POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR THE PROCUREMENT OF

PACKAGE-1: DESIGN, SUPPLY, ERECTION, TESTING & COMMISSIONING OF 132KV TRANSMISSION LINES AND SUBSTATIONS ON TURNKEY BASIS

LOT-1: TRANSMISSION LINES

SECTION 7

FOUNDATIONS

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FOUNDATIONS

7.1 SCOPE

7.1.1 General

The type of foundation to be used at each tower position shall be determined from the results of the geotechnical investigation. The design of the foundation shall be in accordance with the design parameters and associated criteria detailed in this Specification for tender design purposes, but finally in accordance with the parameters of the actual geotechnical investigation.

The Contractor shall ascertain from the geotechnical investigation that the ground conditions are suitable for each foundation. The levels of geotechnical investigation specified are the minimum level required at site. The Contractor shall undertake all necessary geotechnical investigation for the foundation design. Any subsidence or failure, due in the opinion of the Engineer to insufficient care having been taken in either the geotechnical investigation, or installation of the foundations shall be the Contractor's responsibility.

In areas where subsidence is likely to occur the Contractor shall if necessary, carry out modifications to the tower foundations as agreed by the Engineer. Collar or tie beams between the individual footings of a tower shall not be used unless specifically authorized by the Engineer. The Contractor shall not be held responsible for failure of tower and foundations arising from adjacent mineral extraction subsequent to the construction of the transmission line. The Contractor shall, however, be held liable for any lack of foundation or tower stability due to causes other than subsidence due to subsequent mineral extraction.

The Contractor is responsible for obtaining approval from the Engineer and where appropriate statutory regulatory bodies for the type and design of the foundations installed. It should be noted as a general requirement that no site work can commence before such approvals have been obtained. **This is a Hold Point.**

7.1.1.1 The work to be performed under this specification consists of excavation and/or boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of open cast RCC foundation and/or cast-in-situ RCC vertical bored piles of specific diameter, providing all labour, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipments & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with BS 8110 & BS 8004, drawings and specifications. The nature of work shall generally involve construction/installation of open cast foundation and/or cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Employer’s construction drawings and also co-ordination with tower erection contractor for setting of stubs / fixing of anchor bolts (as the case may be).

7.1.1.2 The setting of stub/fixing of foundation anchor bolts (as per approved drawing) shall be the responsibility of the Contractor.

7.1.1.3 The Bidder shall quote based on the provisional Bill of Quantities (BOQ) furnished in the Price Schedule.

7.1.2 Method Statement

The Contractor shall submit to the Engineer a comprehensive method statement giving sequential details of his proposed installation method and include his intended programme. The method statement shall include but not be limited to the following details:

(a) method of excavation. (for all types of foundations) and dealing with water;
(b) method of installation of the pile foundations;
(c) method of installation of rigid frame / river crossing tower foundations,

(d) methods for heating, welding and site bending of reinforcement;
(e) method of placing of concrete;
(f) method of curing and protecting the concrete;
(g) method of backfilling and compacting;
(h) Reinstatement of working areas;
(i) Quality Control procedures;
(j) Site safety procedures.

This is a Hold Point.

7.1.3 Types and Uses

The foundation shall be of open cast type and / or cast in situ piles. Plain Cement Concrete/Reinforced Cement Concrete footing shall be used for all type of normal towers. All the four footings of the tower and their extensions shall be similar for a particular location, except where soil condition and or water table are different at different legs. The total depth of foundation, below ground level shall generally be 3.0 meters. For Hard Rock type and also where specific site conditions / properties demand foundation of different depths (lower or higher), the same shall be adopted. Further, for multi circuit tower foundations, foundation depth shall be 3.5 meters and for river crossing open cast foundations, the foundation depth shall be more than 3.5 meters.

Foundations for towers for different categories of soil conditions shall be selected from the approved types detailed in Appendix 7.A1.

Reinforced concrete pile caps shall be used for all types of piles.

Unless specified to the contrary, foundations for angle/terminal towers shall not have different designs for compression and tension footings, but shall be satisfactory for the most adverse condition of maximum and minimum angles of deviation/entry and with the wind blowing from the most onerous direction.

7.1.4 Classifications of Foundations

7.1.4.1 Concrete Pad &Chimney Foundations

This foundation takes the form of a reinforced concrete flat slab surmounted by a chimney. Alternatively, the slab may be replaced by a truncated concrete pyramid surmounted by a chimney.

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations).

7.1.4.1.1 Normal dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff or agricultural fields (except paddy fields) shall also be classified as normal dry.

7.1.4.1.2 Sandy Dry Soil

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition.

7.1.4.1.3 Wet

To be used for locations:

a) Where sub-soil water is met between 1.5 meters and the depth of foundation below the ground level.
b) Which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields.

7.1.4.1.4 Partially Submerged

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5 metre below the ground level.

7.1.4.1.5 Fully Submerged

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

7.1.4.1.6 Black Cotton Soil

To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

7.1.4.1.7 Fissured – Rock

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

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 0.75 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

7.1.4.1.8 Hard Rock

The locations where chiseling, drilling and blasting is required for excavation, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

7.1.4.1.9 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the footing.

7.1.4.2 Piled Foundations

Pilled shaft foundations shall comprise piles suitably connected below ground level by a concrete cap. The Contractor shall submit his proposed method of installation and Quality Control procedures to the Engineer prior to 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. This is a **Hold Point**.

7.1.4.3 Raft Foundations

Raft foundations for wide based lattice towers shall only be used in areas subject to mining settlement, or very poor ground where piling is not possible.

7.2 DESIGN

7.2.1 General

7.2.1.1 Design of foundations as classified under Cl. 7.1.4 for all towers and towers with extensions shall be developed by the Contractor based on the soil properties as given in Table below.

7.2.1.2 Not used

7.2.1.3 The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation.

7.2.1.4 The construction drawings /working drawings of all type of foundations classified as in clause 7.1.4 shall be provided to the Employer by the contractor progressively during execution stage. The drawings and calculation for other foundations designed for specific site conditions (if required) shall be subnitted based on actual site requirements only.

7.2.1.5 The provisional quantities of foundation required for the project are furnished in the Price Schedule.

7.2.2 Geotechnical Parameters

7.2.2.1 The detailed soil investigation is to be carried out by the Contractor. The Contractor shall develop the pile foundation design based on the soil investigation report for the particular location. The design calculation and drawing required for execution of pile foundation shall be submitted to the Employer by the Contractor**. Complete Soil Investigation report consists of layer wise all Engineering properties of soil like values of Bulk Density (γ), Cohesion (C), Angle of friction (ϕ), Bearing Capacity factors N_c, N_q and N_γ, Ground water Table and history of Flood/submergence in rainy season shall be submitted to the Employer.**

7.2.3 Concrete Mix Design

7.2.3.1 The Contractor shall be entirely responsible for the control of the quality of concrete mixed and placed, in the Works. Before the commencement of any concrete work, the Contractor shall submit to the Engineer, a complete specification giving details of the materials used, source of supply, storage and quality control requirements, including preliminary trial mixes and works' tests reports. This is a **Hold Point.**

7.2.3.2 To ensure the durability of the concrete, the requirements specified in Appendix 7.A6 shall be adhered to with regard to characteristic strength, minimum cement content and maximum free water/cement ratio.

7.3 CONSTRUCTION OF TOWER FOUNDATION, STUB SETTING AND EARTHING

7.3.1 Open cast foundation

7.3.1.1 Excavation

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

7.3.1.1.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, using timbering, shoring, shuttering, dewatering etc. as approved by the Employer. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

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

a) Dry Soil

Soil removable either manually, by means of a spade and shovel or mechanically by proclaims, excavators etc.

Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this

b) Wet Soil

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

c) Dry Fissured Rock

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

d) Wet Fissured Rock

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

e) Hard Rock

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

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

7.3.1.1.5 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling and use of blasting materials shall be taken. In cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc. In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer.

7.3.1.1.6 The Contractor shall arrange & supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Employer.

7.3.1.1.7 Local rules and regulations shall be followed regarding safety of excavation work.

7.3.2 Construction of Bored Cast In-Situ Pile foundation

7.3.2.1 General Requirement

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

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

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

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

7.3.2.2 **Site Preparation**

This section of the specification covers site preparation of the areas as indicated in the drawings.

7.3.2.3 **Reference Points and Bench Marks**

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

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

7.4 MATERIALS

7.4.1 Concrete

All works shall further be carried out in full compliance with all local rules and regulations and the specification. All materials used in the production of concrete, including all admixtures shall be in accordance with the requirements of BS 8500 and BS EN 206.

Cement shall be either:

(a) Portland cement in accordance with BS EN 197-1 strength grade 42.5N;
(b) Sulphate resisting Portland cement in accordance with BS 4027 strength grade 42.5N LA;
(c) Portland cement combined with a minimum of 25% and a maximum of 40% of p1a. Complying with BS 3892 Part 1.

The maximum particle size of the aggregates shall be so chosen as to be compatible with mixing, handling, placing, and workability of the concrete.

Throughout the construction period the quality of concrete mixed at and/or delivered to Site has to be controlled. Tests shall be carried out in the presence of the Engineer or under the supervision of an approved office for testing of such kind of works. The Contractor shall submit to the Engineer, test schedules on the following test at least one month prior to commencement.

(a) Aggregates
(b) Cement
(c) Water
(d) Admixtures and Additives

In case of placing ready mixed concrete, concrete tests can be replaced by the manufacturer's test results.

Concreting for pile foundation shall be done through tremie-pipes or equivalent devices to prevent segregation. For concreting in hot weather, ACI Standard 305R "Hot Weather Concreting" shall be followed and various means may be employed to lower the temperature of concrete such as:

- Cooling coarse aggregate with water by sprinkling and shading
- Using chilled water
- Avoiding the use of the hot cement
- Adequately watering of sub-grade, form-work and reinforcement
- Intensive moist-curing with potable water of the concrete placed

No admixtures shall be used without approval of the Engineer

Where appropriate the Contractor shall take cognisance of CIRIA Special Publication No.31. Recommendations contained in this report shall be adhered to except that in the event of any discrepancies this Specification will take precedence unless authorised by the Engineer.

7.4.2 Potential Alkali Reactivity

Aggregate shall not contain any materials that are reactive with alkalis in the aggregate itself, the cement, the mixing water or in the water in contact with the finished concrete or mortar in amounts sufficient to cause excessive localised or general expansion of the concrete or mortar.

The Contractor may initially assess an aggregate source by testing in accordance with ASTM C289. If potential reactivity is indicated, then mortar bar tests in accordance with ASTM C227 shall be carried out and the results shall comply with the limits given in ASTM C33, before use of the aggregate is approved. Details of the tests shall be submitted to the Engineer. This is a **Hold Point.**

7.4.3 Reinforcement

Unless specified to the contrary high yield steel reinforcement shall be either hot rolled deformed bars or cold worked deformed bars to BS 4449 and shall have type 2 bond classifications.

Mild steel reinforcing shall be plain hot rolled bars to BS 4449. Steel fabric or wrapping fabric shall be to BS 4483. Where mild steel hot rolled deformed bars are used they shall be generally in accordance with BS 4449. Reinforcement shall not be manufactured from scrap steel, unless otherwise approved by the Engineer.

Where specified fusion bonded epoxy coated reinforcement shall be in accordance with the requirements of BS ISO 14654 and 14656. Coated reinforcement shall be delivered to site in its cut and bent form.

Cropped ends and minor discontinuities of the fusion bonded coating shall be factory coated using a suitable repair compound formulated in accordance with the manufacturer's specification.

Where specified fibre enhanced concrete shall contain fibres manufactured from 100 percent virgin polypropylene fibre and designed to achieve maximum distribution and freedom from clustering in the mix.

7.4.4 Reinforcing Bar Coupler

The use of proprietary reinforcing bar couplers to extend reinforcement will be permitted. Details of the coupler system shall be submitted to the Engineer prior to their use. This is a **Hold Point.**

7.4.5 Spacers

Dense sand/cement mortar spacing blocks shall be of a low permeability having similar strength, durability and appearance to the surrounding concrete.

Details of patent spacers shall be submitted to the Engineer. This is a **Notification Point.**

7.4.6 Tying Wire

Tying wire shall be 1.6 mm diameter black annealed mild steel wire for uncoated mild or high yield steel reinforcement.

Coated bars shall be fixed with plastic coated annealed mild steel tying wire.

7.4.7 Anchor Tendons

All the materials used in the installation of anchor tendons including those used for the grout shall be in accordance with the requirements of BS 8081 BS EN 1537.

7.4.8 Gabion Baskets

Gabion baskets and mattresses shall be manufactured from cold drawn steel wire. Minimum wire diameter for baskets galvanised to BS EN ISO 1461 shall be 3.0mm whilst for plastic coated wire galvanised to BS EN 10244-2 shall be 2.7mm. The minimum radial plastic coating thickness shall be 0.25mm.

All steel wires shall be electrically welded at every intersection.

7.4.9 Holding Down Bolts

NOT USED.

7.4.10 Piles

If pre-cast concrete or steel piles are used all materials shall be in accordance with the requirements of the IEC 'Specification for Piling'.

7.4.11 Stubs

Stub steelwork and bolts shall not be inferior to the requirements of Clause 8.3.1.

7.4.12 Earthing

All mild steel used in the manufacture of earthing rods shall comply with the requirements of BS EN 10083 etc.: (minimum strength 600N/m) Earthing rods shall have a minimum diameter of 14 mm.

Phosphor-bronze used in the manufacture of earthing rod couplings shall comply with the requirements of BS 12163 etc.

All compression fittings shall be manufactured from electrolytic tough pitch high conductivity copper, complying with the requirements of BS 13600 and BS EN 1057 and 12449, designation C101.

Earthing conductors shall be in accordance with the following requirements:

(a) Copper strip to BS EN 1652, 1653 and 1654, Grade C101 or C102, minimum cross sectional; dimensions 20 mm x 3 mm.
(b) Hard drawn copper strand to BS 7884, minimum overall diameter 10.65 (7 x 3.55 mm);

(c) Galvanised steel wire to BS 183, minimum overall diameter 9.75 mm (7 x 3.25 mm).

7.5 WORKMANSHIP

7.5.1 General

All workmanship shall be in accordance with the requirements of this Specification, the appropriate British Standard and local regulations including the appropriate health and safety requirements. The Contractor shall comply with all local regulations in respect of safety measures during construction at site. All local regulations shall also be adhered to. Proper strutting, sheeting and bracing, including rearrangement of the installations when necessary, protection of slopes, methods of excavation to reduce risk of slides, etc., shall be the Contractor's responsibility to meet the for design and construction requirements. And workmanship, shall be in accordance with the requirements of ACI 308.1, 301M, 301, 117-117R also.

7.5.2 Site Working Area

The Contractor will be restricted to a specified maximum working area at each tower site. He shall, where required, mark this area to clarify boundary lines to other parties. The Engineer shall be kept informed of any activities by others within the working area.

The Contractor shall remove all vegetation and other debris from the tower site, which will interfere with his operation. Vegetation and debris removed from the tower site shall be disposed off outside the right of way as directed by the Engineer and/or in accordance with local regulations.

The Contractor shall dispose of material and regulate the movement of equipment, and slopes necessary to develop required loading characteristics shall be maintained, especially in side-hill locations.

7.5.3 Supports of Excavation

Excavations shall be adequately supported or formed to ensure stability of the sides and prevent any damage to the surrounding ground or structures. The design of suitable sheet piling and/or timbering for the tower of foundation excavation shall be in accordance with the recommendations of BS 8004 Section 5.

When the Contractor is requested, shall submit details of his temporary support to the Engineer.

Excavation material suitable for re-uses, as backfill shall be stored within the site working area. Excavation top-soil shall be stored separately.

Excavated material unsuitable for re-use shall be removed from site to a recognised dumping area provided by the Contractor, and approved by the relevant authorities.

For excavation in cohesive material the final 150 mm above formation level shall only be removed immediately prior to placing the blinding concrete. This activity shall be programmed to be carried out on the same day.

Excavation shall not be carried out below or adjacent to existing building foundations until under-pinning and shoring has been completed by the Contractor. Existing structures, foundations, and services shall be adequately protected or re-routed by the Contractor.

The Contractor shall not permit water to accumulate in any excavation unless otherwise agreed. Any water whether arising from the excavation or draining into shall be drained or pumped to an approved location well clear of the excavation area in a manner that does not cause erosion, silting or contamination of existing drains and watercourses. Before the method of ground water lowering is selected, adequate knowledge of the ground and water conditions has to be obtained from the results of a soil investigation and/or information, which may be available from the Engineer.

The Contractor shall take adequate steps to prevent adjacent ground from being, adversely affected by loss of fines in any de-watering process.

7.5.4 Use of Explosives

The Contractor shall familiarise himself and comply with the laws and local customs concerning the use, handling and storage of explosives.

(a) Permission

Explosives shall not be used on the Site without the prior approval of the appropriate Military and Civil Security Authorities and without prior written approval of the Engineer. This is a **Hold Point.**

(b) Control

The handling of all explosives on site shall be carried out in accordance with local requirements.

(c) Approval

The Employer shall be given a minimum of 24 hours notice of a proposal to use blasting and shall be given any details they may require concerning the charges and their positions. This is a **Notification Point.**

The Employer may regulate, restrict or prohibit blasting, if in their opinion it is necessary to do so for the safety of persons, property, and limit noise or to safe guard the works.

(d) Blasting

For explosives to be allowed in any area of the site, the following and any local requirements shall be strictly observed.

i) The Contractor will be required to strip overburden and vegetation to expose rock which requires to be blasted;

ii) Where there is any danger of flying rock engineering persons or property, blasting screens made of approved materials shall be laid over the rock to be blasted, to help prevent dangerous projection of fragments;

iii) The use of electric detonators will not be permitted within 60 meters of any overhead power lines;

iv) Delay blasting techniques will be mandatory for all primary blasting with charge limits per delay period being imposed in order that ground vibration from the blasting can be controlled to a peak particle velocity of 25 mm/sec. in the vicinity of any structures or installations;

v) All charges prior to firing will be covered with thick gunny sacking and 1.8m squares of steel mesh weighed down with filled sandbags in order to prevent the projection of rock fragments;

vi) The Contractor will be required to take adequate and effective precautions to prevent debris rolling onto public or private roads and property.

The erection of magazines for storing explosives on site will not be permitted.

7.5.5 Reinforcement

(a) Storage

All reinforcement shall be adequately stored to prevent contamination or damage.

(b) Cutting and Bending

All reinforcement shall be bent cold unless otherwise permitted by the Engineer. Reinforcement shall not be straightened or re-bent in a manner which may cause injury to the material. All reinforcement shall be cut and bent in accordance with the requirements of BS 8666 and BS EN ISO 4066. The reinforcement shall be clearly identified with securely fixed, durable tags.

(c) Fixing

All reinforcement shall be rigidly fixed in position to the concrete cover specified by an approved means. The Contractor shall be responsible for ensuring that the reinforcement is properly towered and maintained in position by the adequate use of chairs, spacers and tying wire.

The reinforcement shall be free of all loose rust, scale or contamination of any kind. The reinforcement shall be inspected/checked after being fixed and no concrete shall be placed around the reinforcement until such checking/inspection has taken place and concrete permission has been signed by the Engineer.

(d) Site Bending

Bending and subsequent straightening of reinforcing bars projecting from the existing concrete shall be undertaking as follows:

i) Unless noted otherwise on the drawings, the minimum distance from the existing concrete to the beginning of a bend and the minimum inside diameter of the bend shall be:

Bar Diameter	**Min Distance from surface to beginning of bend**	**Min Inside bend (mm) radius**
10-24	3 Bar Diameters	3 Bar Diameters
25-32	4 Bar Diameters	3 Bar Diameters
<32	5 Bar Diameters	5 Bar Diameters

ii) Bars of 10 to 16 mm diameter may be bent once without heating, heating is required for subsequent straightening or bending.

Bars of 20 to 32 mm diameter may be bent once and subsequently straightened, heating is required in all cases.

Bars having a diameter greater than 32 mm may be bent only with the approval of the Engineer, heating are required in all cases.

iii) Heat shall be applied as uniformly as possible over a length of bar equal to 10 bar diameters. The centre of the heated length shall be at the centre of the completed bend. The temperature shall be maintained consistent during bending and straightening operations and shall not exceed 350°C. Temperature measuring crayons or a contact pyrometer shall be used to determine the temperature. Care shall be taken to prevent quenching of the heated bars either by application of water, or by a high volume of air.

iv) Straighten bars shall be visually inspected before and after straightening to determine whether they are cracked or otherwise damaged. This is a **Notification Point.**

(e) Epoxy Coated Bars

i) The Contractor shall take all necessary precautions to minimise damage to the coating during off-loading, handling and fixing. All equipment used for handling of coated bars shall have padded contact areas. Coated bars or bundles shall not be dropped or dragged.
ii) Coated bars shall be stored separately to uncoated bars.
iii) Coated bars shall not be cut or bent on site without the prior approval of the Engineer. This is a **Hold Point.**

Cut ends and any damage to the coating shall be repaired in accordance with Clause 7.5.

iv) Coated bars shall be towered on epoxy coated wire chairs or on chairs of dielectric material.

