary ground clearance is obtained.

The spans adjacent to gantries of Substations shall be slack spans.

Where required by the Employer, prior to the issue of the Taking Over Certificate the Contractor shall be responsible for checking that the relative sags of the conductors and earthwires are within the specified tolerance. Such checks shall be carried out at selected points along the route as requested by the Employer.

Clearance between conductors and ground and between jumpers and all structures shall be checked during erection and before handing over the line.

The Contractor shall provide suitable dynamometers, sighting boards and levels mounted for clamping to support steel work, or other approved apparatus necessary for the proper checking of work. When required by the Employer, dynamometers shall be tested and if necessary recalibrated.

The Contractor shall keep a record of the particulars of the sagging of conductors in each section of the routes showing the mean actual sag of the line conductors and date of stringing as well as the ambient and conductor temperature. The data shall be handed to the Employer at the conclusion of erection work.

8.8. WORK AT END OF THE LINE

Slack span connections of conductors and earthwires from the terminal towers to the substation gantry structures are included in the scope of this Contract.

The slack spans will comprise line conductors and earthwires of the same size and type as used on the associated transmission lines, and will be at reduced tensions, with insulator sets of the low duty tension type, as required.

The overhead earthwire system will be connected to the earthwire peaks of substation structures. OPGW, however, will be terminated in the junction boxes to be mounted on the substation gantry structure.

8.9. FINAL INSPECTION

Upon the notification by the Contractor that the work is finished on a completed line, the Employer, prior to issuing the taking over certificate, will inspect the completed Works, in order to ascertain that they have all been carried out in accordance with the Specification and to the Employer's satisfaction.

The final checking shall include but not be limited to:

- Tightening of bolts and fixing of missing members to towers;
- Remove all scaffolds and equipment and clear all debris and other rubbish from the site;
- Restore surface damage, foundation subsidence and carry out erosion control measures, where directed by the Employer or as required by local authorities or regulations;
- Remove all left-over materials at winch yards, drum yards and store yards;
- Complete danger tree clearing and tree reclearing on the easement;
- Check phase sequence plates on both sides of all points of the line;
- Measurement of the line's electrical parameters.

In particular it will be ascertained that at least;

(A) AT TOWER POSITIONS

Backfilling of the excavations, ramming, levelling around foundations, draining of higher footings on sloping ground, dispersal of excess earth etc, is complete.

Concrete protruding above ground is correctly shaped, finished and sealed.

Bituminous or other approved painting has been correctly applied. Steel sections are straight and not damaged. Bolts and nuts are correctly fitted with washers and are properly tightened and locked.

The line conductor and earthwire fittings are erected in accordance with the drawings and are complete. The line conductors and the earthwire are correctly clamped.

All tower steelwork, bolts, nuts and cotter pins, washers and split pins on all fittings are properly fitted. The tower steelwork is free of all foreign matter.

Anti-climbing devices and danger and identification plates are complete and correctly fitted.

(B) ALONG THE TRANSMISSION LINE

The conductors and the earthwire are clean, without strand damage and free of mud, foliage, loose wires, etc. The sags of all conductors and of the earthwire are in accordance with sagging documents and clearances are correct.

All packing and surplus materials have been removed from the site. The cutting and removal of trees and all route clearing is in accordance with the Specification.

All access and inspection tracks are completed and in good condition.

8.10. PAYMENT FOR ERECTED WORK

The method of payment is set out in the Schedule of Rates and Prices of Volume 4. For payment purposes the term "Section" shall mean the complete transmission line. Invoicing of materials and erected work shall be submitted separately for the purpose of accounting.

The Contractor shall submit to the Employer for approval a draft blank printed Form of Measurement Certificate which in a complete form must accompany all invoices.

All measurements for the purpose of payments shall be made jointly by the Contractor and the Employer. Completed Measurement Forms shall be signed by both the Contractor and Employer and shall accompany each interim certificate. Payment will not be authorized without the completed Measurement Form.

Measurements for the purpose of payment for materials supplied and for work erected shall be made on the following basis;

i) Preliminary and profile survey; for the horizontal distance involved measured along the center line of the transmission line.

ii) Foundations; at the unit rates for the approved numbers of each foundation type for each tower type.

The rate for a Special Foundation shall be the most appropriate unit foundation rate adjusted for additional or reduced quantities of excavation, reinforcement and concrete in accordance with the variation rates provided in the schedules.

iii) Towers; for each standard height support and standard body extension, at the appropriate schedule rates, which are to include for all number plates, danger plates, anti-climbing devices etc.

iv) Conductors and earthwires; for the horizontal distance involved, measured along route center line without allowance for sag, scrap or jumpers. Rates include for mid span joints.

The rates in the Schedules for the standard supports, extensions and foundations shall include all work irrespective of access conditions, slope of the ground, nature of the subsoil and the presence of water. Following conditions where certified as abnormal by the Employer will be paid at the appropriate rates in schedules. No extra payments will be made.

Conditions will be certified as abnormal if;

(1) Close timbering is required other than that due to normal or avoidable collapse of soil. This does not refer to Normal, Poor Soil, pile foundation or Water Logged soil foundations where close timbering is deemed to be included in the contract Price. The extra price for close timbering as per price schedules shall be paid for Special foundations only.

(2) Pumping is required other than that due to normal or avoidable accumulation of water. This does not refer to Normal, Poor Soil, pile foundation or Water Logged soil foundations where pumping of water is deemed to be included in the Contract Price. The extra price for pumping as per price schedules shall be paid for Special foundations only.

(3) Rock is encountered which is unsuitable for rock foundations.

No extra payments shall be made for;

(a) Excavation necessary solely for the installation of stub setting templates or extra excavation necessary for setting foundations deeper in sloping ground.

(b) The tower erection methods employed.

(c) Additional costs of transport of materials to the tower site.

(d) Pumping out normal overnight seepage or avoidable accumulation of water.

(e) Strutting and planking of excavation where in the Employer opinion closed timbering is not required.

Payment for close timbering shall be made only for the agreed size of excavation necessary.

Earth is defined as material which can be removed with the aid of shovels and pickaxes. Rock is defined as material for the removal of which the aid of wedges, sledge hammers and crow bars, or drilling and/or blasting is necessary but which cannot be removed with shovels and pick axes.

Additional steelwork hillside extensions for standard towers shall be paid for at the rate of steelwork in schedules.

CHAPTER 9 – AIRCRAFT WARNING SYSTEM

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9. CHAPTER 9 – AIRCRAFT WARNING SYSTEM

9.1. ITEMS AND INSTALLATION OF WARINING SYSTEM

In the restricted areas and where required by the Employer, warning spheres and obstruction low intensity lights or high intensity obstacle lights shall be fitted on the earthwires of transmission line and aviation warning lights on the towers. The towers shall also be painted with red and white colours.