7.5.6 Concrete Trial Mixes

Trial concrete mixes using representative materials shall be carried out under full scale conditions using the Contractor's proposed method subject to the Engineer's approval. In case of use of ready mixed concrete, trial mixes shall only be waived, if an earlier proven mix design is used.

Testing shall be carried out in accordance with BS EN 12350. Trial mix test specimens shall be prepared and tested at approved laboratory. Aggregate used in trial mix shall be collected from the source proposed by the Contractor and approved by the Engineer. The target mean strength of the trial mixes shall be specified concrete cube strength plus adequate safety margin as stated in BS / ACI standard.

To ensure the durability of the concrete, the requirements specified in Appendix 7.A6 shall be adhered to with regard to characteristic strength, minimum cement content slump requirement and maximum free water/cement ratio.

The tests shall be carried out on three different days during which the workability will be recorded and nine cubes made. Among the nine cubes, three will be crushed at seven days; three will be crushed at fourteen days and the remaining three at twenty eight days. This is a **Notification Point.**

7.5.7 Batching

The aggregate and cement shall be proportioned by means of efficient weigh batching machines. The machine shall be carefully maintained and cleaned and they shall be provided with simple and convenient means of checking the weighing mechanism and they shall be checked when required by the Engineer.

Batch materials, shall be measured out within the following tolerances and shall be discharged into the mixer without loss.

Cement - ± 2 percent of the mass of the cement in the batch.

Aggregate - ± 2 percent of the mass of each aggregate in the batch.

Admixtures - ± 5 percent of the amount to be added to the batch.

Mixing Concrete by Machine

The concrete is to be mixed in batches in machines which comply with the requirement of BS 1305. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposition in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their content while running.

7.5.8 Workability

The Contractor shall carry out slump or other workability tests as required during concreting of the works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes.

7.5.9 Blinding Concrete

Blinding concrete shall be provided under specified foundations to a minimum thickness of 75 mm.

7.5.10 Formwork

All formwork shall be accurately constructed to prevent loss of grout and to produce the correct foundation shape. Formwork shall be sufficiently strong to withstand the pressures arising from the concrete during placing and compaction and shall be capable of removal without undue disturbance to the concrete.

All form-work and moulds shall be of such tight construction that slurry cannot flow out at the joints during pouring and compaction. If required, joints shall be sealed with foam rubber strips.

Formwork shall be retained in position after concreting for a minimum period of 48 hours.

7.5.11 Placing and Compacting

Concrete shall normally be discharged from the delivery vehicle within two hours after the time of loading at the ready mix plant in accordance with the requirements of BS 8500 and BS EN 206. With the Engineer's approval these periods may be exceeded with the use of a suitable retarded and/or plasticizer, provided that there is no change in the quality of the concrete. Concrete must at all times -have the desired workability and characteristics at the point of placing. Any concrete which no longer meets this requirement shall be removed from site.

Placing by pump, conveyor or pneumatic method shall be subject to approval by the Engineer. There shall not be any loss of quality in the concrete, nor harmful effects to the works by such methods. Concrete pumps shall be operated by mechanically applied pressure and shall produce a continuous stream of concrete without air pockets.

Where pumps are used the velocity of discharge shall be regulated, by suitable baffles or hoppers where necessary to prevent segregation or damage and distortion of the reinforcement, embedded items and formwork, caused by impact.

When pumps are used on large or complicated pours a standby pump shall be provided.

Precautions shall be taken to avoid depositing water or grout in the Works during starting up operations, or in flushing, or clearing the pipeline. The pipeline shall pass its own length of concrete in not more than 20 minutes.

Chutes used to deliver concrete shall not be sloped so as to cause segregation of the mix.

Concrete shall be fully, compacted by vibration or other approved means and shall completely fill the shutter. Immersion vibrators shall be inserted in such a manner and at intervals as will ensure the satisfactory uniform compaction of the concrete. The vibrator shall penetrate the full depth of the layer and where the underlying layer of concrete has not initially set, they shall enter and re-vibrate the layer to ensure that succeeding, layers are well bonded together. Withdrawal of vibrators shall be such as to prevent the formation of voids. Piles of concrete within the formwork shall not be moved by immersion of the vibrator, nor shall segregation be caused by over vibration. Undue laitance or leakage through the formwork shall be avoided. It shall be fully, worked around reinforcement and other embedded items which shall not be disturbed. The Contractor shall provide standby vibrators.

The Contractor shall maintain records of daily returns of the quantity, concrete mix and location within the Works of all concrete placed. These shall be forwarded to the Engineer when requested.

7.5.12 Joints

Construction joints shall be made across planes of minimum shear and away from planes of maximum bending moments. Vertical construction joints shall be made against properly constructed stop boards firmly fixed and holed where necessary to pass reinforcement. To ensure bond between old and new concrete at construction joints, surfaces of the cast (old) concrete shall be cleaned of all defective concrete, latency, oil,

grease, dirt, loose concrete, etc. and shall properly be roughened by chipping, hammering or other techniques to expose the aggregates and provide sufficient key for the two layers.

The pad and chimney (for pad and chimney type foundations) shall normally be cast in one operation without construction joints. Where the formation of a joint is unavoidable the surface against which the fresh concrete is to be placed shall be prepared in accordance with Clause 6.12 of BS 81 10: Part 1. This is a **Notification Point.**

Construction joints in anchor or pile caps, monoblock and raft foundations shall be treated in similar manner to that described above. When the embedded reinforcement is insufficient to transmit the required design load, additional reinforcement in the form of 'starter' bars shall be provided. No construction joints are permitted in cast-in-situ concrete piles, drilled shaft or side bearing foundations.

7.5.13 Curing and Protection

Curing and protection shall start immediately after the compaction of the concrete and shall ensure adequate protection from:

(a) Premature drying out, particularly by solar radiation and wind;
(b) Leaching out by rain and flowing water;
(c) Rapid cooling during the first few days after placing;
(d) High internal thermal gradients;
(e) Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement or other embedded items.

Where curing compounds are used to protect exposed surfaces from solar radiation and improve moisture retention, they shall be subject to the approval of the Employer. This is a **Hold Point.**

The temperature of the fresh concrete at the time of delivery on site shall be in accordance with requirements of BS 8500 and BS EN 206.

7.5.14 Grouting of Anchor Tendons

The installation and subsequent grouting of anchor tendons shall be in accordance with the requirements of BS 8081 and BS EN 1537.

7.5.15 Drilled Shaft piled Foundations

Drilled shaft shall be installed and concreted strictly in accordance with the recommendations of BS 8004 Sub-clause 7.4.5 and as summarised below:

(a) To ensure drilled shafts remain uncontaminated with spoil, shafts shall be extended by 300 mm or a depth equivalent to the total pitch of the auger blades (excluding continuous flight augers) below the calculated depth of the auger;

(b) When shafts are installed using bentonite slurry techniques the stability of the sides of the shaft shall be maintained throughout the installation by an adequate head of bentonite slurry in conjunction with the temporary casing;

(c) Reinforcing cages shall be provided with roller spacers of an approved type to ensure that the minimum specified concrete cover is achieved, especially as regards the cover at the bottom of the shaft;

(d) The tremie pipe shall have a minimum diameter of 150 mm and shall be filled with an effective plug prior to charging with concrete;

(e) Effective means shall be provided for raising or lowering the tremie quickly by towering the hopper from a crane. The hopper shall have a minimum capacity equivalent to that of the tremie;

(f) The tremie shall always be kept full of concrete and shall adequately penetrate into the concrete to prevent accidental withdrawal if the pipe is surged to discharge the concrete.

Piled foundations shall be installed in accordance with the requirements of the IEC 'Specification for Piling'.

7.5.16 Stub Setting

Stubs shall be held firmly in position by a stub setting template or other device while the concrete is placed. This tower shall be maintained until backfilling of the foundation is complete, or for drilled shaft, anchor and pile caps, monoblocks, rafts etc until a minimum period of 48 hours has elapsed after concreting.

Concrete blocks may be used to tower the lower end of the stub, and they shall have similar strength and durability to the surrounding concrete.

Where holding bolt assemblies are used, setting templates shall be used and retained in position for a minimum of 48 hours.
Stub setting templates shall be used to maintain the position of steel grillage foundation is during backfilling.

7.5.17 Backfilling of Foundations

Backfilling shall be compacted in 300 mm layers to achieve a bulk density of 1.6 Mg/m3, or the value assumed in the design analysis (if this is less than 1.6 Mg/m3).

Commencement of backfilling, shall be a **Notification Point.**

During backfilling, the side sheeting to the excavation shall, where possible, be progressively withdrawn such that the toe of the sheeting, is never more than 600 mm below the surface of the compacted material.

Extreme care shall be taken by the Contractor during compaction to ensure that the foundation is not damaged nor caused to move out of position. During the placing of backfill the hole shall be kept free from water. All temporary timbering and all decomposable material shall be removed from the excavations prior to backfilling.

Refilling around the pile head pits shall be carried out only after all works within the excavations have been inspected and approved by the Engineer.

The Contractor shall select the compaction plant most suitable for achieving the required bulk density. Acceptable methods of compaction shall include, but not be restricted to, the use of vibrating plate compactor or diesel hand operated vibrating Wacker plate. The actual method of compaction selected will depend on the type of material to be compacted and the difficulty in accessing areas within the excavation.

Backfilling of the directly embedded pole annulus shall be undertaken using crushed rock aggregate in accordance with BS EN 12620, with a nominal maximum size of 40 mm.

7.5.18 Site Clearance

As soon as possible at each tower site, backfilling should be completed, surplus soil removed and the site cleared at the Contractor's cost. Final site clearance normally carried out at the same time as fitting of anti-climbing guards and danger and notice plates, shall be undertaken without delay. The Contractor shall be responsible for compacting and re-levelling ground to the original surface level and gradient. Where agreed by the Engineer a percentage of the spoil may be disposed of by local spreading and the balance, if any shall be removed from site.

7.5.19 Reinstatement of Working Areas

Reinstatement of all working, access and storage areas shall be the responsibility of the Contractor.

A programme for reinstatement works shall be submitted to and approved by the Engineer prior to the issue of the taking over certificate.

Reinstatement where specified shall include all necessary topsoil preparation, hydro-seeding and the planting of shrubs and trees to a standard at least equal to the condition of the site prior to construction. The sequence of work shall be such as to ensure establishment of all species and the age and state of growth of plants shall be such as to ensure successful replanting at site.

All such work shall be completed to the satisfaction of the Engineer and the relevant regulatory authorities.

7.5.20 Site Stabilisation

Where foundations are installed on sloping or unstable ground the Contractor shall be responsible for ensuring the stability of the area and the safety of the public, all to the satisfaction of the Engineer and local regulatory authorities.

Stabilisation shall be achieved by approved methods such as retaining walls, buttresses, sprayed concrete, rock bolts, dowels or gabion baskets/mattresses.

Site assembly of gabion baskets and mattresses shall be carried out in accordance with the manufacturer's instructions. Gabions shall be placed in position prior to filling and secured to adjoining gabions with lacing wire. Filling material shall be between 100 and 150 mm; 90 percent of the fill to be retained on a 100 mm ring. The fill shall be tightly packed with no apparent voids, and shall be overfilled by 25-50 mm to allow fat settlement lids shall be laced immediately after filling.

Where necessary to prevent erosion and as stipulated by the Engineer, or the appropriate authority, surface drainage channels shall be provided; surge chambers stopped ends and sub lets shall be formed as required. Where surface vegetation has been removed from sloping ground such that erosion could occur the area shall be reinstated by planting of grasses using hydro-seeding methods or band sprigging.

7.5.21 Site Protection

Where specified tower legs or foundations are in areas open to vehicle access, the Contractor shall install barriers of a type approved by the Engineer to prevent vehicle coming into contact with the tower or foundation.

7.5.22 Protection of Tower and Tower Footing

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

The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank/ bed, undulated terrain, protection of up hill/ down hill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with M-15 concrete (1:2:4 mix). Contractor shall recommend protection at such locations wherever required. Details of protection of tower/tower footing are given in drawing enclosed with these specifications for reference purpose only.

Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift.

The unit rate for backfilling quoted in BPS shall include the required lead and consolidation and leveling of earth after backfilling.

The Contractor has to assess the quantities for protection work of foundations, cost of which shall deem to be included in the Price Schedule.

No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

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

7.5.23 Earthing

The maximum tower footing resistance with earth wires disconnected shall be 5 ohms. Earthing shall be provided with two diagonal legs of each tower as shown in enclosed drawing. If additional earthing is required, additional earthing conductor shall be attached to the tower at the earthing holes specified and shall be sufficiently buried to prevent accidental excavation. The amount of earthing conductor to be buried or earthing rods installed will be dependent upon achieving the required footing resistance.

The excavation for the earthing conductor shall be 400 mm wide and not less than 800 mm deep in cultivated land where required by the Employer. The earthing conductor shall be laid at a depth of approximately 700 mm, being placed centrally in the trench. The trench shall be backfilled with a suitable medium.

The connection between the additional earthing conductor and tower leg shall be by approved thermo-weld joints.

Where necessary in areas of high resistance 90 mm diameter holes shall be drilled along the tower diagonal, each having, an earthing rod surrounded by a Bentonite/ sodium carbonate mix. The depth of hole depending on the resistance of the soil. The earth rod shall comprise standard rods coupled together and connected back, to the tower leg.

For towers within 150 m of a substation and connected to the substation earthing system, no additional earthing, will normally be required.

7.6 PROTECTIVE TREATMENT

7.6.1 Galvanising

All stub steelwork, pole sections and holding down bolts shall be protected by hot-dipped galvanising to comply with the requirements of BS EN ISO 1461.

7.6.2 Epoxy Coal Tar Paint

All directly embedded pole sections, steel pile and caisson sections, guy anchor rods shall be protected by two coats of epoxy coal tar paint. For steel pile sections, this treatment shall only apply to the initial 2 in below final -round level.

7.6.3 Epoxy Coated Reinforcement

Coating, damaged during transit handling or fixing shall be repaired only with the approved repair compound supplied, to ensure compatibility with the Fusion Bonded Epoxy Coating. All repairs shall be carried out strictly in accordance with the manufacturer's instructions.

When the extent of the coating damage on any metre length of bar exceeds 1% of the surface area, the bar shall be rejected. This is a **Notification Point.**

7.6.4 Tower Steelwork and Stub-Concrete Interface

After curing has been completed all exposed concrete above ground level and 300 mm below ground level shall be coated with Coal Tar Epoxy coating applied by either conventional spraying or brushing to give a minimum dry film thickness of 300 µm. The surface of the concrete shall be allowed to cure for at least 28 days prior to surface preparation unless otherwise agreed with the Engineer. After adequate curing all surface laitance, dirt and other contaminants shall be removed. Prior to the application of the coating, cracks in the concrete greater than 2mm in width and surface irregularities, including blow holes, with a depth greater than 10mm, shall be filled with a proprietary fairing coat compatible with the coating system. The surface of the substrate shall be prepared in accordance with the coating manufacturers recommendations. Primers where necessary, shall be obtained from the same manufacturer as the top coat.

All tower steelwork below the maximum anticipated flood level shall be protected by Coal Tar Epoxy coatings. All steelwork to a minimum height of 3m above ground level shall be protected by factory application with the remainder applied on site, including the stub above concrete level.

For factory application the galvanised steel members should be blast cleaned to a minimum Sa2 standard BS 7079 using a fine grade mineral blasting medium. The coating shall be applied by either conventional spraying or brushing to give a minimum dry-film thickness of 300 µm. Prior to application, the Coatings Applicator shall submit procedures for coating, application and quality control measures for approval by the Engineer. This is a **Hold Point.**

The method of application of the coating system shall be in accordance with the approved procedures and manufacturer's instructions. The contractor shall ensure that the proposed coverage rates will enable the specified minimum dry film thickness of each coat to be attained. Wet film thickness gauges shall be used to check the thickness of the applied coating.

Each application of the coating shall be generally free from surface defects, particularly catering, pin-holing, ravelling, and sagging, battiness, and dry spray and cussing. The finished system shall have a uniform appearance.

For site application the same procedure shall be adopted except that use of a 'etch primer' instead of blast cleaning on site will be permitted. The 'etch primer' must be obtained from the same supplier as the coating and applied strictly in accordance with the manufacturers instructions including the cleaning and decreasing of the tower steelwork on site.

7.6.5 Earthing Material

Steel earth rods shall be clad with 99.9 percent electrolytic pure copper molecularly bonded to the steel, with a minimum thickness of 0.35 mm. The earthing conductor at the ground interface and at the connection to the tower shall be protected against corrosion.

7.6.6 Protection of Buried Steelwork

Where it is necessary for tower steelwork to be buried, it shall be buried not more than 1.0 m and shall be protected by an approved medium e.g. mastic impregnated tape or bitumastic paint. Details of the proposed materials, application and Quality Control procedure shall be submitted to the Engineer. This is a **Hold Point.**

7.7 QUALITY CONTROL

7.7.1 General

Type, sample and routine tests shall be undertaken on all materials used in the construction of the foundations, and where appropriate on the complete foundations, or parts of the complete foundation in accordance with the requirements of this Specification.

7.7.2 Bentonite Slurries

Bentonite slurries used to tower the sides of the drilled shaft foundations shall be prepared and controlled in accordance with the recommendations of BS 8004 Clause 6.5.3.8 and as summarised below:

(a) Bentonite shall be supplied in accordance with the Oil Companies Materials Association Specification No. DFCP4;
(b) After mixing, with clean fresh water the fully hydrated bentonite slurry shall have a density of less than 1. 10 g/ml, a viscosity as measured by the Marsh cone between 30s to 90s and a 10 minute gel strength in the range of 1.4 to 10 N/m2;
(c) Immediately prior to concreting, the density of the slurry at a level of 200 mm above the bottom of the shaft shall be less than 1.5 g/ml;
(d) The pH value of the slurry shall be maintained within the range of 9.5 to 12.

7.7.3 Reinforcement

All reinforcement shall be supplied from approved suppliers, complete with the appropriate test certificates in respect of the test requirements of BS 4449 or BS 4483 as appropriate. Copies of these certificates shall be made available to the Engineer upon request. Where test certificates are not available the Contractor shall arrange for the tests to be undertaken in accordance with the specified standards.

7.7.4 Inspection Prior to Concreting

The Contractor shall give the requisite period of notice to the Engineer of his intention to commence any concreting and shall submit at the same time a record of his inspection of completed preparatory works, which shall include all works related to the fixing of reinforcement. This is a **Notification Point.**

7.7.5 Trial Mixes

A trial mix will be approved when the requirements of BS 8500 and BS EN 206 are met. Copies of the trial mix test results shall be submitted to the Engineer.

7.7.6 Workability

The Contractor shall carry out slump or other workability tests as required during concreting of the works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mix.

Slump tests shall be carried out in accordance with the procedure laid down in BS EN 12350-1. A slump test will be accepted as complying with the Specification when the results are within the following limits:

±25 mm or ± one third of the required value, whichever is the greater.

7.7.6.1 Works Cubes

Compliance with the specified characteristic strength shall be based on tests made on cubes at twenty eight days. Cubes shall be made, cured and tested in accordance with BS EN 12350-1. Samples of Concrete shall be taken at the point of discharge from the delivery vehicle.

Unless otherwise directed by the Engineer one set of cubes shall be prepared for each $6m^3$ of concrete placed or tower foundation subject to one set of cubes being formed on each day that concreting is carried out or tower pile foundation subject to one set of cubes being formed on casting of each pile.

One set of cubes consisting of four test cubes shall be made from the working concrete.

In preparation of test cubes/specimens vibrators shall not be used.

Concrete shall be tested for slump at every 1 hour interval.

Each set of cubes shall be accompanied by a certificate noting the details required by BS EN 12350-1.

Cubes shall be tested in accordance with BS EN 12350-1 to determine the density and characteristic strength as follows:

(a) One cube shall be tested at seven days to provide an early indication as to whether the twenty eight day strength is likely to be achieved;
(b) Two cubes shall be tested at twenty eight days, the average strength shall be deemed the test results;
(c) One cube shall be held in reserve for further testing, if required.

The test report shall provide information in accordance with BS EN 12350-1.

Concrete shall be assumed to have achieved its characteristic strength when, at twenty eight days, the conditions specified in BS 8500 and BS EN 206 are met.

Copies of the test reports shall be made available to the Engineer on a regular basis. This is a **Notification Point.**

The Employer will consider whether the concrete in the Works represented by cubes falling below the limits laid down can be accepted, and he may order that any or all of the following, actions shall be taken:

i) Penetration resistance or surface hardness tests;
ii) The drilling of test cylinders in the concrete and testing the samples to destruction by compression;
iii) The cutting out and replacement of such volumes at their discretion which they consider to be defective;

7.7.7 Setting Out Tolerance

Towers shall be centre-pegged with a displacement along the line of the route not greater than 2 in relative to the profile, and to a displacement in transverse alignment not greater than 50 mm relative to a theoretical line adjoining the adjacent angle pegs.

7.7.8 Foundation Setting Tolerances

The maximum permitted stub tolerances measured at the top of the stubs shall be as detailed in Table 7.1 and are to apply immediately prior to erecting the tower. Should these tolerances not be achieved the Contractor shall submit details of his proposed remedial measures to the Engineer for approval. This is a **Hold Point.**

Records of the foundation setting out measurements shall be made available to the Employer.

Table 7.1 - Foundation Setting Tolerances

Principal Dimension	Tolerance
Nominal face dimension	10 mm or ± 0. 1% of face dimension (whichever is greater)
Nominal diagonal dimension	± 15 mm or ± 0. 1% of diagonal dimension (whichever is greater)
Rake of stub from required face or hip slope	1:100
Stub level	
(a) Maximum difference in level between all dimension (whichever is greater)	10 mm or 0.05% of diagonal four stubs of a foundation
(b) Maximum difference between the mean levels of pairs of diagonally opposite stubs	±6mm
Twist of stub in plan	1˚ about longitudinal axis

7.7.9 Backfilling

Testing of the backfill to ensure that the design value of soil bulk density is achieved may be undertaken using an approved penetrometer. Results of the tests shall be made available on request to the Engineer. However, the Engineer reserves the right to request the Contractor to undertake in-situ density tests in accordance with-BS 1377 Part 9 as necessary.

Where imported back-fill is required the following details shall be supplied to the Engineer:

(a) the type of fill
(b) evidence that when compacted a bulk density consistent with the value assumed in the design can be achieved.

7.7.10 Foundation Tests - General

When requested by the Engineer full scale foundations tests both design and routine/proof shall be undertaken on all types of foundations.

Tests shall unless specified otherwise be undertaken in accordance with IEC 61773.

When design tests are required, the sites selected shall be representative of the geo-technical conditions throughout the length of the transmission line, in which the Contractor proposes to install that type of foundation.

The Contractor shall submit to the Engineer the following information:

(a) Details of the test sites, including all geotechnical parameters;
(b) Details of the proposed test equipment, test layout, measuring equipment, test procedure and the test program. This a **Hold Point.**
(c) On completion of the design tests the requisite number of test reports shall be submitted to the Engineer.

The ultimate resistance of the foundation shall unless otherwise specified be determined from the lesser of:

i) the resistance equivalent to a temporary displacement of 25 mm or,
ii) the resistance equivalent to a permanent displacement of 10 mm.

Reports on pile testing shall be submitted to the Engineer and shall contain, among others, the following information:

(a) Layout of test equipment and description
(b) Pile identification, diameter and length
(c) Sketch of soil conditions and ground water location
(d) Complete records of level, load cell and dial gauge readings against date and time throughout the test in a tabulation
(e) Graphs of load and settlement/heave versus time
(f) Graphs of settlement/heave versus load
(g) Remarks concerning any unusual occurrences during the loading of the pile.

(h) 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.

The Engineer will decide on completion of tests and evaluations whether the test piles shall be left in place or shall be extracted. No extra payment will be made for the extraction of test piles.

7.7.11 Concrete Pad & Chimney Foundation - Tests

Unless otherwise specified only design uplift tests on pad and chimney foundations shall be undertaken.

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Hold Point.**

7.7.12 Piled Foundation - Tests

Unless specified to the contrary, design uplift and compression tests on piled foundations (service piles selected by Employer) shall be undertaken. The Contractor shall give the Engineer testing procedure for approval and the requisite period of notice prior to undertaking the tests. This is a **Hold Point.**

The tested pile shall be deemed to comply with its specified ultimate load when, after the load is held for at least 30 minutes, the following criteria are satisfied:

i) The displacement at the head of the pile is less than 25 mm or
ii) The movement of the head of the pile shall be slowing down and less than 0.25 run/hour
iii) The displacement at the head of the pile after all load is removed (after 10 minutes) is less than 10 mm.

7.7.13 Integrity Testing

Integrity tests shall be performed on drilled shaft concrete piled foundations selected by Employer for checking the uniformity, continuity and length of such piles using the acoustic pulse echo method shall be undertaken by a specialist subcontractor appointed by the Contractor. Details of practical experience of the subcontractor along with details of the test equipment, procedure of testing, presentation of test data/results shall be submitted along with tender. The integrity test shall be done at least one time for one pile of each leg selected by the Engineer. The actual method of performing the tests and the interpreting the results shall be subject to the Engineer's approval. This is a **Hold Point.**

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Notification Point.**

The results of the integrity testing shall be made available to the Engineer upon request.

7.7.14 Earthing Resistance Test

Earth electrical resistance tests shall be undertaken at each tower prior to the erection of the earth wire. The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Notification Point.**

On sites subject to seasonal variations in the rainfall, or the level of the water table and sites requiring special earthing arrangements additional earth resistance tests shall be carried out at intervals to establish the affects on the resistance of such seasonal variations.

The method of measurement and equipment to be used shall be subject to the approval of the Engineer. This is a **Hold Point.**

The results of the earth resistance tests both initial and final i.e. after additional earthing has been installed shall be forwarded to the Engineer.

7.7.15 Protective Coatings

Where protective coatings are applied to buried tower steelwork or to exposed concrete surfaces, appropriate routine tests to demonstrate the quality of application shall be undertaken.

The Contractor shall submit to the Engineer his routine test proposals.

This is a **Hold Point.**

The Contractor shall give the Engineer the requisite period of notice prior to undertaking the tests. This is a **Notification Point**. The results of the tests shall be made available to the Engineer upon request.

7.8 RATES AND MEASUREMENT

7.8.1 Open cast Foundation

7.8.1.1 The bidder is required to quote the unit rates for foundations including all activities such as excavation for different types of soils, concreting, supply and placement of reinforcement steel and stub setting etc. in the Price Schedule.

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

7.8.1.3 Not used.

7.8.1.4 Form boxes shall be used for casting of foundations. The rate of founation shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related / required for completion of concreting works of foundation.

7.8.1.5 The rate of foundation shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. The cost of wastage overlaps, spacer bars, chairs, stays, hanger and annealed steel wire shall deem to be included in the rates for foundation.

7.8.1.6 The unit rate of foundation shall be considered include all the activities (either mentioned abobe or not) required for completing the foundation.

7.8.2 Pile Foundation

7.8.2.1 Excavation

7.8.2.1.1 The rate for excavation shall be included in rate for foundation as shown in the Price Schedule. The unit rate of foundation quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job.

7.8.2.1.2 Not used.

7.8.2.1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

7.8.2.2 Cement Concrete

7.8.2.2.1 Actual volume of work as executed or as per drawing issued, whichever is less, measured in cubic meter corrected up to second place of decimal shall be considered for payment as per unit rate quoted in BPS. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sq.m. in area (for each opening) .

7.8.2.2.2 The rate shall include cost for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

7.8.2.2.3 The rate shall also include the volume for structural concrete and lean concrete.

7.8.2.3 Form Work

7.8.2.3.1 The rate of foundation shall include the cost of formworks of different types / shape.

7.8.2.3.2 Not used.

7.8.2.3.3 Not used.

7.8.2.3.4 The rate shall include the cost for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

7.8.2.3.5 The rate shall also include the cost for using fillets for rounding of chamfering junctions, corners, etc.

7.8.2.4 Back filling

The rate shall include the cost of all the necessary backfilling operations required to complete the work as per drawing & Specifications stated in this section.

7.8.2.5 Reinforcement Steel

7.8.2.5.1 The unit rate for foundation shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, and transportation to site by appropriate means as required. The measurement for payments shall be made as per foundation of tower basis. The unit rate for foundation quoted shall be inclusive of all wastage.

7.8.2.5.2 The rate shall be includive of cost of Standard hooks, cranks, bends, authorised laps, etc.

7.8.2.5.3 Not used.

7.8.2.5.4 No extra payment shall be made for supports, spacers, chairs, hangers, etc. of height/length of 300mm and less, required for keeping the steel in position. For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer.

7.8.2.5.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

7.8.2.5.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

7.8.2.6 Piling work

7.8.2.6.1 The various items in the Price Schedule shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

7.8.2.6.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

7.8.2.6.3 Unit rates shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

7.8.2.6.4 Unit rate of foundation shall remain unchanged irrespective of the diameter and depth of pile executed at any location.

7.8.2.6.5 Unit rate for foundation through all kind of soil, including weathered rocks, laterite, shell, hard rock shall be inclusive of bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/debris etc. and disposing same along with the drilling mud up to a distance of 2 kms., flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.

7.8.2.6.6 Unit rate for foundation through soil including weathered rocks, laterite, shell, hard rock shall inclusive of shifting of plant and equipment from one pile location to another location, providing temporary casing as required and removal of the same after completing concreting. The quoted unit rate shall also be inclusive of the empty boring and extra concreting required above the pile cut off level.

7.8.2.6.7 Unit rate of foundation through soil including weathered rock / laterite shall also inclusive of chiseling, if any required, the chiseling through rock in the pile below socketing horizon up to the specified level shall be inclusive of bailing out the pile bore debris/spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/mud up to 2 kms., flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.

7.8.2.6.8 Unit rate shall include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up to a distance of 2 km.

7.8.2.6.9 Unit rates shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.

7.8.2.6.10 The rate quoted for foundation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.

7.8.2.6.11 Not used.

7.8.2.7 Pile Integrity Test

The actual quantity of pile integrity test done shall be calculated in nos. and the unit rate quoted shall be include all necessary equipments, manpower, labor, materials, operations etc. required to complete the work as per clause 7.7.13 of this section. The payment shall only be made after successful completion of the job and submission of complete report for each no. of test.

7.8.2.8 Piled Foundation - Tests

The actual quantity of pile load test done shall be calculated in nos. and the unit rate quoted shall be include all necessary equipments, manpower, labor, materials, operations etc. required to complete the work as per clause 7.7.14 of this section. The payment shall only be made after successful completion of the job and submission of complete report for each no. of test.

APPENDIX 7.A1

NOT USED

APPENDIX 7.A2
NOT USED

APPENDIX 7.A3

NOT USED

APPENDIX 7.A4
NOT USED

APPENDIX 7.A5
NOT USED

APPENDIX 7.A6

CONCRETE MIX PARAMETERS

Grade of Concrete	**Cement Type**	**Minimum Cement Content kg/m^3**	**Maximum Freewater/ cement ratio**
C30	Ordinary Portland Cement (OPC)	370	0.5
C30	Prozzolana Portland Cement (PPC)	370	0.5
C30	Sulphate Resisting Portland Cement (SRC)*	As per BSEN 197-1 CEMII/B-V	

Notes

1. Maximum nominal aggregate size 20mm.
2. For installation of drilled shaft piled foundations using bentonite slurries, minimum cement content shall be increased to 400 kg/m^3
3. Slump range for cap and chimney is 50 mm to 100 mm and for pile 150 mm to 200 mm.

***** If required as per soil and ground water test report.

APPENDIX 7.A7

CONCRETE COVER

Aggressiveness Sulphate Class (1)	**Reinforcement (mm)**	**Stub Steelwork or Reinforcing Designed as 'Stub' Steelwork (mm)**
5	100	150

APPENDIX 7.BI

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

Clause Reference	Documents Description	Comment
7.1.2	Installation Method Statement	
7.1.4.2	Drilled Shaft foundation Method Statement	
7.1.2	River Crossing Tower Foundations Method Statement	
7.4	Concrete Specification	
7.4.2	Potential Alkali Reactivity-Test Results	
7.4.4	Reinforcing Bar Couplers	
7.4.5	Spacers	Details of system
7.5.19	Working area reinstatement	Programme of work
7.6.6	Protection of Buried steelwork	Quality Control proposals
7.7.3	Reinforcement - test certificates	If requested
7.7.4	Inspection prior to concreting	Inspection record
7.7.5	Trial mixes – Test results	
7.7.6.1	Works cubes – Test results	
7.7.8	Foundation Incorrect setting,	Remedial Measure
7.7.8	Foundation Setting out-records	
7.7.9	Imported backfill – detail	
7.7.10	Foundation Tests – test proposal	
7.7.10	Foundation Tests – test results	
7.7.10	Integrity Testing – test records	If requested
7.7.14	Earth Resistance Tests – test records	
7.7.15	Protective coating – Routine tests	
7.7.15	Protection coatings – test records	If requested

APPENDIX 7.Cl

NOTIFICATION AND HOLD POINTS

Clause Reference	**Notification Points**	**Hold Points**
7.1.2		Method statement
7.1.4.2		Drilled Shaft - Method statement
7.2.3.1		Concrete Mix Design -Specification
7.4.2		Potential Alkali Reactivity
7.4.4		Reinforcing Bar Couplers
7.5.4	Use of Explosives	Use of Explosives
7.4.5	Spacers	
7.5.5		Epoxy bars site cutting
7.5.5	Straightening of bars	
7.5.13		Curing compounds
7.5.6	Concrete Trial mixes	
7.5.12	Joints	
7.6.4		Steelwork and stub-concrete Interface
7.5.17	Backfilling	
7.6.6		Protection of buried steel work
7.6.3	Epoxy Coating repair	
7.7.8		Foundation Setting remedial measure
7.7.4	Inspection prior to concreting	
7.7.10		Foundation test program
7.7.6.1	Concrete cube tests	
7.7.11		Concrete pad & chimney foundations – Design tests
7.7.12		Drilled shaft foundations tests
7.7.13	Integrity testing	Integrity testing - test proposals
7.7.14	Earth resistance tests	Earth resistance tests –Test proposals
7.7.15	Protective coating tests	Protective coating – test proposals

APPENDIX 7.Dl

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

BS EN 197-1:	Specification for Portland cement
BS 183:	Specification for general purpose galvanised steel wire strand
BS EN 10244-2:	Specification for testing zinc coating on steel wire & for quality requirements
BS EN ISO 1461:	Specification for hot dip galvanised coatings on iron & steel articles
BS EN 12620:	Specification for aggregates from natural sources of concrete
BS EN 10083,4,5:	Specification for wrought steel for mechanical and allied engineering purposes
BS EN 10088	
BS EN 10089	
BS 1305:	Specification for batch type concrete mixers
BS 1377:	Method of tests for soils for civil engineering purposes
Part 9:	In-situ tests
BS EN 12350-1:	Testing concrete
	Method of sampling fresh concrete on site
BS EN 12390-3:	Method of determining compressive strength of concrete
BS EN 13600:	Specification for high conductivity copper tubes for electrical purposes
BS EN 1652,3,4:	Specification for rolled copper and copper alloys, sheet, strip and foil
BS EN 1057:	Specification for copper and copper alloys. Tubes
BS EN 12449	
BS EN 12163, 4,7:	Specification for wrought steel for mechanical and applied engineering purposes.
BS 3643:	ISO Metric screw threads
BS 3892:	Pulverised - fuel ash
Part 1:	Specification for pulverised - fuel ash for use Alith Portland cement
BS 4027:	Specification for sulphate - resisting Portland cement
BS 4190:	Specification for ISO metric black hexagon bolts, screws and nuts
BS 4449:	Specification for carbon steel bars for the reinforcement of concrete
BS 8666:	Specification for scheduling, dimensioning, bending & cutting of steel reinforcement for concrete
BS EN ISO 4066	
BS 4483:	Specification for steel fabric for the reinforcement of concrete
BS 8500-1,2:	Concrete
BS EN 206-1	Guide to specifying, concrete
	Methods for specifying concrete mixes
	Specification for the procedure to be used in producing, and transporting concrete
	Specification for the procedure to be used in sampling, testing and assessing compliance of concrete
BS 7079	Visual Assessment of surface cleanliness
Part A1	Specification rust grades and preparation grades of uncoated steel substrates and steel substrates after overall removal of previous coatings.
BS ISO 14654:	Fusion bonded epoxy coated carbon steel bars for the reinforcement of concrete
	Specification for coated bars
BS ISO 14656:	Specification for coatings
BS 7884:	Specification for copper and copper cadmium stranded conductors for overhead electric traction and power transmission systems.
BS 8004:	Code of practice for foundations
BS 8081:	Code of practice for ground anchorage
BS EN 1537	
BS 8110:	Structural use of concrete

Part 1:	Code of practice for design and construction
BS EN 10025:	Specification for hot rolled products of non-alloyed structural steels and their technical delivery requirements
ASTM C33:	Specification for concrete aggregates
ASTM C227:	Standard Test Method for Potential Alkali Reactivity of cement/aggregate combinations (Mortar bar method)
ASTM C289:	Standard Test Method for Potential Alkali Silica Reactivity of Aggregates (chemical method)
IEC 61773:	Overhead lines – Testing of foundations for structures

ANNEXURE - B

PILE DATA SHEET

1. Reference No. Location (Co-ordinates)_____ area.

2. Sequence of Piling

3. Pile diameter & Type

4. Working level (Platform level)

5. Cut off level (COL)

6. Actual length below COL

7. Pile termination level

8. Top of finished concrete level

9. Date and time of start and completion of boring

10. Depth of Ground water table in the vicinity

11. Type of strata at pile tip

12. Method of boring operation

13. Details of drilling mud as used :

    i) Freshly supplied mud

    liquid limit
    sand content
    density
    marsh viscosity
    Swelling index
    pH value

    ii) Contaminated mud
    density
    sand content

14. SPT, N values in soil (from the nearest bore hole). UCS value in rock (from the nearest bore hole).

15. Chiseling if any, from....m to.....m.

16. Date and time of start and completion of concreting

17. Method of placing concrete

18. Concrete quantity :

    Actual
    Theoretical

19. Ref. Number of test cubes

20. Grade and slump of concrete

21. Results of test cubes

22. Reinforcement details :

Main Reinforcement	Stirrups : Type
No._____	No._____
Dia_____	Dia_____
Depth_____	Spacing_____

23. Any other information regarding constructions, delay and other interruption to the sequence of work.

NOTE : The above details are required to be furnished by the Contractor before starting the installation work.

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT

FOR THE PROCUREMENT OF

PACKAGE-1: DESIGN, SUPPLY, ERECTION, TESTING & COMMISSIONING OF 132KV TRANSMISSION LINES AND SUBSTATIONS ON TURNKEY BASIS

LOT-1: TRANSMISSION LINES

SECTION 8

TOWERS

SECTION 8

TOWERS

8.1SCOPE

The general description of towers applicable for the package and technical particulars there of are indicated in Section 1 of this Specification.

8.1.1 Classes of Towers

Reference shall be made to Appendix 8.A1 for the classes of tower required.

8.1.2 Designation of Tower Types

Reference shall be made to Appendix 8.A2 for the designation and use of the different tower types.

8.1.3 Standard Height Towers

All standard height towers are those designed to support the conductors at the defined clearance above designated ground under the specified ultimate limit state system loading assuming such towers are at the same level on level ground and at the standard span apart.

Unless specified to the contrary, after taking account of the length of the insulator set all standard height towers shall be arranged so that the point of attachment or suspension of the phase conductors above the ground shall be the same for all tower types.

8.1.4 Extensions

Where specified each type of tower shall be designed to allow for variations in height. Towers with any specified combination of extensions to the standard height tower, shall be capable of carrying all required phase conductors, earthwires, insulator sets and fittings under the specified system loading.

Reference shall be made to the Appendix 8.A3 for the range and type of extensions to be used. Tower with different leg extensions shall be used as per requirement of the route. Where individual leg extensions are specified for lattice steel towers they shall be directly inter-connectable and fully compatible with the basic tower body and all specified body extensions.

8.1.5 Span Criteria

The span lengths specified in Appendix 8.A4 shall be deemed to be the horizontal distance between centre lines of adjacent support. When a span in excess of the specified maximum span is unavoidable, advice on the application should be obtained from the Engineer.

All angle Towers when used with the corresponding maximum angles of deviation and all intermediate type Towers shall be used so that the sum of the two adjacent spans stated in Appendix 8.A4 is not exceeded, provided that no single span length exceeds the specified maximum. Designs shall allow for

the adjacent spans of the maximum specified length with one of the spans at the maximum allowed for a single span.

Section type tower may be used at straight line positions where necessary for uplift conditions or for sectioning and tensioning of the phase conductors and earthwires in a straight run of transmission line route.

Angle Towers shall be suitable for minimum weight spans combined with maximum wind span through the full angular range of line deviations for which the angle Towers are designed.