The position of the spheres and the obstruction lights shall meet the following requirements:

- They shall be fixed on the two earthwires for any span and shall be so staggered that the maximum distance between any two of them on each earthwire is not greater than 60 m
- The first and the last spheres/ obstruction discharge lights in any span shall be approximately 15 m from the towers defining the span

9.2. WARNING SPHERES

The warning spheres shall be fixed on the earthwires in any required span and shall be erected, as required by Chapter 6 of Annex 14 to the ICAO Regulations. Warning spheres shall be fitted to the earth wires of the transmission line. The warning spheres shall be 600 mm diameter and manufactured from fiberglass. The spheres shall be colored international orange which will not fade when subjected to the directed rays of the sun. They shall be manufactured in two halves and designed such hat assembly and attachment to the conductor is simple. Provision for drainage the conductor but will prevent the sphere from twisting or slipping on the conductor. All metal parts used for holdings the spheres in position shall be of mild steel and galvanized.

With twin earthwires, provided the spacing of the spheres on either earthwire is suitably staggered to provide the above requirements, the placing of the spheres can be alternated between the two earthwires at uniform spacing.

9.3. LOW INTENSITY DISCHARGE LIGHTS

Obstruction Low Intensity Discharge lights shall comply with ICAO Annex 14, Section 6.3.11 with operating principle of potential induced gradient to feed discharge light (neon tube) of omni-directional beam of 10 candela. The set shall be comprised the tube in anti-vibrating liquid container, insulating wires, insulator to suspend the light and insulating wires etc.

The system comprises with:

- A light source; and
- An auxiliary conductor to convey the necessary electrical energy

The light source consists of a discharge lamp in a low-pressure neon gas atmosphere that produces red light. The lamp has a lifetime of several tens of thousands of hours. The principle of energy derivation involves an electrical source with low current and high tension; the lamp consists of a long small diameter glass tube with helicoidally winding and two cold electrodes. The unit is housed in a protective sleeve of toughened glass with a diameter of approximately 50 mm. The ends of the protecting tube are hermetically sealed with metallic stoppers so that the internal space can be filled with a special liquid to eliminate radio parasitic emissions. The lamp itself is hung on flexible mountings, with one side to the active line and the other side to the auxiliary conductor. (ICAO 14.6.15)

The auxiliary conductor is a section of metallic conducting wire insulated from the main wire and intended to produce, by a capacitive effect, the electrical energy necessary to operate the lamp. The geometry of the auxiliary conductor depends on the active line and its voltage. The conductor consists of tubes 4 m long made of high-grade aluminum; the number and configuration are determined by the conditions of operation. The length of the auxiliary wire is inversely proportional to the voltage of the main wire. The auxiliary conductor is suspended by glass insulators of high mechanical strength and aluminum jaws to avoid any problem of electrical coupling with the cables. The jaws are fitted for the exact diameter of the electrical cables. The diameter range available is 16 mm to 34 mm; the operating voltage of this lamp is several thousand volts. (ICAO 14.6.16)

Low-intensity obstacle lights shall be fitted to top conductor of the line. The position of the low-intensity obstacle lights shall meet the following requirements.

- They shall be staggered that horizontal distance between any two of them is not greater than 60 m.
- The first and the last low-intensity obstacle lights in any span shall be approximately 15 m from the towers defining the span.

9.4. HIGH INTENSITY OBSTACLE LIGHT, TYPE B

High-intensity obstacle lights, Type B, should be used to indicate the presence of a tower supporting overhead wires.

High-intensity obstacle lights, Type B shall be located at three levels:

- at the top of the tower;
- at the lowest level of the centenary of the wires or cables;
- at approximately midway between these two levels

High-intensity obstacle lights on towers supporting overhead wires should have a daytime intensity of not less than 100 000 cd. The intensity of the lights should decrease to 20 000 cd at twilight and 2 000 cd at night through the use of a photocell control.

The middle level should flash first, the top level flash second and the bottom level flash last. The interval between the flashing of the top level and the bottom level should be approximately twice the interval between the middle level and the top level. The interval between the end of one sequence and the beginning of the next should be about ten times the interval between the middle level and the top level.

9.5. LOW INTENSITY OBSTACLE LIGHT, TYPE B

Where required, Aircraft Warning Lights shall be installed on the towers defined by the Employer.

They shall be manufactured according to the International Standards having the following general features;

- Conforming to Chapter 6 of Annex 14 to the ICAO Regulations
- One lamp per structure having characteristics of Table 6-3 of Annex 14 in ICAO standard
- Having minimum lamp life time of approximately 20,000 hours
- All components shall be corrosion-proof for use during the varying atmospheric and climatic conditions occurring at all seasons.
- The lighting system shall be designed to withstand the induced high voltage that can occur during earth fault conditions.

At tower locations the Contractor shall provide a self-contained power supply system comprising photovoltaic solar cells, batteries, control equipment, cable and accessories, access ladders and platforms required for each set of air traffic obstruction lights. A battery maintenance interval of a minimum of 5 years shall be guaranteed, as shall the minimum luminous flux for the lights. Complete system shall be designed to ensure maximum unattended operation with minimal maintenance.

The light shall be designed to allow it to be directly installed on any vertical or horizontal surface on the peak of the tower. In case the power adapter cannot be installed at the lamp locations, an extension cable assembly with lamp holder shall be provided. All installation shall be in accordance with approved general arrangement drawings and supplier's instructions.

It shall be noted that the supply of equipment shall include the necessary spare parts as per manufacturer's recommendations for a service period of 5 years, the cost of which is deemed to be included in the price quoted in the Schedules.

The tower obstruction light system shall be to the approval of the Engineer.

9.6. AVIATION WARNING PAINT ON TOWER

Where required and to comply with requirements of Airports Authorities the towers shall be painted with two coats of approved epoxy resin type paint with red and white strips of widths complying with ICAO Regulations. The life span of the paint system shall be not less than 10 years and the colours shall not fade within this time under strong sun radiation.

The towers are to be painted in seven sections from the top to the bottom.

CHAPTER 10 – INSPECTION AND TESTING

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10. CHAPTER 10 – INSPECTION AND TESTING

10.1. INSPECTION AND TESTING DURING MANUFACTURE

The Plant shall be inspected and tested during manufacture by the Employer and it is the responsibility of the Contractor to advise the Employer when plant shall be available for inspection.

Test programs shall be prepared and submitted to the Employer for approval. The date of tests shall be announced in time in order to allow participation of the Employer if requested. A test report has to be submitted to the Employer for approval within two weeks after test performance.

Every facility shall be provided by the Contractor to enable them to carry out the necessary inspection of the plant and the costs of all tests during manufacture and preparation of test records shall be borne by the Contractor.

The passing of such inspection or test shall not, however, prejudice the right of the Employer to reject any or all of the Plant if it does not comply with the Specification when erected or give complete satisfaction in service.

Unless otherwise specified in this contract, selection of test samples, number of specimens and acceptance of the results shall be in accordance with the terms of the latest relevant standard where applicable. Where the terms are not given in the relevant standard, the Employer is to instruct the details in advance of the inspection and tests in response to request of the contractor.

Instruments shall be approved and shall, if required by the Employer, be calibrated by the National Physical Laboratory or such other body as may be approved, at the expense of the Contractor.

The costs for all tests are deemed to be included in the Bid Price.

SUMMARY OF TESTS AT THE MANUFACTURES'S WORKS

The following tests shall be carried out at the manufacturer's works

(1)	Line and earth conductors	type (where applicable), routine and sample tests
(2)	OPGW/ OFAC and hardware associated	type (where applicable), routine and sample tests
(3)	Insulators	type (where applicable), routine and sample test

(4)	Insulator Strings	type tests
(5)	Fittings for Insulator and Earthwire	routine and sample tests
(6)	Suspension, Tension clamps and Joints	type and sample test
(7)	Particular Tests	
(8)	Supports	type, routine and sample tests as required by the Employer
(9)	Galvanising	routine tests

10.1.1. CONDUCTORS AND EARTHWIRES

10.1.1.1. GENERAL

The Contractor shall supply a detailed Quality Assurance Procedure including an Inspection and Test Plan (ITP) for all conductors (phase conductor, earthwire, complete OPGW) which shall be submitted to the Employer for approval. The Contractor shall be responsible for performing all tests and inspections required during the production of the conductors.

All materials used in the manufacture of conductors shall be covered by test certificates stating their mechanical and chemical properties to prove compliance with these technical requirements and EN 50182 or IEC 61089, 62219 as appropriate. The following certificates/ test records shall be submitted for approval:

- metallic material test certificate
- conductor stranding equipment non contamination certificate
- galvanization test records.

10.1.1.2. CONDUCTORS

The tests referred below shall be applied for all conductors (phase conductor, earthwire and complete OPGW), in accordance with the requirements of EN 50182 and following standards, as applicable:

-	EN 60889	Hard-drawn aluminum wires
-	EN 50189	Zinc-coated steel wires EN 50326 Conductor grease
-	EN 10244	Galvanization thickness
-	IEC 60468	Measurements of resistivity
-	ISO 7802	Wrapping test

Existing type test certificates may be submitted for the appropriate conductor type and are acceptable provided that they are not older than 8 years and shall include minimum;

- tensile strength as per EN 50182, Chapter 6.4.8
- stress strain curves as per EN 50182, Chapter 6.4.7
- stringing test as per EN 50182, Chapter 6.4.9.

Reference lists are also accepted for the proof of stringing capability.

In case such type test certificates and reference lists cannot be provided, the type tests have to be carried out in presence of the Employer, and the costs have to be covered by the Contractor.

TYPE / SAMPLE tests shall be performed as per EN 50182, Table 5.
In the event of the sample from any length not passing the mechanical or resistance tests, a second and third sample shall be undertaken from the same length, and if one of these also fails under test, the length of conductor (i.e. drum) from which it has been taken shall be rejected.

Details of the test results shall be made available to the Employer upon request for approval.

10.1.1.3. ROUTINE

Tests shall be carried out on individual wires and complete conductor to prove compliance with the details stated in the Employer 's Requirements.

10.1.1.4. GREASE

The manufacturer's type test certificates for proving compliance with the technical requirements as per EN 50326 shall be submitted to the Employer for approval:

Sample tests on grease as per EN 50326 shall be undertaken at the same time as sample tests on the conductor. Grease for the dropping test shall be removed without heating.

10.1.2. OPGW/OFAC CABLES

10.1.2.1. Type Tests

Type tests shall be performed in accordance with the most up to date version of IEC 60794-1, IEC 60794-4, IEEE-1138 and ITU-T Recommendation G.652D. Existing type tests certificates may be accepted provided that tested OPGW / OFAC structure corresponds to the offered one and the certificates are not older than 8 years.

The following type tests are required:

a) stress-strain
b) tensile performance
c) crush and impact
d) temperature cycling
e) water penetration
f) short circuit
g) lightning
h) seepage of flooding compound
i) aeolian vibration (OPGW only)
j) sheave (OPGW only)
k) DC Resistance
l) Salt spray corrosion test
m) Creep test

10.1.2.2. Routine Tests

OPGW/ OFAC on all drums shall be tested for mechanical tests including measurement of overall diameter of OPGW, measurements of thickness of Al and ACS wires, diameter of tube, wrapping test of Al and ACS wires, check of surface quality and OPGW weight, checking of lay length and lay ratio of layers, checking of lay directions, breaking load test of OPGW and DC resistance measurement in accordance with IEC 61232/ IEC 60889/ IEC 61089 or EN 50182 at the factory by the manufacturer as routine tests.

In addition, attenuation shall be measured on each fiber of all OPGW with OTDR at the factory by the manufacturer as routine test.

The Contractor shall submit for approval by the Employer a schedule of factory acceptance tests to prove that the installed system meets the requirements of the Specification.

The proposed test equipment for each test shall be duly presented to the employers' authorized representatives before starting the factory acceptance tests. The valid calibration certificates of test equipment shall be presented prior to commencing the test. Calibration certificates shall be issued by an external independent IEC accredited calibration authority. The man-machine interface /user interface of testing equipment shall be in English or English translation shall be made available

Factory acceptance test for OPGW shall be carried out based on IEC 60793-1-40, IEC 60794-4-10. Unless otherwise agreed the sampling rate for the factory acceptance test shall be minimum 10% of the OPGW drums,

a) Aluminium clad steel wires/ Aluminium alloy wires

Tests for aluminum clad steel wires/aluminum alloy wires shall be carried out in accordance with the requirements of EN 50182, Table 5, IEC 61232/ IEC 60889. Following minimum tests shall be carried out for samples taken on random sampling basis from the outer ends of 10% of the OPGW drums ready for shipment

- Overall diameter
- Tensile strength,
- Elongation after break,
- Resistivity
- Torsion
- Minimum aluminium thickness
- Stress at 1% extension

b) Optical Fibres

Optical fibers of OPGW and OFAC shall be tested in accordance with the requirements of ITU-T Recommendations G652D / G655 and IEC 60793 as appropriate.

Attenuation shall be measured on each fiber of above-mentioned sample drums of OPGW with OTDR. Attenuation coefficient at 1310 nm and 1550 nm, point discontinuities of attenuation shall also be measured. Visual material verification and dimensional checks as per the approved drawings shall be carried out.

Following minimum test shall be carried out for optical fibres

- Fiber attenuation

- Point discontinuities of attenuation
- Attenuation variation with wavelength
- Mode Filed diameter
- Core-Clad concentricity error
- Cladding diameter
- Macro bending loss
- Cable cutoff wave length test

c) Complete OPGW

Following minimum tests shall be carried out for OPGW

- Overall diameter of OPGW
- OPGW surface condition
- Cable unit weight
- Direction of lay
- Lay ratio
- Breaking load
- Temperature cycling test
- Crush test (for one sample)
- Impact test (for one sample)

d) Optical Fibre Approach Cable

Following minimum tests shall be carried out for one sample of OFAC

- Crush test
- Impact test
- Repeated bending test
- Bend test
- Water penetration test

10.1.3. OPGW FITTINGS AND ACCESSORIES

The OPGW suspension and tension attachment-to-tower sets shall be tested for mechanical and thermal performance. These are in particular:

- tensile load test
- clamp bolt tightening test
- aeolian vibration test
- thermal stability tests

The mechanical tests specified in IEC 61073 1, par. 4.5, shall be performed. The test procedures shall follow the recommendations of CIGRE, TF 22.11.03, Guide for Fittings for Optical Cables on Transmission Lines, Part 2A, Testing Procedures (published in ELECTRA No. 188, February 2000).