8.1.6 Minimum Conductor Weight at Intermediate Tower

The total weight supported by any intermediate tower suspension insulator set shall not be less than the specified percentage (see Appendix 8.A4) of the total weight of the corresponding phase conductors in the two adjacent spans. This condition shall apply under the specified loading conditions.

8.1.7 Angle Towers

For angle Towers at the mean angle of deviation, the mean horizontal separation between circuits shall not be less than that of an intermediate type support.

For bundled phase conductors the phase conductor attachment points on each crossarm/gantry shall be arranged to ensure that the nominal horizontal separation between sub-conductors at the tension joint (dead end), is not reduced by more than 25 mm.

8.1.8 Terminal Towers

Terminal Towers shall provide the corresponding separation at the specified line entry. Additional phase conductor attachment points shall be provided at the specified angles of entry. Additional crossarms for down-leads or for use in junction arrangements with full phase tension shall be provided when specified.

8.2 DESIGN AND DRAWING

8.2.1

(i) The hard copies of available proto type load tested tower's structural and shop drawings will be provided to the Contractor by the Employer. However, if the available drawings are found to be incomplete or lacking information, the Contractor is required to prepare additional structural and shop drawings or make correction of existing drawings and that have to be prepared by the Contractor without any additional cost. The Contractor shall inform the Employer before any change/modification/addition of such drawings. The Contractor is required to prepare soft copies of all the drawings (structural and shop drawings) in AutoCAD and provide Employer complete set of all structural and shop drawings in hard copy and soft copy (AutoCAD version). Bidders are requested to inspect the available drawings in the Design Dept. of PGCB to satisfy them regarding the extent of available drawings.

(ii) The tower members may be directly fabricated from the structural/erection drawings wherever the required fabrication details are provided on the same or shop fabrication drawings. However, if the contractor is required to prepare structural/shop fabrication drawings, of their

own, in addition to the structural/ erection drawings with required fabrication details, they may prepare the same without any additional financial implication to Employer. Before taking up mass fabrication, the Contractor shall arrange for one number proto-assembly for each type of towers and extensions which shall be inspected by Employer. The rates for proto assembly of towers along with its extensions are to be quoted separately as given in the SCHEDULE OF PRICE**.** After assembly inspection, the Contractor shall incorporate revisions in the drawings / documents if any on account of proto corrections, and make necessary endorsement with reference to the respective packages / Letter of Awards. The Contractor has to clearly mention on the existing drawing whatever changes/modification has been made by them and they have to provide a list of such changes/modification to the Employer. The revised drawing/documents shall be submitted in 3 (three) copies for final approval by the Employer.

Bidders are requested to propose the tower materials from a manufacturer who will use the same material standard as mentioned in the tower drawings to avoid complicacy during execution stage.

In case the bidder proposes materials as per Standard other than the Standard mentioned in the drawings, they may propose equivalent or higher size member. In that case, they have to submit their proposed Standard in Original language and in authenticated English translation during execution of the Contract. A tower wise and drawing-wise change list is also to be submitted during execution for checking and acceptance of such changes by the Employer.

Same procedure shall be followed in case a material is not available in the market during execution.

All costs, of such modification of towers, shall be borne by the Contractor. In case of any impact is envisaged on foundation reaction due to above, the extra cost due to increased foundation volume, shall also be borne by the Contractor.

(iii) All the drawings shall have a proper name plate clearly displaying the name of EMPLOYER on right hand bottom corner. The exact format of the nameplate shall be handed over to the successful bidder for incorporation of the same on all the drawings. Also all the drawings shall carry the following statement and shall be displayed conspicuously on the drawing:

<u>WARNING</u>: THIS IS PROPRIETORY ITEM AND DESIGN RIGHT IS STRICTLY RESERVED WITH EMPLOYER. UNDER NO CIRCUMSTANCES THIS DRAWING SHALL BE USED BY ANYBODY WITHOUT PRIOR PERMISSION FROM THE EMPLOYER IN WRITING.

(iv) While submitting the structural drawings, bill of materials, shop drawings and any other drawings pertaining to the subject transmission line, the Contractor shall clearly indicate on each drawing EMPLOYER Specification No., Name of the specific Transmission line and project, letter reference no. and date on which the submission are made. The same practice is also to be followed while submitting distribution copies.

It may be mentioned here that the drawings, to be provided to the Contractor, has already been sealed and signed by the Employer. The Contractor may submit the same drawing by correcting the Contractor's name, Project name etc. if agreed by the Employer to save time during execution.

(v) The tower accessories drawings like Number plate, Danger plate, phase plate, Circuit Plate and Step Bolt have been standardized and are enclosed in drawing section of this specification. The contractor is required to submit distribution copies of the above drawings after endorsing the name of the projects. However drawing of Anti-climbing device, D-shackle etc. shall be prepared by the Contractor and shall be submitted to the Employer, in three (3) copies for approval. This drawing shall be prepared in A4 size only.

(vi) The drawings submitted by the Contractor shall be approved/commented by the Employer as the case may be within fifteen (15) days of receipt of drawings in his office. If the designs/drawings are commented by the Employer, the Contractor shall submit revised design/drawings duly incorporating all comments within fifteen (15) days of date of issue of comments. The Contractor shall submit 15 copies of all approved structural drawings and BOM for tower extensions as well as for tower accessories for further distribution by the Employer.

The Employer will not approve the shop drawings. However, after the successful proto assembly test, the shop drawings shall deem to be approved. The Contractor shall, then, provide the Employer complete sets of soft copy (Auto CAD) and hardcopies of the drawings for reference purpose. The overall responsibility of fabricating tower members correctly lies with the Contractor only and the Contractor shall ensure that all the tower members can be assembled/ fitted while erecting without any undue strain on them**.**

(vi) Other than the items indicated above some other drawings and documents, such as BOM, Shop drawings, structural drawings for towers/extensions based on single line diagram given by the Employer, which are required for the project, shall also be developed by the Contractor. However, no extra cost on this account shall be payable to the Contractor.

(vii) As the tower drawings are being provided by the Employer, the Bidder's are requested not to quote any price against tower design in the Price Schedule.

(viii) The foundation reaction forces for these towers are hereby provided in Appendix 8.E1. These shall be used for foundation design for the respective towers during Contract execution.

8.2.2 Attachments to Towers

The attachment of phase conductors, earthwires and erection/maintenance brackets shall be undertaken as follows;

(a) Intermediate Lattice Steel Towers

i) Suspension insulator set and earthwire attachments shall be of an approved swivel or shackle arrangement;

ii) Adjacent to and either side of all suspension insulators set attachment points, additional maintenance points shall be provided, capable of resisting the specified construction and maintenance (C&M) load;

iii) Adjacent to the earthwire suspension set attachment point, an additional maintenance point shall be provided, capable of resisting the specified C&M load;

iv) At each tower body crossarm connection point (bottom chord level) maintenance plates/brackets shall be provided for the attachment of rigging blocks, capable of resisting the specified C&M load;

v) Where it is proposed to erect complete sections of the tower by crane or helicopter then permanent lifting points shall be provided.

(b) Angle/Tension Lattice Steel Tower

i) Tension insulator set attachments shall be of an approved swivel or shackle arrangement;

ii) Adjacent to and either side of all tension insulator set attachment points, additional maintenance points shall be provided, capable of resisting the specified C&M loading. The additional maintenance points shall provide the necessary mountings for stringing and maintenance equipment;

iii) Adjacent to all tension insulator set attachment points, a vertical maintenance attachment point shall be provided, capable of resisting either the specified C&M loads or that imposed by the use of a conductor stringing platform;

iv) Adjacent to the earthwire tension set attachment point, an additional maintenance point shall be provided, capable of resisting the specified C&M loads;

v) At each tower body crossarm connection point (bottom chord level) maintenance plates/brackets shall be provided for the attachment of rigging, blocks, capable of resisting the specified C&M loads.

All tower general arrangement drawings and/or erection diagrams shall clearly indicate the safe working, load capacities of all maintenance points.

8.2.3 Not used.

8.2.4 Tower Fabrication

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

(i) Except where hereinafter modified, details of fabrication shall conform to the relevant international standards.

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

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

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

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

(vi) All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

(vii) The manufacturing of the above items shall be taken up in such a manner that the Equipment/Material offered for inspection to EMPLOYER are on completed tower basis for each type of tower, completed Stubs & Cleats set basis so as to facilitate availability of erectable tower of each type and erectable stubs & cleats set for casting of foundation. Dispatch clearance shall be issued only on Completed Tower Basis for each type of tower (comprising the required Basic Body, body extensions wherever required, four (4) equal or defined unequal Leg Extension, Bolts & Nuts along with Packing and Spring Washers) and on completed Stubs & Cleats set basis for each type of tower foundations (comprising a set of stubs & Cleats, required Bolts and Nuts along with Spring Washers).

Accordingly, the payment shall be released on completed Tower Basis for each type of tower (comprising the Basic Body, body extensions, wherever applicable, bolts & nuts along with spring washer and step bolts, unequal leg extensions wherever applicable for a completed tower) and on completed Stubs and Cleats set basis for each type of foundation (comprising a set of stubs & cleats, required Bolts and nuts along with Spring Washers) based on the weight of the tower parts as calculated as per Clause **8.2.4(ix)** and fasteners based on the unit rates incorporated in the contract.

(viii) The provisional quantities of tower & line materials required are mentioned in the respective Schedules of SCHEDULE OF PRICE. Final quantities shall be determined after completion and approval of the detailed route survey. The final quantities of tower shall be confirmed by the Employer based on the requirement of quantities of various towers furnished by the Contractor after completion of detailed survey as well as requirement of spares for O & M purpose as indicated in table below. Hence it will be responsibility of the Contractor to intimate the exact requirement of all towers and various line materials required for line immediately after the survey.

(ix) This clause is applicable if the Price Schedule indicates the tower price as weight basis:

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

8.2.6 Downlead Tensions

The maximum downlead tension shall be as specified in Appendix 8.A5. However, for the purpose of tower design they shall be assumed to be zero except where the vertical load component increases the stresses in tower members. These tensions shall be assumed to apply at both ends on low duty tension insulator sets.

8.2.7 Downdroppers to Substation Equipment

The design of downdroppers shall take into account the limiting strength of substation equipment specified in Appendix 8.A5.

8.2.8 Ultimate Applied Loading

Not used.

8.2.9 Allowable Ultimate Unit Stresses

The allowable ultimate unit stresses used in the determination of the nominal strength of support members shall be based on the following criteria:

(a) For lattice steel tower shall be based on the recommendations contained in BS 8100-3 or ANSI/ASCE Std 10-97. For Std 10-97 the appropriate reference stress levels shall be based on the values specified in BS 5950, and as summarized below:

Grade	Reference Stress Level (N/mm²)	
S235JRG2	235	≤ 16 mm Nominal Thickness
	225	> 16 ≤ 40 mm
S275JR	275	≤ 16 mm
	265	> 16 ≤ 40 mm
S355JO	355	≤16 mm
	345	> 16 ≤ 40 mm

(b) For lattice steel tower where the appropriate design stresses are not contained in the specified code of practice/manual, reference shall be made to BS 5950;

8.2.10 Design Criteria

The maximum allowable slenderness ratios for members of lattice steel towers shall be:

For leg members, crossarm chords	120
For other load-bearing compression members	200
For secondary bracings	250
For tension only members	350
For angles with slenderness ratios measured about their x-x and/or y-y axis	200

Secondary bracings shall be designed in accordance with the requirements of BS 8100-3.

Members shall be of such size, shape and length as to preclude damage or failure from vibration or stress reversal, including the detailing of the connections.

The minimum thickness and diameter of material used in members and bolts shall be in accordance with the requirements of Appendix 8.A6.

8.2.11 Bolted Joints

Where appropriate all metal parts shall be secured with bolts and nuts with single spring washers. All nuts and bolts shall be in accordance with clause 8.3.3 unless specified to the contrary.

When in position all bolts shall project through the corresponding nuts by at least three threads, but such projections shall not exceed 10 mm. No screwed threads shall form part of a shearing plane between members.

The nuts of all bolts attaching phase conductor insulator sets, earthwire sets, maintenance brackets/plates, access ladder brackets, fall arrest system attachment brackets shall be locked in an approved manner preferably by locknuts.

The diameter of bolts used for towers shall be 16mm and 24 mm only.

The bolts of any one diameter in a tower/pole shall be one grade of steel.

Leg members shall be joined in such a way that electrical continuity is maintained to ground.

8.2.12 Electrical Clearances - Live Metal and Earthed Steelworks

Minimum clearance between live metal and earthed steelwork shall be in accordance with the requirements of Appendix 8.A7.

8.2.13 Downlead Clearances

The clearance in still-air between downleads shall be in accordance with the requirements of Appendix 8.A7. In exceptional circumstances and with the approval of the Engineer, under conditions of maximum (opposing) conductor swing and sag, the clearance may be reduced to the values specified in Appendix 8.A7.

8.2.14 Anti-Climbing Devices

Each support shall be fitted with an approved type of anti-climbing device as specified in Appendix 8.A8. The height of the anti-climbing device shall be adjustable and shall be within the limits specified in the Appendix.

Where specified the anti-climbing device shall be provided with a hinged section where access for personnel is required. The hinged section shall be capable of being bolted and locked in the closed position with either a bolt, nut and locknut or a padlock. In the open position, no projection to impede safe access shall be permitted.

In no case shall an anti-climbing device be installed where it can be bypassed from a side slope or internal bracing.

Barbed wire type anti-climbing devices shall comply with the following requirements (if allowed):

(a) Barbed wire shall be of the mild steel type with high security long barbs 15 mm long set at 50 mm spacing, but in all other respects the barbed wire shall comply with BS 4102, Section 4;

(b) For lattice steel towers the minimum distance between strands or between strands and horizontal tower member/pole sections shall not be less than 150 mm;

(c) No unprotected space greater than 230 mm across shall be left inside the device;

(d) Spacers shall be fitted at 1.5 m intervals and shall be attached to tower members where possible;

(e) Normally 5 strands of barbed wire are required outside the tower face and 3 strands inside;

Spiked type anti-climbing devices shall comply with the following requirements:

(a) The minimum spike diameter shall not be less than 10 mm, and shall project horizontally 50 mm and curve vertically down by 40 mm.

(b) Where spikes are bolted to the support frame the spike threads must be clenched after installation.

8.2.15 Livestock Guards

Means shall be provided on all lattice steel towers and tower extensions to avoid the risk of livestock being caught between tower members and being injured.

Tower members near the around shall be sufficiently robust to avoid being damaged by livestock. To enable supplementary livestock guards to be added, spare holes, normally 17.5 mm diameter and 300 mm apart, shall be provided on each face of the main leg members and the appropriate faces of bracing members, for a distance of approximately 1200 mm from ground level.

8.2.16 Bird Guards

Where specified bird guards of an approved type shall be fitted to intermediate towers fitted with suspension insulator sets. The bird guard shall either comprise a saw-tooth plate, or a length of earthwire suitably distanced and splayed out at each end and clamped to the cross arm member.

8. 2.17 Access Facilities

Each support shall be fitted with approved access facilities as specified in Appendix 8.A8. The following requirements for specific types of access facilities shall apply as appropriate.

(a) Step Bolts

i) Step bolts shall be fitted between specified levels at 450 mm spacing;

ii) On double circuit towers they shall be fitted on the right hand leg on both transverse faces; for single circuit towers they shall be fitted on the right hand leg on one transverse face;

iii) The first step bolt below each cross arm or gantry shall be located on the transverse face of the leg, and all remaining step bolts shall be fitted, alternatively on the remaining of the support;

iv) On terminal and junction towers, provision shall be made for fitting of step bolts on all legs;

v) Step bolts shall not be less than 16 mm diameters, fitted with nut, washer and nut and shall project not less than 150 mm from the support when fitted;

vi) For steel poles, removable step bolts or step brackets in accordance with the requirements of (v) shall be fitted. The step bolt brackets shall be permanently attached to the pole;

vii) Where support legs are fabricated from solid round sections, clamp type steps shall be provided at similar spacing and projection as step bolts.

(b) Ladders

i) Ladders shall be fitted between specified levels, support faces and either externally or internally;

ii) Ladders shall be in accordance with BS 4211, 400 mm between internal faces and 400 mm rung spacing;

iii) Rest platforms shall where specified be fitted at approximately 30 m height increments with the rest platform 850 mm square and fitted with a guard rail (1000 mm above the platform), intermediate rail and toe board (projecting 100 mm);

iv) Ladders shall project 1100mm above platforms, unless other hand holds are provided and shall be between 150 to 230 mm from the platform where side access to the platform is provided.

(c) Fall Arrest Systems

i) Fall arrest system shall be in accordance with the requirements of BS EN 360;

ii) The system shall be either a guided type fall arrester on a rigid anchorage line to BS EN 353-1, or a guided type fall arrester on a flexible anchorage line to BS EN 353-2.

(d) Work Platforms

i) Work platforms shall be provided with hand rails as detailed in clause (b) iii);

ii) Platforms shall be designed for a transient load of 200 kg vertically concentrated load over any square with a 300 mm side, plus a 200 kg/sqm vertically distributed load applied simultaneously to produce the worst loading condition.

iii) Flooring for platforms shall be the open type metal in accordance with BS 4592.

8.2.18 Danger and Identification Plates

All towers shall be fitted with danger and identification plates as specified in Appendix 8.A 8.

8.2.19 Earthwire Bonding

Attachment holes for the connection of earthwire bonds shall be provided adjacent to the earthwire attachment point.

8.2.20 Earthing of Towers

Attachment holes for the connection of the ground earthing conductor shall be provided on all lattice towers standard heights adjacent to the stub connection, leg and body extension and cleats of stubs.

8.2.21 Not used.

8.2.22 Fabrication Drawings

This clause shall be read in conjunction with the other clause(s) regarding fabrication drawing in this specification. The Contractor shall submit the following fabrication drawings to the Engineer;

(a) Panel assembly (fabrication) drawings;
(b) Erection drawings;
(c) Stub setting diagrams;
(d) Stub, anchor bolt assembly.

Panel assembly drawings shall show all material in place, complete with all fabrication and connection details. A complete tabulation listing all pieces for the portion of the support detailed shall be shown on each drawing.

Each erection diagram shall show one support panel, together with a key diagram indicating its location on the complete support. Each piece shall be identified by its mark number. The number and length of bolts and number and type of nuts and washers required for proper assembly shall be shown at each connection. A complete tabulation listing all the material needed for the support panel including all bolts, nuts, fill and bevel washers and locknuts, shall be shown on each drawing. The tabulation shall show the quantity, the mark number, the description of the piece (including size and length), the total mass (including the allowance of 3.5% additional mass for galvanising) to the nearest 0. 1 kg of all the pieces of the same mark, and the number of the drawing on which the shop detail of the piece can be found. The quantities including 5% excess of step bolts, bolts, nuts, fill and bevel washers, and locknuts shall be shown.

The Contractor shall make all changes to the detail (fabrication) and the erection drawings which the Engineer determines necessary to make the finished support fabrication conform to the requirements and intent of this Specification. The Contractor shall not proceed with any fabrication until after the submission of the fabrication drawings. This is a **Hold Point**.

8.2.23 Cradle Guard

Cradle guards shall be installed at highway crossings and railway crossings and shall be designed for 126 kgf/m^2 wind pressure.

8.3 MATERIALS

8.3.1 Steel

All steel shall comply with BS EN 10025 or BS EN 10210 as appropriate, unless otherwise specified and shall be suitable for all the usual fabrication processes, including hot and cold working within the specified ranges.

The quality of finished steel shall be in accordance with BS EN 10163. All steel shall be free from blisters, scale, laminations, segregation and other defects. There shall be no rolling laps at toes of angles or rolled-in mill scale.

Unless specified to the contrary the following grades of steel shall be applicable:

(a) Mild steel shall be either grade S235JRG2 or S275JR.

(b) High tensile steel shall be grade S355JR for sections less than 20 mm thick and S355JO for sections greater or equal to 20 mm thick, except for plates which shall be greater or equal to 40 mm thick.

(c) Steel plate used for folded, pressed braked or stretch bending pole towers shall be grade S275JO for mild and grade S355JO for high tensile.

(d) Mild and high tensile steel hollow sections shall be grades S275JOH respectively.

(e) High tensile steel solid round sections shall be grade S355J, IG3.

Steel section profiles shall be in accordance with the requirements of BS 4: Part 1, BS 4848: Part 2, BS 4848: Part 4, BS EN 10024, BS EN 10034 and BS EN 10056-2 as appropriate.

Hot rolled steel plate 3 mm thick- or above shall be in accordance with the requirements of BS EN 10029.

For designing of towers, preferably rationalised steel sections has been used. During execution of the project, if any particular section is not available, the same shall be substituted by higher section. Any cost on account of the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Owner before any substitution and records of such substitutions shall be maintained by the Contractor.

8.3.2 Malleable Cast Iron

Malleable cast iron shall be in accordance with the requirements of BS 6681 for whiteheart or pearlite and BS 2789 for spheroidal graphite.