The tensile test shall be agreed with the OPGW manufacturer and the optical attenuation shall be measured. The clamp bolts have to be tightened according to the recommended moments and the OPGW shall be checked afterwards visually.

The aeolian vibration test shall be coordinated with IEC 60794.

10.1.3.1. OPGW - JOINT BOXES

The hardware for OPGW/OPGW and OPGW/OFAC joints shall be subjected to type tests. The Joints for OPGW (joint enclosure and splices) are subject to the requirements of IEC 61073, IEC 61300.

Joint boxes type tests shall include minimum a water immersion test for proving the joint water tightness and seals, with measuring of attenuation variation of the splice and loss characteristic in an assembled joint at the start and end of a seven (7) days immersion period. Type test certificates may be submitted to the Employer for approval.

10.1.3.2. TESTS AFTER DELIVERY

After the arrival of the conductors, earthwire and OPGW at site, they will be inspected and shall pass to the satisfaction of the Employer such of the tests as he may deem necessary to satisfy himself that the conductors and OPGW supplied conform to the Employer`s Requirements.

Conductors and OPGW which do not pass the tests satisfactorily may be rejected forthwith and shall be replaced at the Contractor's expense.

10.1.4. COMMISSIONING TESTS- OPGW

The following commissioning tests shall be carried out for OPGW:

a) End to end optical wave-guide fiber continuity and attenuation measurement test (using OTDR)
b) Attenuation measurement test (using optical power meter and optical power generator)

These tests shall be carried out from equipment connector end at one site to corresponding end of the remote site. These tests shall be carried out in both directions.

The OPGW performances shall be measured between the joint boxes installed on the terminal gantries. The link attenuation shall be measured for each fiber.

The total line attenuation at 1550 nm shall not be greater than:

N_s x 0.06 + L x 0.22 on each fiber,

Where

N_s = total number of splices in line;

L = length of the OPGW measured between the joint boxes mounted on the terminal gantries (including the excess in length due to sags and joints).

c) Bit error rate count over 360 Hrs. (15 days) of continuous transmission test code at 2.048/155.52 M.bits/sec, generated by Optical Line Terminal Multiplexers/Regenerative Repeaters, already installed by OLTE Contractor.

Test procedure, recording sheets, and schedule for commissioning tests shall be submitted for the Employer approval. The Contractor shall provide all the test equipment required with a valid calibration certificate issued by an appropriate calibration body for the commissioning.

Upon completion of the above tests the lines shall be energized at full working voltage before handing over and the arrangement for this, and such other tests as the Employer shall desire to make on the completed lines shall be assisted by the Contractor who shall provide such labour, transport and other assistance as is required without extra charge. Apparatus for special tests shall be provided by the Employer.

10.1.5. INSULATORS

The insulator units and the insulator sets used in this Contract will be subjected to type, sample and routine tests according to;

- IEC 60383 Insulators for OHL >1000 V, Ceramic or glass insulator units, test methods
- IEC 60437 Radio Interference Test
- IEC 60507 Pollution Test

- IEC 60587 Test methods for evaluating resistance to tracking and erosion
- IEC 60591 Sampling rules and acceptance criteria.

Type tests including radio interference type tests, may be waived on the production by the Contractor of the requisite number of certificates by an internationally acceptable independent Testing Authority showing that the insulators concerned have successfully passed type tests in accordance with BS EN 60383 or IEC 60383, 60437 and 60575 or other relevant BS/IEC standards.

10.1.5.1. TYPE TEST

The Bidder shall submit in his Bid, test certificates and the test data for the offered type of insulator units.

The following type tests are required;

1) Steep front wave flashover test
2) Thermal-mechanical performance test
3) Electro-mechanical failing
4) Power Arc test

10.1.5.2. SAMPLE TEST

The insulators for sample test shall be selected at random from batches. The number of samples shall be as indicated in IEC 60383 and the samples shall be subjected to the tests in accordance with IEC 60383. The test results shall comply with this standard.

Electromechanical failing load test shall be performed in accordance with IEC 60383- 1.

10.1.5.3. ROUTINE TEST

Every insulator shall pass the tests in accordance with IEC 60383.

10.1.6. INSULATOR STRINGS - COMPLETE SETS

10.1.6.1. TYPE TESTS

One string of each type selected by the Employer (other than the light duty strings), shall be subject to the following tests in accordance with the provisions of BS EN 60383 or IEC 60383 and 60437 or other relevant BS/IEC standards.

(1) Impulse tests:

Dry withstand (Procedure B of IEC 60060) and dry 50% flashover, positive and negative polarity

(2) Power frequency tests:

Wet and dry withstand and wet flashover

(3) Radio interference tests

(4) Corona tests

Tests shall include arcing horns, vibration dampers and other fittings attached to the conductors in service.

10.1.7. INSULATOR STRINGS – COMPONENT HARDWARE

The clamps and fittings used in the insulator sets and for attachment to tower as well as for the conductor assembling will be submitted to type, sample and routine tests according to IEC 61284 or BS 3288: Part 1, as agreed with the Employer.

Two samples each of tension clamps and tension and non-tension joints shall be submitted to mechanical and electrical type test, galvanizing, and section of mechanical routine tests in accordance with the appropriate sections of BS.3288; Part 1 and of this Specification. The Employer from time to time shall make further similar tests as may be required to ensure that the quality of the product is being maintained throughout the Contract.

10.1.8. SUPPORTS

10.1.8.1. SHOP ASSEMBLY TEST

One tower of each type and height, including every combination of body extension, shall be assembled in the shop to such an extent as to ensure proper field erection. The test shall be performed with the Employer in attendance. Any member distorted, twisted or bent due to incorrectness of detailed drawing shall be corrected.

Reaming of mismatched holes will not be permitted. A reasonable amount of drifting will be allowed in assembling.

In cases where assembly test are to be carried out at a place other than the intended testing facility, the Contractor shall provide facilities to check the assembly of the support structure prior to the loading test for the support structure.

Assembly may be vertical or horizontal. If the assembly is horizontal, blocking and adequate support shall be provided to prevent distortion and overstressing of members to ensure proper fit. In assembling, only sufficient number of bolts need to be used to hold members in their position one to another.

If any errors on the drawings or fabrication are discovered, all incorrect drawings shall be revised and the corrected part shall be re-fabricated and re-assembled at the Contractor's expenses. All revised drawings shall be re-submitted for approval.

10.1.8.2. LOADING TEST

Each tower shall then be tested in accordance with IEC 60652 and subjected to such test loads in order to prove compliance with the ultimate loading conditions including the safety factors applied in an approved manner, without showing signs of failure or permanent distortion in any part.

Strain measurements of five selected members of the testing support structure shall be obtained using strain gauges in accordance with accepted industry standards for each loading step of all load cases including during the destructive test. Members, which strain measurements are to be obtained shall be decided by the employer's representative.

Eight test specimens from eight different compression members with effective slenderness ratios less than 120 and tension members of the support structure shall be taken for each grade of material for testing on mechanical properties of the material to check the compliance of the material with the appropriate specification.

The suspension towers shall be tested to destruction as described below.

The tension towers shall be tested to destruction too, or at least to ultimate design loads or as instructed by the Employer.

Steel towers submitted for test shall be galvanized unless specific approval is obtained.

The Employer is entitled to attend tests and inspections, and the Contractor shall bear all costs and expenses of tests and attendance as per price schedules. The Contractor shall give the Employer notification in writing, not less than 45 days in advance, of the date when towers will be ready for test. Test program shall demonstrate procedures of test in order to proof the specified technical requirements and be subject to approval by the Employer prior testing starts.

Additional tests may be called by the Employer to ensure that the required quality is met. The Contractor shall supply all necessary labor, material, equipment and competent and authorized test personnel. Calibration of equipment is deemed to be included. Six (6) copies of test reports and/ or certificates are to be provided showing all results and information necessary. If the Employer waive to attend the

test, it will neither relieve the Contractor of his full liability to meet the required quality and to complete the works nor prejudice or affect the rights of the Employer set forth under this contract.

The test shall be performed with the Employer in attendance and in accordance to IEC 60652 "Loading tests on overhead towers" and complying with the following requirements:

a) Tower

The tower shall be fabricated according to the detailed drawings approved, in a manner as close to final production procedures as practicable. The tower shall be complete in every detail. Markings for test tower members shall be prefixed with the letter "T".

b) Erection

The tower shall be erected on a rigid foundation using the specified tower bolts and nuts tightened to the specified torque.

c) Rigging

The Contractor shall submit for approval diagrams showing the proposed methods of applying loads and deflection measuring.

d) Loading

Test loads shall be the working loads multiplied by corresponding safety factors. All test loads corresponding to conductor and earthwire loading shall be applied directly to the regular attachment details provided for those loads. Test wind loads equivalent to wind loads on the tower shall be applied where convenient and in such a manner that the locations and the summations of applied load and overturning moment are as close as possible to the actual conditions, as designed.

An extra compressible member is not allowed for use in applying wind loads on tower. To ensure application of full-test loads to the tower, friction losses in rigging shall be computed and added to the rigging loads.

The first load case in an angle tower testing program should be the one that produces the largest leg force. If subsequent load cases also give sufficiently high leg force, tower bolts at major joints must be loosened and retightened prior to the test to minimize residual loads.

e) Loading program

The Contractor shall program the tests for the decisive load cases in order to most favorably demonstrate that the towers will carry all design loads and conditions specified in the loading diagrams.

g) Load tests

The initially applied loads and the increment of loading shall be 25% of the working loads given in the loading diagrams. However, the increments of load shall be in accordance with IEC 60652.

Each load increment shall be maintained for not less than two minutes except that under full design load, the period of five minutes shall be maintained and during this time there shall be no slacking off or adjustment of the loads.

All test loads shall be removed completely before the loads for testing under different loading conditions are applied. The ultimate normal conditions or the most critical load case shall be the last test to be carried out in the presence of the Employer/ Employer.

Load Cell Calibration shall be carried out before and after each test or series of tests in the presence of the Employer.

h) Destruction test

After the successful completion of the ultimate load tests, the tower shall be further tested to destruction by increasing the loads for a given loading case, as specified/approved by the Employer.

The load increments shall not exceed 5% of the ultimate design load. Each load increment shall be held at least five minutes while deflections are being recorded. The maximum test load may be limited to 1.3 times the ultimate design load.

i) Modification of tower components

Any conspicuous yielding or permanent deformation or any failure of any part of the tower under any of the tests specified shall be considered a defect. If a defect develops, the Contractor shall modify the design of the tower and submit it to the Employer for approval. The modified tower shall then be re-tested.

The expenses associated with re-design and re-test due to a defect in the Contractor's work shall be borne by the Contractor.

j) Material tests

Steel materials used for tested towers shall be subject to mechanical and chemical properties tests in order to prove compliance with the relevant material standards.

Tests shall be performed by the Contractor at no additional cost to the Employer. The test specimens shall be selected as follows:

- four sets selected from the destruction members of each test tower
- four sets selected from the undisturbed members of each test tower
- two sets of bolts and nuts selected from the adjoining destruction members of each test tower
- two sets of bolts and nuts selected at random from each test tower.

k) Acceptance Criteria

Acceptance criteria shall be considered as per IEC 60652.

j) Reports

The Contractor shall furnish certified copies of full reports of all tower and material tests, the calibration of the dynamometers or gauges, including clear photographs of the test set-ups and nature of all failures, diagrams showing deflection of towers at each interval of loading, de-tailed diagrams showing the manner in which all the loads were applied and deflection records.

All structure tests on which results are approved shall be paid for at the rates stated in schedules.

When destruction tests are carried out payment shall be made for the destroyed tower at the appropriate Schedule rate.

No part of a tower tested to destruction shall be used in the permanent works and

the Contractor shall confirm disposal to the Employer in writing.

Where tower tests are satisfactorily completed and not taken to destruction, the tower shall be carefully inspected after dismantling to ensure that no parts have been damaged, bundled separate from routine tower materials, and marked for use in the permanent works at apposition of relatively light loading. A complete set of new bolts shall be supplied in such cases, and their cost shall be deemed to be covered by the Contract Rates.

10.1.8.3. SAMPLE TESTS

Sample testing on steel material shall be performed as specified in Clause 5.15

10.1.8.4. ROUTINE TESTS

The Employer will inspect as soon as available at the Contractor's works the first consignment of complete foundation steelwork and stub setting templates. Thereafter inspection of galvanized steelwork will be limited to complete structures, with or without foundation steelwork, the weight of steel to be inspected for each inspection visit has to be agreed by the Employer.

Where additional inspection visits are required to be made due to shortcomings or deficiencies, the cost of travel, subsistence and accommodation of the Employer will be borne by the Contractor.

10.1.9. GALVANISING

Galvanized wire shall be tested in accordance with BS EN 10244. Galvanized articles other than wire shall be tested in accordance with BS EN ISO 1461. Attention is drawn to the formation of white rust as detailed in Clause1.33. If evidence of white rust is apparent upon receipt at Site of bundled steel sections, the Employer shall order the Contractor to make such tests as he deems necessary to determine the extent of damage if any and the remedial measures necessary.