8.3.3 Bolts, Nuts, Clevis Pins and Washers

Unless specified to the contrary the following grades of steel shall be applicable:

(a) Material quality of bolts of 12 mm diameter shall be Grade 4.6 according to ISO 898.

(b) Material quality of bolts and clevis pins of 16 mm diameter and over shall be Grade 5.6 according to ISO 898.

(c) Material quality of non-structural step bolts shall be Grade 4.6 according to ISO 898.

(d) Material quality of nuts shall be Grade 4.6 or 5.6 according to ISO 898 and appropriate to the material quality of bolts.

Unless other specified, bolts and nuts shall be ISO Metric Black Hexagon to BS 4190, and shall be threaded ISO Metric Course Pitch to BS 3643: Part 2, Tolerance Class 7H/8g.

Countersunk and other bolts without hexagon heads shall have slotted heads.

All flat washers shall comply with the requirements of BS 4320, Form E, Grade 4.6 or 5.6 appropriate to the material quality of bolts. Unless specified to the contrary they shall be 3 mm thick. Pack washers shall have an external diameter of twice the nominal bolt diameter +15 mm, a hole diameter of nominal diameter +2 mm and a thickness as specified on the appropriate fabrication drawing.

Single core spring washers shall comply with the requirements of BS 4464, Type B.

Split pins shall comply with the requirements of BS 1574 and shall be of authentic stainless steel capable of complying with the requirements relating to the inter crystalline corrosion test of BS 970: Part 1.

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

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

Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm dia bolt and 4.5 mm for 24 mm bolt.

To avoid bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of members more than three (3) times its diameter.

The bolt positions in assembled towers shall be as per structural drawing.

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

To ensure effective in-process Quality control it is desirable that the manufacturer should have in house testing facility for all tests like weight of zinc coating, shear strength and other tests etc. The

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

8.3.4 Welding

Consumable for use in metal arc welding shall be in accordance with the requirements of BS 5135.

8.3.5 Flooring

Open type floor shall be fabricated from either steel complying with BS EN 10025 Grade S275JR or BS 1474 Grade HE30. Minimum thickness for load bearing, transverse and pressed bars shall not be less than 3.0 mm.

8.4 WORKMANSHIP

8.4.1 General

The work shall be carried out in a thoroughly reliable and workmanlike fashion in order to ensure satisfactory assembly and erection, interchangeability of similar members, accuracy of dimensions, position and alignment of holes.

Punched holes, shall wherever practicable, be Jig, NC or CNC punched true to form and free from rags, burrs and distortions. Punches and dies shall be strictly monitored to ensure that any producing, irregular holes or defects previously mentioned shall be immediately replaced. Drilled holes shall be clean, free from burrs and square to the surface of the material.

Hole diameters shall be in the black unless specified to the contrary. For bolts up to but not including 22 mm diameter - nominal diameter +1.5 mm. For bolts 22 mm diameter or greater - nominal diameter +2.0 mm.

8.4.2 Cutting

Cutting of materials by either cropping, shearing, guillotining will be permitted up to and including the thickness specified below:

Quality (sub-grade)	JR - 16 mm
	JO - 20 mm

Materials of either greater thickness or higher quality (sub-grade) must be either machine frame-cut or cold sawn. Hand held flame-cutting is not permitted.

Where materials are cropped, sheared or guillotined, the finished edge shall be free form rags, burrs, notches and distortions. Flame-cutting of grade S355 steel shall be preceded by a slight pre-heat by passing the cutting, flame over the area to be cut and the cutting speed reduced in comparison to those normally used for Grade S275 steels of similar thickness. Every effort shall be made to avoid having the flame-cut edge in tension, especially in grade S355. The flame-cut edges shall be lightly dressed after cutting to remove notches etc.

8.4.3 Drilling and Punching

Punching, full sized holes will be permitted up to and including the thick nesses specified below:

Quality (sub-grade)	JR - 16 mm
	JO - 20 mm

No hole shall be punched where the thickness of the materials exceeds the finished diameter of the hole. Finished holes shall be true to form and free from rags, burrs and distortion.

Materials of either greater thickness or higher quality (sub-grade) must be either drilled to final diameter or punched 2 mm undersize and reamed or core drilled to final diameter.

The welding, up of misplaced holes is not permitted without the prior approval of the Engineer. This is a **Hold Point**. In the case where approval is granted, the new hole must be drilled where it passes through or adjacent to the weld are of the previous hole irrespective of material grade or thickness.

8.4.4 Presswork/Bending

All bends in Grades S355JO and S355J2G3 steel over 90 in 1000 shall be made hot within the temperature range of 850 to 1000 degrees Celsius, but normal cold correction will be permitted. Means shall be provided for the random checking of temperatures (Tempilstiks or Pyrometer).

Bends in Grades S235JRG2 and 275JR steel plates up to 10 mm thick may be made cold up to an including 1175 in 1000.

Bends, open and close flanges in angle sections may be made cold up to and including 600 in 1000.

However, in both of the above cases, the Contractor shall take adequate precautions to avoid the risk of subsequent galvanising embrittlement.

Bends shall be of even, profile and free from surface damage due to press tools indentations.

The formation of bends by the 'cut and weld' method unless specified on the drawings, is not permitted without prior approval of the Engineer. This is a **Hold Point.**

8.4.5 Welding

All welding shall be carried out in accordance with BS 5135.

Pre-heating, where required, shall be checked by the use of Tempilstiks or similar over an area of 150 mm either side of the weld area.

Assembly welds (tacks) shall be carried out to the same procedures and welding conditions as the main welds and shall be at least 50 mm long.

Stop-start positions shall be kept to a minimum and shall be kept clear by a minimum of 25 mm of all corners and edges of plates (i.e. the weld must be laid down continuously at these points). Where the first run in multi-run welds is larger than subsequent runs, welding should continue until completed, thereby ensuring the weld area is not allowed to cool. After completion the unit should be allowed to cool slowly and should not be subjected to draughts or low temperatures.

Where materials are to be galvanised, all welds shall be continuous so as to ensure a pickle-tight connection and shall be thoroughly cleaned (preferably by shot-blasting) to remove all slag, manganese (Carbon Dioxide welding), and weld splatter.

8.4.6 Erection Marks

Before leaving the fabricator's works, all members shall be stamped with distinguishing numbers and/or letters corresponding to those on the general arrangement or fabrication drawings. Additionally, the agreed fabricator's identification symbol must appear adjacent to the erection mark.

Erection marks shall be stamped on before galvanising, using characters at least 10 mm high and shall be clearly legible after galvanising.

Erection marks shall be located as follows:

(a) All members - stamped within 600 mm of the end but clear of holes;

(b) Plates or flat bars - stamped at most suitable position between holes;

(c) Main leg and elevation diagonal members - stamped at top end of bar;

(d) Horizontal members - stamped at either end of bar;

(e) Steel poles 100 mm either side of the joint.

Where malleable cast iron fittings are used the erection mark shall be 6 mm high raised characters, where appropriate the following information shall be included:

(a) specified minimum failing load;

(b) date of manufacture (month and year)

(c) cast code.

The erection marks shall be as bellow:

AAAA-BBB-C

Where,

AAAA – Tower Type
BBB – Mark Number

C – Steel Grade (H for high tensile steel and M for mild steel)

Erection Mark coding shall be agreed with the Engineer. This is a **Hold Point.**

8.5 PROTECTIVE TREATMENT

8.5.1 Galvanising of Towers

Unless otherwise specified after completion of all fabrication processes (including all drilling, punching, stamping, cutting bending and welding) support steelwork, poles and pole steelwork, including nuts, bolts and washers shall be hot-dip galvanised and tested in accordance with the requirements of ISO 1461. Electro-galvanizing is not an acceptable alternative. The minimum average coating thickness shall be as follows:

	Thickness (µm)	**Mass (g/m^2)**
Steel articles which are not centrifuged:		
5 mm thick and over	85	610
Under 5 mm but not less than 2 mm	64	460
Grey and malleable iron castings	85	610
Threaded works and other articles which are centrifuged	43	305

Under marine environment, the fabricated tower parts and stubs shall have a minimum overall Zinc coating of 900 gms/sq. m of surface are except for plates and sections below 5 mm which shall have a minimum overall Zinc coating 610 gm/sq. m of surface area. The average Zinc coating for al sections and plates 5 mm and above shall be maintained as 127 microns and that for plates and sections below 5 mm shall be maintained as 87 microns.

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 cause for rejection.

The ingot zinc used for galvanising shall comply with the requirements of BS 3456.

All materials prior to galvanising shall be free from oil, grease or any substance which may adversely affect the quality of finish.

The zinc coating shall be adherent, reasonably uniform, smooth, continuous and free from imperfections such as black/ bare spots, ash rust strains, bulky white deposits / wet storage strains and blisters.

Castings should be as free as possible from surface porosity and shrinkage holes and should be cleaned by grit blasting, electrolytic pickling or by other means specially suitable for castings.

The preparation for galvanising and the galvanising itself shall not adversely affect the mechanical properties of the coated materials.

Unless otherwise specified, all materials shall be treated with Sodium Dichromate in order to prevent wet storage stains (white rust) during storage and transport.

All galvanised materials shall be stored used.

The surface preparation for fabricated tower parts and stubs for hot dip galvanizing shall be carried out as indicated herein below:

(i) **Degreasing & Cleaning of Surface:** Degreasing and cleaning of surface, wherever required, shall be carried out in accordance with relevant International Standard. After degreasing the article shall be thoroughly rinsed. However, if acidic degreasers are used rinsing is not required.

(ii) **Pickling:** Pickling shall be done using either hydrochloric or sulphuric acid as recommended at International Standard. The actual concentration of the acids and the time duration of immersion shall be determined by the Contractor depending on the nature of material to be pickled. Suitable inhibitors also shall be used with the acids to avoid over pickling. The acid concentration, inhibitors used, and maximum allowable iron content shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.

(iii) **Rinsing:** After pickling, the material shall be rinsed, preferably in running water to remove acid traces, iron particles or any other impurities from the surface. Two rinse tanks are preferable, with water cascading from the second tank to the first to ensure thorough cleaning. Wherever single tank is employed, the water shall be periodically changed to avoid acid contamination, and removal of other residue from the tank.

(iv) **Fluxing:** The rinsed article shall be dipped in a solution of Zinc ammonium chloride. The concentration and temperature of the flux solution shall be standardized by the contractor depending on the article to be galvanized and individual circumstances. These shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program. The specific gravity of the flux solution shall be periodically monitored and controlled by adding required quantity of flux crystals to compensate for drag-out losses. Free acid content of the flux solution also shall be periodically checked and when it is more than two (2) grams of free acid per litre of the solution, it shall be neutralized. Alternatively, Ph value should be monitored periodically and maintained between 5.0 to 5.5.

(v) **Drying:** When dry galvanizing is adopted the article shall be thoroughly dried after fluxing. For the purpose of drying, the contractor may use hot plate, air oven or any other proven method ensuring complete drying of the article after fluxing and prior to dipping in the molten zinc bath. The drying process shall be such that the article shall not attain a temperature at which the flux shall get decomposed. The article thus dried shall be galvanized before the flux coating picks up moisture from the atmosphere or the flux layer gets damaged or removed from the surface. The drying procedure, time duration, temperature limits, time lag between fluxing, drying, galvanizing etc shall form part of plant standard to be formulated and submitted to employer along with Quality Assurance Program.

(vi) **Quality of Zinc:** Any one or combination of the grades of zinc specified in IS 209 or IS 13229 or other comparable international standard shall be used for galvanizing. The contractor shall declare the grade(s) of zinc proposed to be used by them for galvanizing. The molten metal in the

zinc bath shall contain minimum 98.5 % zinc by mass. It shall be periodically measured and recorded. Zinc aluminum alloy shall be added as per IS 2629.

(vii) **Dipping Process:** The temperature of the galvanizing bath shall be continuously monitored and controlled. The working temperature of the galvanizing bath shall be maintained at 450+/ - 10 degree C. The article should be immersed in the bath as rapidly as possible without compromising on safety aspects. The galvanizing bath temperature, immersion angle & time, time duration of immersion, rate of withdrawal etc shall be monitored and controlled depending upon the size , shape, thickness and chemical composition of the article such that the mass of zinc coating and its uniformity meets the specified requirements and the galvanized surface is free from imperfections and galvanizing defects.

(viii) **Post Treatment:** The article shall be quenched in water. The quench water is to be changed / drained periodically to prevent corrosive salts from accumulating in it. If water quenching is not done then necessary cooling arrangements should be made. The galvanized articles shall be dipped in chromating solution containing sodium dichromate and sulphuric acid or chromic acid base additive at a predetermined concentration and kept at room temperature to retard white rust attack. The temperature of the chromate solution shall not exceed 65 degree C. The articles shall not be stacked immediately after quenching and dichromating. It shall be ensured that the articles are dry before any further handling operation.

(ix) **Storing, Packing and Handling:** In order to prevent white rust formation sufficient care should be exercised while storing handling and transporting galvanized products. The articles shall be stored in an adequately ventilated area. The articles shall be stored with spacers in between them and kept at an inclination to facilitate easy drainage of any water collected on the articles. Similar care is to be taken while transporting and storing the articles at site.

The Contractor shall prepare a detailed galvanizing procedure including Flow Chart with control parameters and all plant standards as required above and submit to OWNER for approval as part of Quality Assurance Plan.

8.5.2 Fasteners

For fasteners, the galvanizing shall conform to relevant BS or International Standard. The galvanizing shall be done with centrifuging arrangement after all mechanical operations are completed. The nuts, may however be tapped (threaded) or rerun after galvanizing and the threads oiled .The threads of bolts & nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of bolts. Spring washers shall be electro galvanized as per requirement of relevant standard.

All bolts and screwed rods, including the threaded portions, shall be galvanised. 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. Black steel packing or bins shall not be spelter by spinning or brushing. 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.

Bolts shall be delivered with nuts run up the full extent of the thread.

8.6 TOWER ERECTION

8.6.1 General

The Contractor shall provide the Engineer with a method statement giving sequential details of the erection method and including his intended program.

The method statement shall be submitted to the Engineer for acceptance the requisite period before support erection commences. This is a **Hold Point**.

8.6.2 Safety

The erection shall be carried out in accordance with guidance given in the relevant parts of BS 5531 and current health and safety legislation.

8.6.3 Site Storage

All support steelwork stored at site shall be kept clear of the ground where possible. Contact with brackish water, or other substances likely to attack galvanising shall be avoided and all tower members kept in a clean and tidy condition.

Preventative measures shall be taken to prevent deterioration of galvanised or other protective surfaces during transport, storage and erection. Superficial rust stains shall be removed without causing damage to the protective surfaces.

8.6.4 Damaged Steelwork

Unless otherwise directed, steelwork damaged during off-loading, transportation, storage or erection shall be replaced.

8.6.5 Damaged Galvanising

The renovation of damaged area of galvanising shall be carried out using a technical agreed with the Engineer. This is a **Hold Point**.

8.6.6 Workmanship

The Contractor shall ensure that Towers are not strained or damaged in any way during erection.

As far as practical, bolt heads, rather than nuts, shall be on the inner or downward faces of support joints. Bolt locking, after erection shall be in accordance with the requirements of Appendix 8.A.8.

All holes that align through both components of double angle (back to back) members shall be filled by fitting, a bolt, with suitable pack washers between components. All spare holes (eg. holes for alternative positions of supplementary fittings) in double angle members shall be included in this requirement.

Towers shall be erected vertically within a tolerance of 0.005 percent of the overall height before conductor erection.

8.6.7 Anti-Climbing Devices, Danger and Identification Plates

As soon as practical after completion of support erection, anti-climbing devices, danger and identification plates in accordance with the requirements of the clause 8.2.19 shall be fitted.

All ladders and temporary step bolts below the anti-climbing device shall be removed when erection work is not in progress.

8.6.8 Aircraft Navigation (Obstruction Aids)

Where required aircraft navigation obstruction lights complete with all necessary cabling, control equipment, solar panels, storage batteries, access ladders and platforms shall be fitted.

All installation shall be in accordance with approved general arrangement drawings and supplier's instructions.

8.7 QUALITY CONTROL

8.7.1 General

Routine tests on raw material and fabricated individual members (components) of lattice steel towers and associated steelwork shall be undertaken in accordance with the requirements of this Specification. Prototype (type) tests on lattice steel towers shall be undertaken when required by the Engineer in accordance with the requirements of Clause 8.7.7.

All steel ex-mills or received from merchants' stocks shall be marked to identify the cast or casts from which it was made in accordance with Section 9 of BS EN 10025 and Section 10 of BS EN 10210, and be covered by a test (mill) certificate stating the mechanical, chemical and where specified the impact properties and carbon equivalent value and clearly showing the cast numbers; to prove compliance with tables 2 and 5 of BS EN 10025 and tables Al and A3 of BS EN 10210.

The optional impact test BS EN 10210 option 1.6 for quality JO steel hollow sections is required.

Unless agreed to the contrary the following maximum Carbon Equivalent Values (CEV) for steel supplied in accordance with BS EN 10025 and BS EN 10210 shall not be exceeded:

Grade	S235	0.35
	S275	0.41
	S355	0.45

see also BS 5950 Part 2, Clause 4.2

All high tensile steel solid round sections shall be ultrasonic tested for laminations at the rolling mills in accordance with the requirements of BS 5996.

In the event of test certificates being unobtainable, the Contractor shall arrange, at his own cost, for the independent testing and analysis of materials. Testing shall be in accordance with the requirements of BS EN 10025, Section 8 and BS EN 10210, Section 7**.**

The material grades of all individual pieces of shall be capable of positive identification at all stages of fabrication.

Steels of different quality shall be stored separately.

Bolts and nuts shall be covered by the appropriate test certificate in respect of the tests requirements stated in BS 4190.

Copies of all test certificates shall be made available to the Engineer.

8.7.2 Welding

Unless specified to the contrary all structural welded joints shall be undertaken using approved welding procedures in accordance with BS EN 288.

Copies of the welding procedures shall be made available to the Engineer upon request. However, for all welding associated with the fabrication of high tensile steel solid round sections, or where the combined thickness of the material is in excess of 60 mm, the welding procedures shall be submitted to the Engineer for approval, together with the related quality control documentation such as electrode storage, drying and handling requirements. This is a **Hold Point.**

All welders shall be tested to meet the requirements of BS EN 287 Part 1 using the appropriate test corresponding to the weld positions and parent materials to be used. Copies of the test certificates shall be made available to the Engineer upon request.

The Engineer reserves the right to have any welding operator retested at any time at no extra cost.

Unless specified to the contrary all welding shall be subjected to a non-destructive testing (NDT) programme. Where necessary, this may involve the appointment by the supplier of an independent NDT organization approved by the Engineer who will undertake the NDT programme. This is a **Hold Point.**

The NDT organization shall have operators suitably qualified to Level 2 of PCN/WSB/MT/001/87. The NDT organization shall submit their proposed procedures for approval. This is a **Hold Point**. The Contractor shall then ensure that the approved procedures are rigidly adhered to.

The Contractor shall arrange for the appropriate level of weld/inspection to be undertaken, which shall not be less than the following minimum requirements. For details of the required level of inspection reference should be made to Appendix 8.A9.

Level 1: 100 percent visual inspections in accordance with the requirements of BS 5289.

Level 2: 10 percent of the overall output shall be magnetic particle tested to the acceptance criteria stated in BS 5135 Tables 18 and 19, Category C (except for porosity, see Note A) for butt and fillet welds respectively.

Level 3: 10 percent of each welder's output shall be magnetic particle tested to the acceptance criteria stated in BS 5135 Tables 18 and 19, Category B (except for porosity, see Note A) for butt and fillet welds respectively.

Level 4: 20 percent of each welder's output shall be magnetic particle tested to the acceptance criteria stated in BS 5135 Tables 19, Category B (except for porosity, see Note A) for fillet welds**.**

Level 5: 10 percent of each welder's output shall be ultrasonic tested, with a further 10 percent of each welder's output magnetic particle tested - both to the acceptance criteria in BS 5135, Table 18, Category B except for porosity, see Note A) for butt welds.

Note: A All welds, especially butt welds must be continuous to ensure a pickle-tight connection when galvanised.

B Ultrasonic testing to be in accordance with BS 3923, Part: 1.

C Magnetic particle testing to be in accordance with BS 6072.

All weld inspection/testing, shall be undertaken a minimum of 48 hours after the completion of the respective weld. This is a **Notification point.**

Copies of the NDT inspection reports for weld inspection levels 5 and 4 shall be made available to the Employer.

Copies for the NDT inspection reports for weld inspection level 3 and 2 shall be made available to the Employer upon request.

8.7.3 Castings

All malleable cast iron castings shall be thoroughly inspected after sand blasting and any casting with castings defects e.g. sand inclusions and metal penetrations, cracking, raised core, porosity shall be scrapped.