10.2. TESTS AT SITE

Where ordered by the Employer site investigation tests shall be paid for at the rates entered against the relative items in schedules. The rates shall include for all necessary transport, work, materials and instruments entailed in testing to a satisfactory result except where the work is called out under conditions which have been certified by the Employer as abnormal. In such cases close timbering and pumping shall be paid for under this appropriate schedule rates.

10.2.1. SOIL INVESTIGATION TEST

10.2.1.1. GENERAL

SURFACE CONDITION

By submitting the bid, the Contractor affirms that he has carefully examined the site and all conditions affecting work under this contract. The Contractor shall examine the soil investigation results and submit for the Employer approval the type of the foundation proposed at each tower.

PERFORMANCE OF WORK

No work shall be performed except in the presence of the soil mechanic experts or his authorized representative and the Employer. At least two (2) working days' notice shall be given prior to commencing any phase of the work specified herein. Whenever the contractor is permitted to perform work at night or on weekends or holidays, he shall reaffirm the notice at least twenty-four (24) hours prior to performing such work, so that proper inspection may be provided.

CLEANING UP

The contractor shall at all times keep the premises clean and free from accumulations of waste material and rubbish caused by his employees or work, on completion of the boreholes he shall remove all rubbish, tools and equipment and leave the site in a neat and clean condition. No debris shall be burned nor shall it be deposited on adjoining property.

Where requested by the Employer, the additional site investigation tests shall be performed by the contractor against payment at the rates entered in the respective items in schedules. The rate shall include for all necessary transport, works, materials and instruments entailed in testing to a satisfactory result.

10.2.1.2. CONE PENETRATION TEST

In-Situ tests by means of dynamic or static probing test methods shall be carried out, at least 1 (one) test at every tower's center peg unless otherwise instructed by the Employer to investigate soil conditions at the tower location. Selection of probing test method shall be based on the site condition or as instructed by the Employer.

Except for soft and hard rock foundation the depth of investigation shall be minimum two times the breadth of foundation below the founding level of the foundation, except for pile foundation where separate tests are to be performed.

The number of tests and/or their depth may differ according to the necessity or direction of the Employer. The cost shall be deemed to be included in the price of profile survey.

10.2.1.3. BORE HOLE TEST

If required by the Employer the Contractor shall carry out soil investigations at the specific tower center peg or leg or as otherwise directed. The boring of at least 50 mm diameter shall be carried out to a depth as specified herein further on.

Compactness of soils is to be investigated by means of standard penetration tests carried out in depth of 1.5, 3.0, 4.0, 5.0, 6.5 and every 1.5 m further below.

Distributed samples are to be taken from every soil layer, at least every two meters. Undisturbed samples are to be taken from every cohesive layer and from any layer, which is considered as a bearing layer. Water level is to be recorded.

All borehole walls shall be protected by casings (except in stable rocks and hard cohesive soils).

The borings shall be performed as dry borings, wherever possible, so that the sequence and depth of each soil layer can be clearly identified from the soil samples (flush borings are not permitted).

The Contractor shall be responsible for any subsidence or failure due, in the opinion of the Employer, to the contractor having taken insufficient care in the choice or installation of the foundations, or to inaccuracy of any soil information provided by the Contractor.

Results of these tests shall be included on the profile to give a preliminary indication of the ground bearing properties and water level.

- The depth of boreholes should continue to bedrock if a hard stratum of N-value more than 50 is not encountered.
- In case of pile foundations, depth of investigation should be at least 3 m below the bedrock level.
- Borehole records shall comprise with the descriptions of all strata encountered in sub-surface, SPT records, sampling information and natural water table level. In case of rock coring, core recovery (CR) and rock quality designation (RQD) shall be provided with the borehole records.

The Bidder shall state in his Bid the proposed type of equipment to be used for this test. Site investigation shall be carried out at each tower location of the line. The cost shall be deemed to be included in the price of foundations.

10.2.1.4. REQUIREMENTS FOR SOIL REPORTS

The soil reports shall be made in such detail that a foundation recommendation for every OHL tower is made. The soil report shall also include all logs and tables and the summary of laboratory test results (table). The main requirements are as follows:

(i) Lay out Location Plan of Soil Investigation

A location plan shall be made, showing at least:

- The plot with contours and northern direction;
- Scale;
- Location of structures;
- Location of boreholes, soundings, trial pits, in situ density tests, etc.,
- Legend (key).

(ii) Soil profiles (Cross-section)

The results of the subsoil investigations shall be presented in the form of cross-sectional drawings, having a vertical scale of 1:500 and showing at least.

- Actual ground level at the points of investigation (related to the official elevation system).
- Results of boreholes including standard penetration test (SPT) graphs,
- Proposed foundation levels,
- Limit lines of soil layers (soil strata),
- Groundwater level
- Legend (key)

(iii) Logs Tables

The report shall include the following information: Bore logs, diagrams, logs of laboratory tests, including: - actual ground level, - description and limits of various soil layers, - samples taken, - SPIT results, - VST results. - Water levels - depth of borehole/pit/sounding

(iv) Chemical Analysis

The groundwater and soil shall be chemically analyzed and classified with regard to its aggressive action. Classification shall comply with recognized standards, e.g. Building Research Establishment Digest (BRE Digest NO.253) or DIN 4030. At least 3 sets of samples shall be analyzed.

(v) Conclusions

The investigation shall enable the positioning of the bearing layers and the depth of the groundwater table (especially maximum groundwater level) to be determined. Clear recommendations for all foundations shall be derived from the investigations. These recommendations shall refer to the bearing capacity of the subsoil and the appertaining settlements in accordance with the type of foundation finally chosen.

For pile foundations in addition details shall be given below:

- Recommended pile type and bearing capacity (for tensile and compressive loads).
- Depth of pile tips
- Drivability,
- Difficulties to be expected during pile performance and recommended installation method,
- Ultimate skin friction value for every soil strata and proposed pile shaft material.

When the contractor has carried out other tests at his own expense, not ordered by the Employer, the results shall be made known to the Employer and conversely, where the Employer had independent tests made along the route of the line, such information shall be made available to the contractor.

10.2.1.5. LABORATORY SOIL TESTS

The Contractor shall obtain soil samples and submit them for tests to an approved laboratory to determine the necessary properties of the soil for purpose of foundation designs. Such information shall be detailed in approved manner and conclusions given as to recommend bearing pressures to be adopted.

10.2.1.6. GROUND BEARING TESTS

Where ordered by the Employer the Contractor shall carry out ground bearing test to determine the ground bearing capacity, by means of loading a 300 mm square plate in an approved manner described in BS-5930 code of practice for site Investigation.

The cost shall be deemed to be included in the price of foundation.

10.2.2. FOUNDATION TESTS

10.2.2.1. CONCRETE AND MATERIAL TESTS

Six specimens of each sample obtained from each of 3 consecutive batches, shall be tested for compressive strength assessment at 7 days and 28 days (three specimens at 7 days and three specimens at 28 days) in accordance with BS 5328. The test shall be carried out in a laboratory approved by the Employer. The trial mix proportions shall be approved if the average strength of a set of 9 specimen tested at 28 days exceeds the specified characteristics compressive strength.

The contractor is fully responsible for carrying out all necessary materials tests as required by the relevant applicable standards or as directed by the Employer, in order to ensure quality of the works.

The manufacturers' Test Certificate provided do not suspend to perform random tests on the supplied materials to be made by efficient and qualified staff in laboratories on site or in the Contractor's workshop or elsewhere. Also, the contractor shall perform all necessary cube and slump test according to this specification or as requested at any time by the Employer.

The Contractor shall obtain from materials supplier the certificate of Test, proof sheets, mill sheets etc. required by the relevant applicable standards, showing that the materials have been manufactured in accordance with the requirements of this specification. Neither the omission of the Employer to send an Inspector nor the production of the Manufacture certificate of Test as aforesaid shall affect the liberty of the Employer to reject delivered materials if they are found to be not suitable, or not in accordance with this specification.

Where materials or workmanship are rejected by the Employer the objected part must immediately be removed from the site or demolished and removed at the Contractor's sole cost.

Before and during pouring of the concrete the Contractor shall carry out slump and concrete sample test at the foundation works, as required by the Employer.

The contractor shall carry out tests on samples of concrete from the foundation works, as required by the Employer.

The test specimens shall be 150 mm cube and the mould shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mould shall be provided with a metal base having a smooth machined surface. The interior surfaces of the mould and base shall be lightly oiled before concrete is place in the mould.

Test specimens shall be molded by placing the fresh concrete in the mould in 50 mm layers, each layer being thoroughly compacted with a steel bar 380 mm long and having a ramming face 25mm square and weighing 2.8 kg. The concrete shall be subjected to at least 35 strokes per layer. Alternatively, the concrete may be compacted by vibration, each layer being vibrated by means of an electric or pneumatic hammer or by means of a suitable vibrating table.

Concrete for the test specimens shall be taken at the point of deposit. To ensure that the specimens are representative of the concrete in the foundations a number of samples shall be taken from different points. Each sample shall be large enough to make one test specimen and shall be taken from one point in the work.

The test specimens shall be stored at the site at a place free from vibration, under damp sacks for 24 hours, + 1/2 hour, after which time they should be removed from the moulds, marked and stored in water at a temperature between 10°C and 2I C until the test date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in a damp sand, or other suitable damp material, and shall reach the laboratory at least 24 hours before test. On arrival at the laboratory they shall be similarly stored in water until the date of the test.

The test shall be made at the age of the concrete corresponding to that for which the strengths are specified. Compression tests shall be made between smooth plane steel plates without end packing and a load shall be applied axially at the rate of approximately 13.8N/mm per minute. One compression plate of the testing machine shall be provided a ball seating in the form of a portion of a sphere, the center of which coincides with the central point of the face of the plate. Test specimens shall be placed in the machine in such a manner that the load is applied to the sides of the specimens as cast.

The results shall be handed in triplicate to the Employer, as soon as possible after testing.

If the results of tests as described under Sub Clause 7.2.2. show, that the quality of concrete is inadequate or if other defects are revealed, or if directed by the Employer the following check tests shall be carried out;

- Rebound hammer test to obtain approximate indication of the strength of the concrete.
- Cutting cores in accordance with requirements of Part 4 of BS 1881.

Furthermore, the Electromagnetic Cover Measuring tests in accordance with BS 4409, Part 4. Shall also be carried out to conform the setting out and position of reinforcement.

If requested by the Employer the Contractor shall perform compactness test of backfilling to prove that the works conform to the Specification.

The costs of all these tests shall be deemed to be included in the Contract price.

If the result of any of these tests is not satisfactory, the Contractor will be instructed to take down or cut out that part of the works concerned and to reconstruct to comply with the Specification. Cost of such repair or substitute works and any necessary remedial measures shall be to the Contractor's expenses.

10.2.2.2. PILE TESTS

When ordered by the Employer the Contractor shall carry out pile bearing and uplift tests for all types of pile generally in accordance with the method given in the British Standard Code of Practices CP.2004 - Foundations or VDE 0210. Such tests shall be carried out to determine the ultimate uplift and bearing values at any given site. Payment for pile tests shall be made at the rate given in schedule.

Cost of tested piles shall be paid separately as per respective rates of Schedules.

The Bidder/Contractor shall carry out successful foundation load tests in order to prove the suitability of the pile foundation selected. The results of the tests shall be submitted in a format for approval by the Employer.

The following types of tests are to be considered:

I) Piling Type Tests (Preliminary Pile Test)

Prior to piling commencement, the Bidder/Contractor shall install two test piles of each type of pile proposed.

The piles shall be considered as acceptable in case the obtained load-settlement/heave- diagrams do not indicate movements beyond permissible limits as per Bidding Documents or the relevant Standards.

Other (working) piles shall not be installed until the load tests have been conducted and the results evaluated.

Type test piles shall not be utilized within the works and shall be treated in such a way that they do not obstruct the further works.

Cost of preliminary test piles shall be paid separately as per respective rates of Schedules.

II) Piling Foundation Bearing / Uplift Test (Working Pile Test)

The Bidder/Contractor shall perform the minimum number of above tests as mentioned in the price schedule. If required additional number of tests shall be carried out upon the request of the Employer.

III) Sonic Pile Test

After installation of the working piles, the integrity of all driven piles (100%) is to be checked successfully by means of sonic pile testing equipment. Cost for this pile test shall be included in the relevant pile foundation cost given in schedule.

DETAILS FOR PILE TESTS

1. LOADING

The Bidder/Contractor shall execute the test piles using the same equipment, which he intends to use for execution of all the piles. The test piles should be of the same length and same type as the piles proposed for the project. Loads shall be applied in the direction of the resultant force acting on the pile.

The loading tests of piles shall be in accordance with the procedure outlined in BS or equivalent, as approved by the Employer.

Type tests (preliminary pile tests) are to be loaded to either 250% of the anticipated design load, or to the ultimate bearing load. At least two load cycles have to be made during type testing, the first reaching from 0% to 100% and the second - after off-loading - to 250% of the design load. Load steps shall normally not exceed 25% of the design load.

For routine tests (working pile tests) a loading to 150% of the design load is required. At least two load cycles have to be carried out, the first reaching from 0% to 100%, and the second - after off-loading to 150% of the design load.

2. TEST REPORTS

Reports on pile testing shall be submitted to Employer and shall contain, among others, the following information:

(i) Layout of test equipment and description

(ii) Pile identification, diameter and length

(iii) Sketch of soil conditions and ground water location

(iv) Complete records of level, load cell and dial gauge readings against date and time throughout the test, preferably in tabulation

(v) Graphs of load and settlement/heave versus time

(vi) Graphs of settlement/heave versus load

(vii) Remarks concerning any unusual occurrences during the loading of the pile

(viii) Test reports on integrity testing of piles shall include clear sample diagrams of acceptable signals for comparison purpose, as well as sample graphs indicating defects or doubts on the integrity of the pile.

Payment for pile test will be made as follows;

All cost including preparation, transportation, piling, testing, site clearing after test, analysis and preparation of report shall be included.