8.7.4 Check Erection

Prototype structures (and, where required by the Engineer repeat structures) shall be check erected in order to verify the accuracy of detailing and fabrications, including forming, location and size of bolt holes, clipping and shearing.

The degree of check erection shall be sufficient to verify not only the main structure, but all ancillary steelwork such as platforms, walkways, ladders etc.

In the case of lattice towers, the minimum check erection required shall be one face lying horizontally and the adjacent face erected in the vertical plane, complete with hip and plan bracings. Crossarms and earthwire peaks shall be completely assembled.

Sufficient blocking and support shall be provided to prevent distortion and overstressing of the members to ensure proper fit. Assembly shall be accomplished without extraordinary effort to align bolt holes or to force pieces into position. Bolt holes shall not be reamed or enlarged.

All modifications found necessary at the time of check erection shall be accurately recorded and the Contractor's drawings, NC tapes etc., shall be amended. Where necessary, modified G.A. drawings shall be forwarded to the Engineer.

Unless otherwise specified the check erection may be undertaken in either the black or galvanised condition. Where materials are check erected galvanised, all modified items, those subjected to damage or prolonged contact with black steel shall be re-galvanised at the supplier's cost.

The Contractor shall give the Engineer the requisite period of notice prior to a check erection being ready for inspection. This is a **Hold Point**.

8.7.5 Galvanizing

Tests for galvanised members and components shall be carried out at the works to ensure compliance with the requirements of BS 729. Details of the test results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also be made available to the Employer upon request. When requested the fabricator shall, at his own cost, provide a pot melt analysis.

8.7.6 Tolerances

The fabrication tolerances after galvanising, which are not to be considered cumulative, shall be as follows:

(a) On linear dimensions of nominal sections as per BS 4, BS 4848, BS EN 10024, BS EN 10029, BS EN 10034 & BS EN 10056-2

(b) On overall length of member	± 1 mm
(c) On centres of holes	± 1 mm
(d) On centres of groups of holes	± 2 mm
(e) On back-gauges	± 1 mm
(f) On corresponding holes in opposite faces of an-le or channel sections	± 1 mm
(g) On specified hole diameter on the punch side (in the black) or where drilled	+ 0.3 mm - 0 mm
(h) Taper on punched holes as measured between the specified hole diameter on the punch side and the hole diameter on the die's side (in the black-) shall not exceed	+ 1.00 mm
(i) On specified bends, open and close flanges	± 20/1,000
(j) On the specified included angle (in plan) between welded leg connections or bracing connection plates	± 20/1,000

The permitted tolerance from straightness after galvanising shall not exceed an offset of 1: 1,000, except for hollow sections which shall not exceed 1:600 measured at the worst point. For members greater than 3 m in length, the offset shall be measured over any 3 m length in the member.

8.7.7 Tower Test

Before taking up mass fabrication, the Contractor shall arrange for one number proto-assembly for each type of towers and extensions.

8.7.8 Certificate of Conformity

The certificate of conformity shall be supported by the following documentation:

(a) material test (mill) certificates;
(b) bolt and nut certificates;
(c) NDT welding inspection (levels 5 & 4);
(d) test reports of any prototype or sample tests undertaken;
(e) the results of any ultrasonic testing of solid round sections;
(f) the results of any welding NDT inspections (levels 3 & 2);
(g) Welder's test certificates;
(h) galvanising thickness records;
(i) the ingot zinc certificates;
(h) galvanising pot melt analysis;

8.7.9 Quality Control after Erection

The Contractor shall be responsible for checking that the Towers are complete and that all bolts have been correctly tightened before conductor commences. A record of this work shall be kept by the Contractor and made available to the Engineer on request.

Critical bolts are to be marked after erection with red paint to ensure priority checking during maintenance.

Where appropriate, test on the aircraft obstruction lighting shall be undertaken to prove compliance of the system. Records of the tests shall be made available to the Engineer upon request.

APPENDIX 8.Al

CLASSES OF TOWER

1. Overland Portion

(a) Normal Base width Double circuit towers

132 kV double circuit three phase vertical formation lattice steel towers with ACSR (Grossbeak) phase conductor and one 7/3.25 GS earthwire equivalent OPGW.

These towers will generally be used in Chandraghona – Rangamati – Khagrachari line. However, these towers may also be used in other transmission lines in this lot, if necessary.

(b) Narrow Base width Double circuit towers

132 kV double circuit three phase vertical formation lattice steel towers with ACSR (Grossbeak) phase conductor and one 7/3.25 GS earthwire equivalent OPGW.

These towers will generally be used in three lines except Chandraghona – Rangamati – Khagrachari line. However, these towers may also be used in Chandraghona – Rangamati – Khagrachari line, if necessary.

(c) Four circuit towers

132 kV four circuit three phase vertical formation lattice steel towers with ACSR (Grossbeak) phase conductor, one 7/3.25 GS earthwire and one 7/3.25 GS earthwire equivalent OPGW.

2. River Crossing Portion:

132 kV double circuit three phase vertical formation lattice steel towers with ACSR (Mallard) phase conductor and one 7/4.25 GS earthwire equivalent OPGW.

APPENDIX 8.A2

DESIGNATION & USES OF TOWERS

Designation	Angle of Deviation/Entry	Description	Type of Insulator Set
132 kV Double Circuit Tower			
1DL	0°	Intermediate	Suspension
1D1	0° - 10°	Angle	Heavy Suspension
1D25	10° - 25°	Angle/ Section	Tension
1DT6	25° - 60°	Angle	Tension
	0° - 30°	Terminal	Tension
1DR	0°	River Crossing	Suspension
1DAX	0° - 30°	Anchor	Tension
132 kV Four Circuit Tower			
1QL	0°	Intermediate	Suspension
1Q15	0° - 15°	Angle	Heavy Suspension
1Q30	15° - 30°	Angle/ Section	Tension
1QT6	30° - 60°	Angle	Tension
	0° - 30°	Terminal	Tension

APPENDIX 8.A3

EXTENSIONS

Tower Type	Type of Extension	Range (m)
132 kV Double Circuit Tower		
1DL	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0
1D1	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0,E12.0 & E15.0
1D25	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0
1DT6	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0
1DR	Body/Leg	Standard & M10
1DAX	Body/Leg	Standard & E4.5
132 kV Four Circuit Tower		
1QL	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0
1Q15	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0,E12.0 & E15.0
1Q30	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0
1QT6	Body/Leg	Standard, E1.5, E3.0, E4.5, E6.0 & E9.0

Note: 1) "Standard" means the Standard Height of Tower from Ground Level to Earthwire Peak without any extension.
2) 'E' means Extension of Tower (Body/Leg) additional with the Standard Height of Tower.
3) 'M' means Reduction of Tower (Body/Leg) to the Standard Height of Tower.
4) The number after 'E' stands for extension of tower in meter.

APPENDIX 8.A3.2

Not used

APPENDIX 8.A4

SPAN CRITERIA

Please refer to Section 1 of this specification

APPENDIX 8.A5

APPENDIX 8.A5.1

Not used.

APPENDIX 8.A5.2

Not used.

APPENDIX 8.A5.3

DOWNLEAD TENSIONS

Maximum phase downlead tension	7 kN
Maximum earthwire downlead tension	4.5 kN
Maximum slack span	70 m

APPENDIX 8.A6

MINIMUM THICKNESS & DIAMETER OF MATERIAL

The minimum thickness and diameter of material used in members and bolts shall be as detailed below:

(a)	For leg members and compression chords in gantries and cross arms.	(mm)	6
(b)	For other members (including earthwire peaks) carrying calculated stress.	(mm)	5
(c)	For secondary members without calculated stress.	(mm)	5
(d)	Gusset plates for lattice towers.	(mm)	6
(e)	Bolt diameter for members	(mm)	16 & 24 or as per Employer's supplied drawings

APPENDIX 8.A7

1. ELECTRICAL CLEARANCES - LIVE METAL & EARTHED STEELWORK

Please refer to Section 1 of this specification

2. SPATIAL DISTANCES

Please refer to Section 1 of this specification

3. DOWNLEAD CLEARANCES

Please refer to Section 1 of this specification

APPENDIX 8.A8

APPENDIX 8.A8.1

OVERLAND SECTION

1.	**ANTI-CLIMBING DEVICES (ACD)**		**Required / Not Required**
	(a)	Barbed wire type at a minimum height above ground level …….. (m)	if required as per 132kV tower design
	(b)	Spiked type at a minimum height above ground level ……..(m)	3.0
	(c)	Ladder to be fitted with spike type ACD with a lockable gate at a minimum height above ground level….. (m)	Not required
	(d)	Bolt Locking	All bolts below the bottom crossarm level shall be locked by locknuts, sample drawing of which is enclosed in drawing Section (Antitheft)
2.	**ACCESS FACILITIES**		
(a)		Step bolts fitted between	Ground level & within 1m of top of towers
(b)		Ladders fitted between (or provision for)	Not required
(c)		Rest platforms	Not required
(d)		Work platforms	Tension tower at all Crossarm level
(e)		Fall arrest system	Not required.
3.	**DANGER & IDENTIFICATION PLATES**		
(a)		Danger Palate	Required
(b)		Tower Number, Circuit Identification & Phase Color Plate.	Required

APPENDIX 8.A8.2

RIVER CROSSING SECTION

Not used.

APPENDIX 8.A9

QUALITY CONTROL WELD INSPECTION LEVELS

Level 1: All welded items not covered by higher level of inspection

Level 2:

Level 3: Conductor attachment fittings for all types of tower.

APPENDIX 8.A.10

TOWER TEST REQUIREMENTS

Proto Assembly:

All towers with all extensions shall require proto assembly tests to be performed in the manufacturer's premises before starting the batch manufacturing of towers.

All costs related to such tests shall deem to be included in the Contract Price.

Visual Check, Galvanizing test and Mechanical Test of Members/Nuts & Bolts/Plates:

Before mass (batch) fabrication/manufacturing of tower materials the Contractor shall submit the proto assembly test report of 132kV towers for acceptance of the Employer. The Contractor shall precede mass fabrication of towers after acceptance of the said test report by the Employer. After mass fabrication, tower members shall visually check for dimension and galvanizing thickness (which shall include weight basis test also). Mechanical tests shall also be done on the finished tower materials.

All costs related to such tests shall deem to be included in the Contract Price.

APPENDIX 8.B.l

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

Clause Reference	Document Description	Comment
8.2.22	Design Calculation	Not required
8.2.23	Fabrication Drawings	Not required
8.6.1	Method Statement	Not required
8.7.1	Material Test Certificates	
8.7.1	Bolt & Nut Test Certificates	
8.7.2	Welding procedures	If requested
8.7.2	Welders test certificates If requested	If requested
8.7.2	NDT procedures	
8.7.2	NDT Inspection reports	
8.7.2	NDT Inspection reports If requested	If requested
8.7.5	Galvanising test records If requested	If requested
8.7.5	Ingot zinc certificates	If requested
8.7.5	Pot melt analysis	If requested
8.7.7	Prototype tower test programme	
8.7.7	Prototype test reports	
8.7.8	Certificate of conformity	
8.7.9	Tower Erection records	If requested

APPENDIX 8.C.l

NOTIFICATION AND HOLD POINTS

Clause Reference	Notification Points	Hold Points
8.2.22		Design Calculation
8.2.23		Fabrication Drawings
8.4.3		Misplaces Holes
8.4.4		Formation of Bends
8.4.6		Erection Marks
8.6.1		Method Statement
8.6.5		Damaged Galvanizing
8.7.2		Welding procedure
8.7.2		NDT organisation
8.7.2		NDT procedure

APPENDIX 8.D.1

REFERENCE STANDARDS

The reference standards and other documents referred to in this specification are listed below:

IEC 652:	Loading Tests on Overhead Line Towers
BS 4:	Structural Steel Sections
Part 1:	Specification for hot rolled sections
BS 183:	Specification for general purpose galvanised steel wire strand
BS 443:	Specification for testing zinc coatings on steel wire and for quality requirements.
BS 464:	Specification for thimbles for wire ropes.
BS 729:	Specification for hot-dipped galvanising coating, on iron and steel article.
BS 970:	Specification for wrought steel for mechanical and allied engineering purposes.
Part 1:	General inspection and testing procedures and specific requirements for carbon, carbon manganese, alloy and stainless steel.
BS 1474:	Specification for wrought aluminium and aluminium alloys for general engineering purposes bars, extruded round tubes and sections.
BS 1574:	Specification for split cotter pins.
BS 2789:	Specification for spheroidal graphite or nodular graphite cast iron.
BS 3643:	ISO Metric threads.
Part 2:	Limits and tolerances for course pitch screw threads.
BS 3923:	Method of ultrasonic examination of welds.
Part 1:	Method of manual examination of fusion welds in ferric steel.
BS 4102:	Steel wire and wire products for fences.
BS 4190:	Specification for ISO metric hexagon bolts, screws and nuts.
BS 4211	Ladders for permanent access to chimneys, other high structures, silos and bins.
BS 4320:	Specification for metal washer for general engineering purposes. Metric series.
BS 4464:	Specification for spring, washers for general engineering and automobile.
BS 4592:	Industrial type metal flooring, walkways and stair treads.
BS 4848:	Hot rolled structural steel sections.
Part 2:	Specification for hot-finished hollow sections.
Part 4:	Equal and unequal angles.
BS 5135:	Specification for arc welding of carbon and carbon manganese steels
BS 5289:	Code of practice. Visual inspection of fusion welded joints.
BS 5531	Code of practice. For safety in erecting structural frames.
BS 5950:	Structural use of steelwork in buildings.
BS 5996:	Methods of ultrasonic testing and specifying, quality grades of ferric steel plates.
BS 6072:	Methods for magnetic particle flow detection.
BS 6681:	Specification for malleable cast iron.
BS EN 287:	Approval testing of welders for fusion welding.
BS EN 288:	Specification and approval of welding procedures for metallic materials.
BS EN 353:	Personal protective equipment against falls from heights guided type fall arresters.
BS EN 353-1:	Specification for guided type fall arresters on a rigid anchorage line.
BS EN 353-2:	Specification for guided type fall arresters on a flexible anchorage line.
BS EN 360:	Personal protective equipment against falls from a height. Retractable type fall arrestors.

BS EN 1179:	Specification for Zinc & Zinc Alloys.
BS EN 10024:	Hot rolled taper flange I-sections. Tolerance on shape and dimensions.
BS EN 10025:	Specification for hot rolled products of non-alloyed structural steels a their technical delivery requirements.
BS EN 10029:	Tolerance on dimensions, shape and mass of hot rolled steel plat 3 mm thick or above.
BS EN 10034:	Structural steel I and H sections. Tolerance on shape and dimensions.
BS EN 10056:	Specification for structural steel equal and unequal angles
Part 2	Tolerance on shape and dimension
BS EN 10163:	Delivery requirements for surface conditions of hot rolled steel plates, wide flats and sections.
Part 1	General requirements
Part 2:	Plates and wide flats
Part 3:	Sections
BS EN 10210-1:	Hot finished structural hollow sections of non-alloy and fine grained structural steels- Technical delivery requirements
BS DD 133	Code of Practice for strength assessment of members of lattice towers masts.

ANSI/ASCE Std 10-97 Design of Steel Transmission Towers.

APPENDIX 8.E1

FOUNDATION REACTION FORCES

APPENDIX 8.E1/1

132 kV Double Circuit Towers
(Narrow Base Width)
(Including Foundation Strength Factor)

Tower Type	Down Thrust (Along the Leg)	Uplift (Along the Leg)	Horizontal Component	
			Hx (Transverse)	Hz (Longitudinal)
	Kg	kg	kg	kg
1DL	115226	107703	772	772
1D1	190459	177936	3339	3339
1D25	264413	212986	5839	5839
1DT6 (Angle)	340720	258860	5853	5853
1DT6 (Terminal)	375471	433954	6537	6537

APPENDIX 8.E1/2

FOUNDATION REACTION FORCES

132 kV Double Circuit Towers
(Normal Base Width)
(Including Foundation Strength Factor)

Tower Type	Down Thrust (Along **Global** Axis)	Uplift (Along Global Axis)	Horizontal Component	
			Hx (Transverse)	Hz (Longitudinal)
	Kg	kg	kg	kg
1DL	55235	48413	2217	1384
1D1	86118	76892	2669	1351
1D25	115198	104239	4172	2719
1DT6 (Angle)	162422	146903	5836	3858
1DT6 (Terminal)	199634	180032	6079	6410
1DAX	653454	657055	23264	15652
1DR	423418	401070	43473	48594

APPENDIX 8.E1/3

FOUNDATION REACTION FORCES

132 kV Four Circuit Towers
(Normal Base Width)
(Including Foundation Strength Factor)

Tower Type	Down Thrust (Along the Leg)	Uplift (Along the Leg)	Horizontal Component	
			Hx (Transverse)	Hz (Longitudinal)
	Kg	kg	kg	kg
1QL	127705	111399	4118	2449
1Q15	255355	229080	5531	4066
1Q30	306244	279876	6808	5344
1QT6 (Angle)	411063	364820	8929	7790
1QT6 (Terminal)	502180	459627	10039	8044

APPENDIX 8 E1

APPROX. TOWER WEIGHTS

NORMAL BASE WIDTH

It may be mentioned here that the payment for tower shall be made as per unit (per tower) basis as the Price quoted in the Price Schedule. However, no price adjustment shall be made due to increase/decrease of tower weight during execution. As such, bidders are requested to inspect the available structural drawings in PGCB design office and get ensured them regarding tower weight. The drawing list is enclosed in the drawing Section.

Weight are including 3.5% extra for Galvanising

DESCRIPTION	STRUCTURAL WT. KGS.	BOLTS & WT. KGS.	STUB & CLEAT WT. KGS.	TOTAL WT. KGS.	REMARKS
1DL+0 M	4795.01	321.46		5116.47	
1DL+(-) 3 M	4105.16	298.35		4403.51	
1DL+1.5 M Extn.	5096.34	343.21		5439.55	
1DL+3 M Extn.	5666.39	355.5	170.36	6021.89	
1DL+4.5 M Extn.	5982.69	365.43		6348.12	
1DL+6 M Extn.	6524.71	401.54		6926.25	
1DL+9 M Extn.	7588.21	442.05		8030.26	
A. C. D	145.77	5.2		150.97	
BIRD GUARD	9.32			9.32	
1D1+0 M	5824.76	341.02		6165.78	
1D1+(-) 3 M	4794.9	301.44		5096.34	
1D1+1.5 M Extn.	6218.65	353.42		6572.07	
1D1+3 M Extn.	6813.98	393.03		7207.01	
1D1+4.5 M Extn.	7521.34	414.36	256.47	7935.70	
1D1+6 M Extn.	7966.13	437.88		8404.01	
1D1+9 M Extn.	9683.8	489.67		10173.47	
1D1+12 M Extn.	10576.53	530.49		11107.02	
1D1+15 M Extn.	12523.3	592.25		13115.55	
A. C. D	153.05	5.33		158.38	
BIRD GUARD	9.32			9.32	
1D25+0 M	7087.59	391.59		7479.18	
1D25+1.5 M Extn.	7714.83	403.7		8118.53	
1D25+3 M Extn.	8153.86	431.49		8585.35	
1D25+4.5 M Extn.	9134.45	475.54	307.60	9609.99	
1D25+6 M Extn.	9626.67	498.32		10124.99	
1D25+9 M Extn.	10954.75	543.42		11498.17	
1D25+(-) 3 M Extn.	5840.37	337.02		6177.39	
A. C. D	153.55	5.33		158.88	
1DT6+0 M	11926.58	538.34		12464.92	
(ANGLE TOWER)					
1DT6+(-) 3 M	9839.2	472.82		10312.02	
1DT6+1.5 M Extn.	12547.21	561.19	536.88	13108.4	
1DT6+3 M Extn.	13436.41	594.03		14030.44	
1DT6+4.5 M Extn.	15371.66	652.69		16024.35	
1DT6+6 M Extn.	16044.88	663.56		16708.44	
1DT6+9 M Extn.	17855.7	721.68		18577.38	
A. C. D	155.46	5.58		161.04	
1DT6+0 M	11881.38	528.24		12409.62	
(TERMINAL TOWER)			541.84		
AUX. X-ARM	515.59	20.23		535.82	
A. C. D	155.46	5.580		161.04	

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT
FOR THE PROCUREMENT OF
PACKAGE-1: DESIGN, SUPPLY, ERECTION, TESTING & COMMISSIONING OF 132KV TRANSMISSION LINES AND SUBSTATIONS ON TURNKEY BASIS

LOT-1: TRANSMISSION LINES

SECTION 8A

POLES

SECTION 8A

POLES

8A.1 Scope

This specification includes the design, manufacture, galvanizing, testing and supply of 132kV or 230kV telescopic steel self supported double circuit monopoles (suspension and tension pole structure) including cross arms, earth wire peaks, base plates, anchor bolts for foundations, bolts & nuts including washers, hangers, D-shackles and all types of pole structure accessories like number plate, danger plate, anti-climbing device, step bolts including its fixing arrangements and other items not specifically mentioned in this Specification but are required for the successful completion of the job. The poles shall be of hex decagonal uniformly tapered in more than one piece.

No welding is allowed after galvanization.

The bidder shall submit all the technical data, as required in the Schedule of technical particulars & guarantee for the pole.

All information including design calculation, drawings, catalogues, materials standards, welding procedure and standard, fabrication and erection procedure shall be submitted by the Bidder.

8A.1.1 Classes of Poles

Reference shall be made to Appendix 8A.A1 for the classes of pole required.

8A.1.2 Designation of Pole Types

Reference shall be made to Appendix 8A.A2 for the designation and use of the different pole types.

8A.1.3 Standard Height Poles

All standard height poles are those designed to support the conductors at the defined clearance above designated ground under the specified ultimate limit state system loading assuming such poles are at the same level on level ground and at the standard span apart.

Unless specified to the contrary, after taking account of the length of the insulator set all standard height poles shall be arranged so that the point of attachment or suspension of the phase conductors above the ground shall be the same for all pole types.

8A.1.4 Span Criteria

The span lengths specified in Appendix 8A.A4 shall be deemed to be the horizontal distance between centre lines of adjacent support. When a span in excess of the specified maximum span is unavoidable, advice on the application should be obtained from the Engineer.

All angle poles when used with the corresponding maximum angles of deviation and all intermediate type poles shall be used so that the sum of the two adjacent spans stated in Appendix 8A.A4 is not exceeded, provided that no single span length exceeds the specified maximum. Designs shall allow for the adjacent spans of the maximum specified length with one of the spans at the maximum allowed for a single span.

Section type pole may be used at straight line positions where necessary for sectioning and tensioning of the phase conductors and earthwires in a straight run of transmission line route.

Angle poles shall be suitable for minimum weight spans combined with maximum wind span through the full angular range of line deviations for which the angle poles are designed.

8A.1.5 Minimum Conductor Weight at Intermediate Pole

The total weight supported by any intermediate pole suspension insulator set shall not be less than the specified percentage (see Appendix 8A.A4) of the total weight of the corresponding phase conductors in the two adjacent spans. This condition shall apply under the specified loading conditions.

8A.1.6 Angle Poles

For angle poles at the mean angle of deviation, the mean horizontal separation between circuits shall not be less than that of an intermediate type support.

For bundled phase conductors the phase conductor attachment points on each crossarm/gantry shall be arranged to ensure that the nominal horizontal separation between sub-conductors at the tension joint (dead end), is not reduced by more than 25 mm.

8A.1.7 Terminal Poles

Terminal Poles shall provide the corresponding separation at the specified line entry. Additional phase conductor attachment points shall be provided at the specified angles of entry. Additional crossarms for down-leads or for use in junction arrangements with full phase tension shall be provided when required.

8A.1.8 Pole type, length and shape

Each monopole shall be suitable to support 6 (six) conductors in vertical configuration & one earthwire equivalent OPGW for 132kV double circuit poles. Please refer to relevant Appendix for further details about pole type, length and shape.

Conductor cross-arm shall be of cantilever steel type, octagonal cross-section, connected by bolted flange.

Pole shall be connected with foundation chimney (Chimney top shall be at 300mm above GL) above GL with properly designed anchor bolt, base plate and stiffener system.

Maximum base diameter of the heaviest pole shall not exceed 2m.

8A.2 DESIGN

8A.2.1 General

Poles shall have the general arrangements and configurations shown in the drawings included with the Specification. They shall be designed to resist the specified system loading taking into consideration the required strength co-ordination factors. Clearances between live parts and supporting steelwork and between the phase conductors and ground or other obstacles shall be as specified.

All pole designs shall be such as to facilitate inspection, painting, maintenance, repairs and operation with the continuity of supply being the prime consideration.

The design shall be such that the number of different parts shall be as few as possible to facilitate transport, erection and inspection. The maximum weight of the heaviest section should be limited to that within the normal lifting capability of the proposed erection equipment.

Where fabrication processes employed adversely affect the material properties, or introduce zones of high stress concentration the overall design of the structures shall take such factors into account.

8A.2.2 Attachments to Poles

The attachment of phase conductors, earthwires and erection/maintenance brackets shall be undertaken as follows;

(a) Intermediate Lattice Steel Poles

i) Suspension insulator set and earthwire attachments shall be of an approved swivel or shackle arrangement;

ii) Adjacent to and either side of all suspension insulators set attachment points, additional maintenance points shall be provided, capable of resisting the specified construction and maintenance (C&M) load;

iii) Adjacent to the earthwire suspension set attachment point, an additional maintenance point shall be provided, capable of resisting the specified C&M load;

iv) At each pole body crossarm connection point maintenance plates/brackets shall be provided for the attachment of rigging blocks, capable of resisting the specified C&M load;

v) Where it is proposed to erect complete sections of the pole by crane or helicopter then permanent lifting points shall be provided.

(b) Angle/Tension Lattice Steel Pole

i) Tension insulator set attachments shall be of an approved swivel or shackle arrangement;

ii) Adjacent to and either side of all tension insulator set attachment points, additional maintenance points shall be provided, capable of resisting the specified C&M loading. The additional maintenance points shall provide the necessary mountings for stringing and maintenance equipment;

iii) Adjacent to all tension insulator set attachment points, a vertical maintenance attachment point shall be provided, capable of resisting either the specified C&M loads or that imposed by the use of a conductor stringing platform;

iv) Adjacent to the earthwire tension set attachment point, an additional maintenance point shall be provided, capable of resisting the specified C&M loads;

v) At each pole body crossarm connection point maintenance plates/brackets shall be provided for the attachment of rigging, blocks, capable of resisting the specified C&M loads.

All pole general arrangement drawings and/or erection diagrams shall clearly indicate the safe working, load capacities of all maintenance points.

8A.2.3 Loading Conditions

Poles shall be designed in accordance with the provisions of this specification and relevant Appendices at end of this Section.

The poles shall be designed and dimensioned for maximum simultaneous load. The design load shall be calculated as per standard codes of practice taking into following load assumptions:

i. Maximum working tension (MWT) for conductor and earthwire (OPGW) shall be applied 35% of ultimate tensile strength (UTS).

ii. Maximum operating temperature shall be of 80°C and minimum temperature shall be of 5°C.

iii. Maximum wind on conductor and earthwire shall be of 41.2m/sec (10 minute mean wind speed at 10m elevation). Effect of height on wind speed shall be considered as per criteria given in Climatic loading.

The effect of oblique wind 30° & 45° shall be considered in addition to 0° in normal condition. All tower load cases shall be considered in minimum and maximum angles.

8A.2.4 Climatic Loading

The climatic loadings on the conductors and insulators have been calculated using the following expressions:

The Contractor shall apply the reliability factor such as $K_1 = 1.15$ to calculate for climatic loadings.

(a) Conductors

$F_c = q_{des} C_f A \cos^2 \varphi$

where:

q_{des} = design wind pressure including height and spatial effects (kg/m^2)

$= q_0 \alpha K_1$

$q_0 = 1/2 \rho V^2$

$\rho = 0.12$

Conductor: V (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = 41.2m/s

Earthwire: V (Average wind) x 1.1

$\alpha = (H/10)^{1/n} \rightarrow (n=5)$

H = Conductor average height and earthwire height

C_f =Force coefficient

=1.00 Conductors & Earthwire

A = full projected area perpendicular to the wind (m^2)

φ = angle of incidence of the wind to the conductors.

Note: The effective force is perpendicular to the conductor.

The total effect of the wind upon bundle conductors will be equal to the sum of the actions on the individual sub conductor.

(b) Insulators

$F_I = q_{des} C_f A$

where:

q_{des} = design wind pressure including height and spatial effects (kg/m^2)

$= q_0 \alpha K_1$

$q_0 = 1/2 \rho V^2$

$\rho = 0.12$

V (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = 41.2m/s

$\alpha = (H/10)^{1/n} \rightarrow (n=5)$

H = Insulator average height

C_f = Force coefficient (1.4)

A = area of insulator perpendicular to the wind (m^2)

(c) Lattice Towers

For lattice towers the following formulae shall be used to calculate the wind loading on the tower.

$$F_t = q_0 K_1 \{H/10\}^{\alpha} (1+0.2\text{Sin}^2 2\varphi) (A_1 C_{f1} \text{Cos}^2\varphi + A_2 C_{f2} \text{Sin}^2\varphi)$$

where:

$q_0 = 1/2 \rho V^2$

$\rho = 0.12$

V (Average wind) = wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years = 41.2m/s

H = height to the centre of pressure of the panel (m) under consideration, except High Intensity Local Wind load case

α = 0.2 for all load cases except High Intensity Local Wind load case

=0.2 for High Intensity Local Wind load case where H=h, h=total height of the tower

φ = angle of incidence of the wind to face 1

A_1, A_2 = area of members in face 1 and 2

C_{f1}, C_{f2} = Force coefficient for faces 1 and 2

For flat sided members $C_{ff} = 3.96 (1-1.5Ø + Ø^2)$

Ø = solidity ratio

For circular section members $C_{fc} = 2.25 (1-1.5Ø + 3.125Ø^2)$

For mixed construction $C_f = C_{ff} \frac{A_f}{A} + C_{fc} \frac{A_c}{A}$

where: A = total area of members, A_f area of flat sided members and A_c area of circular members.

Note: 1) Where access ladders are fitted, they should be included in the respective face area;

2) For horizontal formation towers between the gantry and the waist, for any wind direction apart from 'longitudinal' both inner and outer transverse faces should be considered;

For non symmetrical towers, the formulae given in (c) shall not be used, but either single or multi-frames shall be considered.

(d) Single frames

$F_f = q_0 K_1 \{H/10\}^{\alpha} C_f A \cos^2 \varphi$

where

$q_0 = 1/2 \rho V^2$

$\rho = 0.12$

V (Average wind) as per IEC 60826= wind speed at 10m height, corresponding to an averaging period of 10min. having a return period of 50years= 41.2m/s

$\{H/10\}^{\alpha}$ = as defined in (c)

A = area of the members in the frame

C_f = force coefficient factor defined below:

$[1.58 + 1.05(0.6 - Ø)^{1.8}] \times [\frac{A_f + (0.6 + 0.4 Ø^2 A_c}{A}]$ for $Ø \leq 0.6$

where

A_f = area of flat sided members (m^2)

A_c = area of circular members (m^2)

Ø = solidity ratio

For multi-frames the shielding of the 2nd frame should be considered, utilizing the expression:

$A = (A_1 + \eta A_2)$

where

A_1 = area of frame 1 determined above

A_2 = area of frame 2 determined in accordance with the above

η = shielding factor

$= \eta^1 + 0.15 (\omega - 1) (Ø - 0.1)$ but ≤ 1.0

$\eta^1 = (1 - Ø)\ 1.89 \left(\frac{A_f + 0.83A_c}{A}\right)$ but ≤ 1.0

ω = spacing ratio

8A.2.5 Normal Load Condition

Transverse Loading

Wind pressure at right angles to the lines on the whole projected area of conductors and groundwires of the specified lengths (wind spans), pole and pole accessories, insulators and all other fittings and the transverse components of the maximum working tensions of conductor & earthwire due to maximum horizontal deviation angle of the line.

Vertical Loading

The weight of all insulator & fittings, conductor & earthwire, Poles alongwith crossarms, cross braces, etc. plus a load of 150kg regarding the weight of a lineman with tools.

Eccentric Loading

Poles shall be checked for eccentric loading caused by stringing of conductor for one circuit and one earthwire on one side of the pole. In checking the poles for this kind of loading the loads mentioned above for vertical, transverse and longitudinal loads shall be considered for three conductors and groundwire on one side of the pole in addition to wind on pole and weight of pole.

8A.2.6 Two conditions of security loadings have been considered in the design of the Poles:

(a) Broken Wire Conditions

Poles shall be designed for conditions of any two phase conductor broken or one earthwire and any one phase conductor broken.

The maximum tension of the phase conductors and earthwire for unbalanced longitudinal loads due to breakage of phase conductors and groundwire shall be considered 70% of their maximum working tensions.

Poles shall be designed to keep safely the torsional moment from the phase and earth conductors string forces on one circuit.

All attachment points with no broken wire load shall have the vertical, transverse and longitudinal loads as specified under normal loading condition. The points with broken wire longitudinal loads shall have the vertical and transverse loads due to the broken wire weight and wind spans together with the transverse component of the phase or ground wire from the unbroken span.

Each pole shall be designed so that no failure or permanent distortion occurs when tested with applied forces considering the safety factors as mentioned in Clause hereunder.

(b) Anti Cascade Condition

1D25P and 1DT6P poles shall be checked for the following anti cascading conditions with all conductor and earthwire intact only on one side of the pole:

(i) Transverse loads

These loads shall be taken no wind condition for tensions of conductor/earthwire under everyday temperature due to the maximum horizontal angle deviation of the line.

(ii) Vertical loads

These loads shall be the sum of weight of conductor/earthwire as per weight span of intact conductor/earthwire, weight of insulator strings and accessories.

(iii) Longitudinal loads

These loads shall be the pull of conductor/earthwire at everyday temperature and no wind applied simultaneously at all points on one side with zero degree line deviation.

8A.2.7 Downlead Tensions

The maximum downlead tension shall be as specified in Appendix 8A.A5. However, for the purpose of tower design they shall be assumed to be zero except where the vertical load component increases the stresses in pole section. These tensions shall be assumed to apply at both ends on low duty tension insulator sets.

8A.2.8 Down droppers to Substation Equipment

The design of down droppers shall take into account the limiting strength of substation equipment specified in Appendix 8**.**A5**.**

8A.2.7 Overload Factor

Related to the loads applied the following minimum overload factors under maximum simultaneous working loads shall apply.

Description	Normal Condition	Broken Wire Conditions
Overload factor based on elastic limit to design Pole, connection of pole with foundation	2.0	1.5
Foundation strength factor (to be multiplied with ultimate pole reaction)	1.23	1.23

8A.2.8 Elastic Deflection

The maximum pole top deflection shall be of 2% of the overall length at all load cases without overload factors.

8A.2.9 Design Criteria for Cross-Arms and Fittings

The pole cross-arms shall be designed as per requirement given in clause 11 under all specified loading condition.

All pole fitting, including nuts and bolts shall be hot dip galvanized in accordance with the BS 729:1971. The zinc coating shall be smooth clean and of uniform thickness and free from defects. All drilling punching cutting shaping and welding of parts shall be completed and burrs shall be removed before the galvanizing process is applied.

All fittings shall have the identification code number directly marked with indelible paint after galvanizing.

The permitted variation from stated dimension shall be as follows except mentioned otherwise.

Material sizes: +/-1mm

Any welding shall be carried out in accordance with the procedures of an international standard approved by PGCB and these procedures tested in accordance with AWS standard. All welding shall be continuous and shall be of a size and type capable of developing the full strength of the parent metal without permanent distortion in the finished fitting.

8A.2.10 Electrical Clearances - Live Metal and Earthed Steelworks

Minimum clearance between live metal and earthed steelwork shall be in accordance with the requirements of Appendix 8A.A7.

8A.2.11 Anti-Climbing Devices

Each support shall be fitted with an approved type of anti-climbing device as specified in Appendix 8A.A8. The height of the anti-climbing device shall be adjustable and shall be within the limits specified in the Appendix.

Where specified the anti-climbing device shall be provided with a hinged section where access for personnel is required. The hinged section shall be capable of being bolted and locked in the closed position with either a bolt, nut and locknut or a padlock. In the open position, no projection to impede safe access shall be permitted.

In no case shall an anti-climbing device be installed where it can be bypassed from a side slope or internal bracing.

Barbed wire type anti-climbing devices shall comply with the following requirements:

(a) Barbed wire shall be of the mild steel type with high security long barbs 15 mm long set at 50 mm spacing, but in all other respects the barbed wire shall comply with BS 4102, Section 4;
(b) For lattice steel towers the minimum distance between strands or between strands and horizontal tower member/pole sections shall not be less than 150 mm;
(c) No unprotected space greater than 230 mm across shall be left inside the device;
(d) Spacers shall be fitted at 1.5 m intervals and shall be attached to tower members where possible;
(e) Normally 5 strands of barbed wire are required outside the tower face and 3 strands inside;

Spiked type anti-climbing devices shall comply with the following requirements:

(a) The minimum spike diameter shall not be less than 10 mm, and shall project horizontally 50 mm and curve vertically down by 40 mm.
(b) Where spikes are bolted to the support frame the spike threads must be clenched after installation.

8A.2.12 Bird Guards

Where specified bird guards of an approved type shall be fitted to intermediate towers fitted with suspension insulator sets. The bird guard shall either comprise a saw-tooth plate, or a length of earthwire suitably de-stranded and splayed out at each end and clamped to the cross arm member.

8A.2.13 Access Facilities

Each support shall be fitted with approved access facilities as specified in Appendix 8A.A8. The following requirements for specific types of access facilities shall apply as appropriate.

(a) Ladders

i) Ladders shall be fitted between specified levels, support faces and either externally or internally;
ii) Ladders shall be in accordance with BS 4211, 350 mm between internal faces and 300 mm rung spacing;
iii) Rest platforms shall where specified be fitted at approximately 10m height increments with the rest platform 850 mm square and fitted with a guard rail (1000 mm above the platform), intermediate rail and toe board (projecting 100 mm);
iv) Ladders shall project 1100mm above platforms, unless other hand holds are provided and shall be between 150 to 230 mm from the platform where side access to the platform is provided.

8A.2.14 Danger and Identification Plates

All towers shall be fitted with danger and identification plates as specified in Appendix 8A.A8.

8A.2.15 Design Calculations

The Contractor shall submit the following design calculations to the Engineer:

(a) wire clearance diagram;
(b) line diagram;
(c) pole design calculations (in an approved format) indicating the applied loading alongwith calculation, loading tree, body wind load calculation, the design load for each section under the critical loading case, allowable load etc; Pole shall be design by using PLS-Pole software version 12.1 or earlier. The Contractor will require submitting the backup file of pole design, spread sheet for loading calculation (with formula) and all drawings in Auto CAD format during the submission for approval.
(d) wire clearance diagrams for each terminal and junction position.

The Contractor shall not proceed with any pole prototype test until after the approval of the design calculation. This is a **Hold Point.**

8A.2.16 Standards

The poles and fittings specified herein shall conform to the latest version of the appropriate recognized international standards in particular.

BS 729 – 1971	:	Hot dip galvanized coatings on iron and steel articles.
ISO	:	Bolts, nuts & washers.
BS 4360	:	Specification for weldable structural steel.

Design of members and connection to foundation (with anchor bolt, base plate and stiffener) shall have to be in accordance to ASCE/SEI 48-05.

8A.2.17 Material and Fabrication

8A.2.17.1 General

All materials shall be new and conform to the relevant standard specifications referred to in this specification.

8A.2.17.2 Materials

The minimum yield strength of steel to be used for manufacture of pole shall be 355 N/mm^2 as per ASCE/SEI 48-05.

All type of pole fittings and accessories shall be manufactured from steel having minimum yield strength of 245 N/mm^2 as per ASCE/SEI 48-05.

8A.2.17.3 Fabrication

All welding of the poles shall be carried out at the manufacturer's plant. No site welding will be permitted.

Welds shall be parallel to the longitudinal axis of the pole and shall be fillet welds or full penetration butt welds. All welds shall be capable of withstanding, without failure or cracking the stresses in a pole when subject to its ultimate design load. Only two longitudinal welding is allowed for each section of pole. No circumferential welding is allowed.

Dimensional Tolerances:

The tolerance on thickness -0% +10% on each sheet.

After assembly telescopic poles shall not exceed to their stated length by ±125mm and their out of straightness shall not exceed 1/300 of their height. The minimum thickness of the material shall be 3mm for a length of 3.0 meters from the bottom end. The design of pole shall be on the basis of minimum values considering tolerance.

8A.2.17.3.1 Presswork/Bending

All bends in Grades S355JO and S355J2G3 steel over 90 in 1000 shall be made hot within the temperature range of 850 to 1000 degrees Celsius, but normal cold correction will be permitted. Means shall be provided for the random checking of temperatures (Tempilstiks or Pyrometer).

Bends in Grades S235JRG2 and 275JR steel plates up to 10 mm thick may be made cold up to an including 1175 in 1000.

Bends, open and close flanges in angle sections may be made cold up to and including 600 in 1000.

However, in both of the above cases, the Contractor shall take adequate precautions to avoid the risk of subsequent galvanising embrittlement.

Bends shall be of even, profile and free from surface damage due to press tools indentations.