For estimation purpose pile is the same as of to be used for TDL tower and depth from GL is 15m. Price adjustment in difference of depth will be made by unit rate of pile of TDL tower in Schedules of Rates and Prices.

In case pile is differ, price adjustment will be made by following formula.

"Extended pile depth from GL x unit rate of the pile – 15m x unit rate of TDL pile"

10.2.2.3. ROCK ANCHOR AND FOUNDATION TESTS

ROCK ANCHOR TEST

Where rock foundation is used in hard rock, as provided for by the Specification, the Contractor, when ordered by the Employer, shall type test individual anchors by tensile test loading to failure. The type test shall be considered satisfactory if the steel bar falls by yielding of the steel at, or above, its design ultimate strength.

The test shall be paid per rate as entered in schedules.

ROCK ANCHOR FOUNDATION TEST

Anchor foundation pull out testing shall be installed away from permanent foundation anchors but in the same rock. The frequency of testing shall depend upon the different types of hard rock and the number of tests performed shall be such as to give confidence in the encountered employment of rock anchor foundations and experience of the type of rock suitable for their use.

The cost of the test including cost of cleaning up the site after the test and the tested anchors are deemed to be included in the cost of foundation.

10.2.3. TESTS DURING ERECTION

10.2.3.1. Support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the earth conductors are erected. The placing of the test electrodes shall normally be along the center line of the route in such direction as to ensure that the lowest resistance to earth is recorded, and a note shall be made of the direction in the test leg.

The schedule used for recording earth resistance test data shall contain in addition to the measured ohmic values, details of the surface soils and general ground conditions at the time of test.

10.2.3.2. Soil Resistivity Test

Where ordered by the Employer soil resistivity tests shall be recorded in an approved manner.

10.2.3.3. Additional Tower Footing Resistance

If in the opinion of the Employer it is necessary to reduce the tower footing resistance by approved means such as galvanized stranded counterpoise conductor, the Contractor shall make further tests after the additional measures have been carried out and before the earth wires are erected. Any further re testing shall be carried out as necessary without extra charge.

10.2.3.4. Conductor and Earthwire Joint Tests

The resistances of all completed clamps, joints and terminal fittings shall be accurately measured by the Contractor in the presence of the Employer inspector. Where the joint consists of several parts bolted together (e.g. dead end clamp with bolted on jumper terminal) the resistance to be measured is that of the complete assembly. The resistance of any such fittings shall not exceed 75% of the resistance of an equivalent length of conductor, measured adjacent to the fittings, and the current carrying capacity shall be at least 100% of that of the conductor as per BS 3288 Part 1(1997).

In addition, the centralization of the steel inner sleeves of joints shall be checked by the Employer inspector before erection. Details of the method shall be submitted to the Employer.

The Contractor shall provide suitable equipment (such as the Digital Micrometer) for making the above tests, and shall submit details of the proposed instruments to the Employer for approval. Suitable clamps shall also be supplied for connecting the current leads of the measuring instrument to the test sample to provide adequate surface contact at the interfaces. Test probes as used for potential contacts are unsuitable for current connections. Stringing of conductor and earthwire shall not commence until the instruments are on site and ready for use.

10.2.3.5. Measurement of Galvanizing Test

The Contractor shall have available on site for the Employer use an instrument suitable for the accurate checking of galvanizing thickness. The gauge shall be available from the time of arrival of the first consignment of steel work until the issue of the taking over certificate for the last line completed.

10.2.4. TESTS ON LINE COMPLETION

The Contractor shall be responsible for satisfying the Employer when the lines are ready to be tested and shall conduct the tests in the presence of and as instructed by the Employer. If any failure is detected, the Contractor shall locate and determine the cause of the failure and shall make any replacement or repair necessary or correct any errors in the installation to the satisfaction of the Employer and at no extra cost.

Prior to the energizing, the Contractor shall provide the Employer with a written statement that all personnel and all temporary erection earthing points are withdrawn and the line is ready for energizing.

The line shall be energized at full working voltage before handing over and the arrangement for this, and such other tests as the Employer shall desire to make on the complete line according to the usual Standards of Practice of the Employer shall be made by the Contractor who shall provide such labour, transport and other assistance as required without extra charge.

Prior to the hand-over of the completed line, the following (as a minimum) tests shall be carried out and wit messed by the Employer, to prove that the erected line is ready for energization:

- Phase sequence tests
- Conductor electrical continuity proving tests for each phase, by telephone connection or an alternative method approved and witnessed by the Employer;
- Insulation (Megger) tests for each phase. Insulation strength test shall be carried out between each phase conductor and earth, and between phase conductors by means of an approved Insulation tester
- Tower earthing system electrical resistance measurements by means of a high frequency instrument supplied by the Contractor and approved by the Employer.
- OPGW performances, including OTDR tests.
- Measurement of the electrical parameters (line impedance, resistance, etc.
- Phase sequence and line continuity

COMMISSIONING TESTS- OPGW

The following commissioning tests shall be carried out for OPGW:

a) End to end optical wave-guide fiber continuity and attenuation measurement (this test shall be carried out from equipment connector end at one site to corresponding end of the remote site. This test shall be carried out in both directions).

The OPGW performances shall be measured between the joint boxes installed on the terminal gantries.

The link attenuation shall be measured for each fiber.
The total dispersion at 1550 nm shall not be greater than:
Ns x 0.06 + L x 0.24 on each fiber,

Where

Ns = total number of splices in line;

L = length of the OPGW measured between the joint boxes mounted on the terminal gantries (including the excess in length due to sags and joints).

b) Bit error rate count over 360 Hrs. (15 days) of continuous transmission test code at 8/34/140 M.bits/sec, generated by Optical Line Terminal /Regenerative Repeaters, already installed by OLTE Contractor.

Test procedure, recording sheets, and schedule for commissioning tests shall be submitted for the Employer approval. The Employer at least two will attend the commissioning tests. The Contractor shall provide all the test equipment required for the commissioning.

Upon completion of the above tests the lines shall be energized at full working voltage before handing over and the arrangement for this, and such other tests as the Employer shall desire to make on the completed lines shall be assisted by the Contractor who shall provide such labour, transport and other assistance as is required without extra charge. Apparatus for special tests shall be provided by the Employer.

10.2.5. HANDING OVER ON COMPLETION

On completion of the final checking and testing, the Contractor shall deliver to the Employer a written statement (Taking Over Certificate) certifying that each line is complete in every respect, that all earths placed by the Contractor have been removed and that every member of the Contractor's staff has been informed that nobody is allowed to work on the line unless a working permit signed by the Employer is issued.

Tools, appliances and spare materials required for maintenance of the transmission line shall be handed over as detailed in the price schedules.

The documentation to be handed over prior to the issue of the Certificate of Completion shall include:

- Site Test Certificates (with the results of the site checks/ tests/ commissioning tests)
- as-built drawings
- list of spare parts
- Punch list showing that all pending work, remedying of defects and damages have been executed.