The formation of bends by the 'cut and weld' method unless specified on the drawings, is not permitted without prior approval of the Employer**. This is a Hold Point.**

8A.2.17.3.2 Welding

All welding shall be carried out in accordance with BS EN 61011-1 and -2.

Pre-heating, where required, shall be checked by the use of Tempilstiks or similar over an area of 150 mm either side of the weld area.

Assembly welds (tacks) shall be carried out to the same procedures and welding conditions as the main welds and shall be at least 50 mm long.

Stop-start positions shall be kept to a minimum and shall be kept clear by a minimum of 25 mm of all corners and edges of plates (i.e. the weld must be laid down continuously at these points). Where the first run in multi-run welds is larger than subsequent runs, welding should continue until completed, thereby ensuring the weld area is not allowed to cool. After completion the unit should be allowed to cool slowly and should not be subjected to draughts or low temperatures.

Where materials are to be galvanised, all welds shall be continuous so as to ensure a pickle-tight connection and shall be thoroughly cleaned (preferably by shot-blasting) to remove all slag, manganese (Carbon Dioxide welding), and weld splatter.

8A.2.17.4 Corrosion Protection

All poles internally and externally are to be hot dip galvanized in accordance with BS 729.

Any galvanized surface of the pole damaged after delivery and within the warranty period shall be scrapped back to a firm base and two full thickness coats of zinc rich primer applied to the damaged area and overlapping the

sound galvanizing by ten (10) mm. If in the opinion of PGCB the damage to the galvanizing is extensive then that pole shall be removed from site and re-galvanized.

After galvanization of poles the external surface of all poles below ground level and 500mm above ground level shall be painted as follows:

a) After cleaning with brush and degreasing, one coat of phosphoric acid based etch primer shall be applied internally and externally.
b) One coat airless spray of coal tar pitch epoxy paint for a dry film thickness of 1 × 100 microns shall then be applied on the inner surface of poles.
c) Two successive coat airless spray of coal tar pitch paint for a dry film thickness of 2 x 100 microns shall be applied on the outer surface of poles.

8A.2.17.5 Marking of Pole

The poles shall have an identification directly marked with indelible paint on the pole at a position approximately 5.0 meters from the bottom end which is clearly and indelibly marked with:

a) Date of manufacture and identification mark of manufacturer.
b) Length of pole in meters.

The pole shall also be marked with a permanent horizontal line at G.L. All male sections shall be marked with permanent horizontal line at the respective overlapping length from the top.

8A.2.17.6 Earthing, Base Plate and Pole cap

Each pole shall be self supporting structure of hexadecagonal tapered steel pole connected to foundation with base plate, anchor bolt and stiffener and shall be provided with pole cap. Attachment holes for the connection of the ground earthing conductor shall be provided on all poles adjacent to the base plate & anchor bolt connection and near top of the pole for earthing bond connectioin. The material of the base plate and pole cap shall be galvanized steel and minimum thickness of pole cap and base plate shall be 2.0mm & 6.0mm respectively. The base plate shall have proper fixing arrangements for easy fixing at site. The size of the base plates shall be min. 800 × 800mm.

8A.2.17.7 Earthing Materials

Each set of monopole shall be supplied with a set of the required earthing materials whose cost shall be included in the price of monopoles.

8A.2.17.8 Assembly of Telescopic Poles

Each pole shall be assembled in the factory and prior to assembly all seam welds on joint mating surfaces shall be ground flush. All spots in the galvanizing on mating surfaces shall be ground and/or filed flat and if the galvanizing is damaged it shall be repaired.

During the application of the compressive load to force the sections together the joints shall be agitated by striking them with wooden or rubber mallets or by any other method as approved by PGCB. The galvanized coating shall not be damaged by this method of assembly.

8A.2.17.9 Anti-Climbing Devices, Danger and Identification Plates

As soon as practical after completion of support erection, anti-climbing devices, danger and identification plates in accordance with the requirements of specification shall be fitted.

All ladders and temporary step bolts below the anti-climbing device shall be removed when erection work is not in progress.

8A.3 Proof test

These shall be carried out before full scale manufacture of pole commences, after any changes are made to the approved design of pole; or at any time Employer considers necessary to confirm that the pole still satisfy the design requirements.

Full scale proof test of a shall be performed on poles as specified in the Appendix. The pole shall be similar in all essential features or design and construction to those purchased.

The test arrangements shall confirm ASCE 48-11 section 8 with the specific details stipulated in this section.

Test Load:

Test loads shall be the design loading trees of the following two loading combinations-

a) Everyday Loading (T30 + no wind) Vertical maximum- Stage 1 load

b) Normal Operating Condition (T5+Full wind 22.5º)- Stage 2 load

Test Load Application:

The test shall be carried out in 2 stages:

a) Stage 1

The load shall be gradually and uniformly applied in increments of 40% to 100% of the serviceability limit state design load up (Everyday condition loading combination maximum vertical).

The 100% loading shall be maintained for 5 minutes. The load shall then be gradually reduced to zero.

The amount of pole top deflection (pole shaft and the conduction, earthwire attachment point) at 100% loading (at 1st minute and 5th minute) and after the load release shall be recoded.

b) Stage 2

The test load shall be gradually re-applied up to the 100% of the maximum ultimate limit state load (Normal Operating Condition 22.5º Wind maximum vertical loading combination) and the deflection recorded. The load shall be increased in 20% increments from 0% to 100%.

The 100% loading shall be maintained for 1 minute.

At each load increment the load and deflection shall be recorded.

Test Report:

The following particulars shall be recorded for each test made:

a) Manufacturers name and plant location
b) Pole classification and type.
c) Dimension of the pole.
d) Date manufactured.
e) Date tested.
f) Increments of load
g) Deflections at each increment of load (for both 1st and 2nd stage loading).
h) Permanent defection after removal of 1st stage loading.
i) Load at failure.
j) Nature of failure.
k) Video of the along the axis of the pole at design working and ultimate loads plus photographs of the failure zone on the pole.

Acceptance Criteria:

The poles shall be considered acceptable if:

a) Deflection of the pole shaft top at 100% Stage 1 loading is less than the diameter of the pole shaft top.

b) Residual deflection of the tip of the pole and the crossarm ends (conductor, OHEW, OPGW) after the 1st stage test loading is removed does not exceed 100mm.

c) Deflection of the pole shaft top at 100% Stage 2 loading is less than 5% of the pole height above ground.

d) The pole shall withstand the 100% Stage 2 loading without any type of failure. No material or component shall be deformed under Stage 1 and Stage 2 loading.

8A.4 Failure to satisfy acceptable criteria

Failure Condition	**Remedial Action**
Does not meet condition "a" above	Design and test shall be rejected. Revised design and test shall be required.
Does not meet condition "b" above	Design may be considered as acceptable provided that, a) All other conditions are satisfied b) The foundation is designed for additional moment generated by twice the measured residual deflection.
Does not meet condition "c" above	Design and test shall be rejected. Revised design and test shall be required.
Does not meet condition "d" above	Design and test shall be rejected. Revised design and test shall be required.

8A.5 Apart from the above, following tests/check shall be done on the poles:

8A.5.1 During Proof Test

1. Checking of dimensions and the weight of each type of individual segments.
2. Checking of the Dimension and the weight of the Assembled Pole, crossarms and the Fittings as per approved drawing.
3. Testing of the thickness of the Zinc coating.
4. Chemical composition test for Carbon, Sulfur and phosphorus contents.

8A.5.1 After Mass Fabrication (before despatch) – 10% of each shipment

1. Checking of dimensions and the weight of each type of individual segments.
2. Assembly test and checking of the Dimension and the weight of the Assembled Pole and the Fittings as per approved drawing.
3. Testing of the thickness of the Zinc coating.
4. Chemical composition test for Carbon, Sulfur and phosphorus contents.

APPENDIX 8A.Al

CLASSES OF POLE

The steel poles requires in this Project is as follows:

1. 132kV double circuit three phase in vertical formation telescopic steel poles with Grosbeak (636 MCM ACSR) phase conductors and one 7/3.25 steel earthwire equivalent OPGW.

APPENDIX 8A.A2

DESIGNATION & USES OF POLES

Designation		**Angle of Deviation/Entry**	**Description**	**Type of Insulator Set**
132kV				
1DLP		0°-1°	Intermediate	Suspension
1D1P		0° - 3°	Angle	Heavy Suspension
1D25P		0° – 25°	Angle/Section	Tension
1DT6P		25° – 60°	Angle	Tension
		0° – 30° (angle of entry)	Terminal	Tension
1D9P		60° – 90°	Angle	Tension

APPENDIX 8A.A3

EXTENSIONS

NOT USED

APPENDIX 8A.A4

APPENDIX 8A.A4.1

SPAN CRITERIA

1.0	**Climatic Loadings and Security Loadings (Intact Conditions)**					
1.1	**Suspension & Tension Pole**					
					230kV	**132kV**
(a)	Wind span (A)			(m)	-	165
(b)	Maximum weight span	Suspension Pole		(m)	-	263
		Tension Pole		(m)	-	300
(c)	Minimum weight span	Suspension Pole		(m)	-	105
		Tension Pole		(m)	-	zero
1.2	**Terminal Pole**					
(a)	Wind span (A)	-		(m)	-	165
(b)	Maximum weight span	-		(m)	-	263
(c)	Minimum weight span	-		(m)	-	zero
1.3	**Unbalanced tension in front and back span in Normal Condition**					
(a)	Suspension & Heavy Suspension Pole	3% of maximum working tension of conductor & earthwire				
(b)	1D25P Pole	33% of maximum working tension of conductor & earthwire				
(c)	1DT6P Pole	33% of maximum working tension of conductor & earthwire				
2.0	**Security Loadings (Broken Wire Conditions)**					
2.1	**Suspension & Tension Support**					
(a)	Wind span (A)			(m)	-	124
(b)	Maximum weight span	Suspension Poles		(m)	-	198
		Tension Poles		(m)	-	225
(c)	Minimum weight span	Suspension Poles		(m)	-	79
		Tension Poles		(m)	-	zero
2.2	**Unbalanced Tension to be Considered**					
(a)	Suspension Poles	0.6 x Max. working tension of Earthwire. 0.6 x Max. working tension of Conductor.				
(b)	Tension Poles	1.0 x Max. working tension of Earthwire. 1.0 x Max. working tension of Conductor.				

2.0	**Security Loadings (Cascade Conditions)**			
3.1 Suspension & Tension Poles				
(a)	Wind span (A)		(m)	zero
(b)	Maximum weight span	Tension Towers	(m)	225
3.2 Unbalanced Tension to be Considered				
(a)	Tension Poles	100% of conductor and earthwire tensions under everyday temperature and no wind		
4.0	**Broken Wire Assumption**			
4.1	**Suspension & Heavy Suspension Pole**			
(a)	Earthwire/OPGW is broken. However, earthwire/OPGW is not broken with conductor at the same time			
(b)	Both the conductors of one phase are broken.			
4.2	**Tension Poles**			
(a)	One earthwire and both the conductors of one phase of same side with the earthwire are broken.			
(b)	Two phases (including both conductors per phase) of the same side are broken. However 4.2(a) and 4.2(b) shall not occur at the same time.			

Note (A): All specified wind spans have been adjusted for spatial effects using the expression (wind span x 0.75 + 30m) for pole design purposes.

APPENDIX 8A.A5

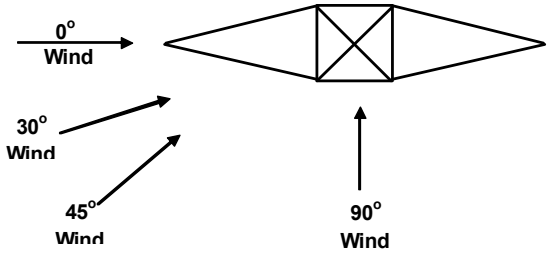
APPENDIX 8A.A5/1

ASSUMED SYSTEM LOADING CRITERIA

132kV poles will be designed as per loading criteria specified in this specification.

The Contractor's attention is drawn to the requirements of this specification with regard to Construction & Maintenance loading.

Wind directions are as shown in the sketch:



APPENDIX 8A.A5-2

SLACK SPAN AND DOWNLEAD TENSIONS

Maximum phase conductor slack span and downlead tension (per sub-conductor)	7.0 kN
Maximum earthwire slack span and downlead tension	4.5 kN
Maximum Slack span	70m

The above conditions apply under the specified MWT conditions as defined in Conductor specification.

APPENDIX 8A.A6

MINIMUM THICKNESS & DIAMETER OF MATERIAL

Not used

APPENDIX 8A.A7

1. ELECTRICAL CLEARANCES - LIVE METAL & EARTHED STEELWORK

Please refer to the electrical clearance criteria for 132kV towers to be used for this project.

2. SPATIAL DISTANCES

			132kV Pole
(a)	Minimum height of phase conductors at the support on standard height, from ground level	(m)	17.0
(b)	Minimum shielding angle of the earthwire (still air) from the vertical	(degrees)	30°
(c)	Maximum swing of the earthwire from vertical	(degrees)	85°
(d)	Minimum vertical spacing between adjacent phases	(m)	4.0
(e)	Minimum projected horizontally spacing between adjacent phases spaced vertically	(m)	-
(f)	Minimum vertical spacing between phase conductor and earthwire	(m)	3.2
(g)	Minimum horizontal spacing between adjacent phase conductors spaced horizontally.	(m)	-

3. DOWNLEAD CLEARANCES

(a)	The minimum clearance in still air at the assumed maximum conductor temperature between adjacent downleads shall not be less than.	m)	4.2
(b)	In exceptional circumstances and with the approval of the Employer, based on the condition of maximum (opposing) conductor swing and sag, the clearance may be reduced to.	(m)	-

APPENDIX 8A.A8

		Required / Not Required
1.	**ANTI-CLIMBING DEVICES (ACD)**	
(a)	Barbed wire type at a minimum height above ground level …….. (m)	Not required
(b)	Spiked type at a minimum height above ground level ……..(m)	3.0m
(c)	Ladder.	Required above ACD
2.	**ACCESS FACILITIES**	
(a)	Step bolts fitted between	Not used
(b)	Ladders fitted between	Required
(c)	Rest platforms	Not used
(d)	Work platforms	Not used
(e)	Fall arrest system	Not used
3.	**DANGER & IDENTIFICATION PLATES**	
(a)	Danger Plate	Required
(b)	Pole Number, Circuit Identification & Phase Color Plate.	Required

APPENDIX 8A.A9

QUALITY CONTROL WELD INSPECTION LEVELS

Level 1:	All welded items not covered by higher level of inspection
Level 2:	
Level 3:	Conductor attachment fittings for all types of towers.

APPENDIX 8A.A10

POLE TEST REQUIREMENTS

132kV Poles

PROOF TEST

1DT6P
1D9P

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT
FOR THE PROCUREMENT OF
PACKAGE-1: DESIGN, SUPPLY, ERECTION, TESTING & COMMISSIONING OF 132KV TRANSMISSION LINES AND SUBSTATIONS ON TURNKEY BASIS

LOT-1: TRANSMISSION LINES

SECTION 9

INSULATORS

SECTION 9 INSULATORS

CONTENTS

SECTION 9 INSULATORS

9.1 SCOPE

Both the type of insulator unit and insulator set, whether suspension or tension used on each type of support shall be approved, and shall have proven use under similar environmental and operational conditions.

Insulator strings shall comprise of porcelain disc insulator units. All types of insulators to be supplied under this Contract shall be supplied from the same manufacturer.

Reference shall be made to Appendix 9.A1 for details of the specific requirements. Where specified porcelain insulators shall be glazed Munsell Grey in accordance with BS 5252 or equivalent.

9.2 DESIGN

9.2.1 General

All insulator units shall be designed to withstand the design service voltages including lightning, switching and power frequency, the mechanical loads relevant to the installation-service-maintenance conditions, the service temperature and environmental effects. Internal stresses due to expansion and contraction of any part of the insulator unit shall not lead to deterioration.

The design of insulator units shall be such as to avoid local corona formation and no significant radio interferences shall be exhibited. Cap & Pin insulator units shall comply with the general requirements of the IEC 60305 standard, except where specified otherwise in this Specification and insulator units shall have straight head design to avoid concentration of mechanical stress. Cross section sketch of insulators unit showing the head design is included in the enclosed drawing in Section 19.

Pin and Cap

(i) Pin and Cap shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric, of such design that it will not yield or distort under load conditions.

(ii) The pin ball shall move freely in the cap socket but without danger of accidental uncoupling during erection or in position. The design of the disc should be such that stresses due to expansion or contraction in any part of the insulator shall not lead to deterioration.

Security clip

(i) Security clip for use with ball and socket coupling shall be of R-shaped hump type which shall provide positive locking of the coupling as per IEC: 60372. The legs of the security clips shall be spread after installation to prevent complete withdrawal from the socket. The locking device should

be resilient, corrosion resistant and of suitable mechanical strength. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall locking device allow separation of insulator units or fittings.

(ii) The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of clip may be engaged by a hot line clip puller to provide for disengagement under energised conditions. The force required to pull the security clip into its unlocked position shall not be less than 50N (5 kg) or more than 500N (50 kg).

Insulator units shall have straight head design to avoid concentration of mechanical stress. Cross-section sketch of insulators unit showing the head design is included in the enclosed drawing in drawing section.

9.2.2 Electrical and Mechanical Characteristics

The individual insulator units shall be complete insulator sets shall have the electrical and mechanical characteristics stated in Appendix 9.A2.

9.2.3 Couplings

Couplings between individual insulator units shall be as specified in Appendix 9.A1. Ball and socket couplings shall be in accordance with the requirements of IEC 60120. Sockets shall either have W type security clips, or a split pin (R) clip in accordance with the requirements of IEC 60372 as specified.

9.2.4 Pollution

The design of insulator units shall take into account the principles contained in IEC 60815 for the specified pollution category. However, minimum creepage values (mm/kV) shall be as specified.

9.2.5 Zinc Sleeve

Cap and pin insulator units shall where specified be fitted with zinc sleeve pins to prevent cracking due to pin corrosion caused by the effects of pollution and high humidity. The exposed part of the sleeve shall have a mass of at least 5(five) gram and metallurgic alloy bonded to the insulator pin. The bonded area of sleeve shall be a minimum of 80% the sleeve/pin interfacial area in accordance with IEC 61325.

9.2.6 Insulator Protective Device

The design of insulator protective fittings including corona shields shall comply with the following requirements:

(a) Shall effectively protect the insulator units, and the fittings from damage caused by power arcs;

(b) shall effectively improve the voltage distribution along the insulator string;

(c) shall effectively improve the corona performance of the insulator set;

(d) shall be designed in such a way as not to be subject to breakage fatigue due to wind induced vibration;

(e) shall withstand a specified mechanical load.

(f) shall be suitable where specified for live-line maintenance.

For details of the materials, workmanship and quality control requirements for insulator protective fittings reference shall be made to Section 10 of this Specification.

9.2.7 Low Duty Insulator Sets

Low duty tension sets shall be used for the downleads between terminal supports and substation gantry structures or other positions where the conductor tensions are of a reduced value. At the lower end of the downleads the low duty tension sets shall be capable of having their units reversed.

9.2.8 Tension Insulator Sets-Earth End Linkages

Additional earth end adjustable linkages shall be provided where necessary to ensure that either the specified clearance is maintained between the tension insulator set and the support body/crossarm, or that satisfactory pairing is achieved between the phase sub-conductors.

9.2.9 Corona and RI Performance

All surfaces must be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localised pressure. The metal parts shall be so designed and manufactured that it shall not generate any Radio Interference beyond specified limit and not produce any noise generating corona under the operating conditions.

9.2.10 Interchangeability

The disc insulators inclusive of the ball and socket fittings shall be of standard design suitable for use with the hardware fittings of any manufacturer conforming to relevant International Standards.

9.2.11 Maintenance

(i) The disc insulators offered shall be suitable for employment of hot line maintenance techniques so that the usual hot line operations can be carried out with ease, speed and safety.

(ii) Bidders shall indicate the methods generally used in the routine hot and dead line maintenance of EHV Lines for which similar disc insulators have been supplied by them. Bidders shall also indicate the recommended periodicity of such maintenance.

9.3 MATERIALS

9.3.1 Porcelain

High grade, wet process porcelain used in the manufacturer of insulator units shall comply with the requirement of IEC 60672. The porcelain used in the manufacture of shells shall be sound, free from defects thoroughly vitrified.

9.3.2 Glaze

Where specified porcelain insulators shall be glazed Munsell Brown or Grey in accordance with ANSI Z55.1. The glaze shall cover all exposed parts of the insulator and shall have a good lusture, smooth surface and good performance under the extreme weather conditions of a tropical climate. It shall not crack or chip by ageing under the normal service conditions. The glaze shall have the same coefficient of expansion as of the porcelain body throughout the working temperature range.

9.3.3 Cement

Cement used in the manufacture of the insulator shall not cause fracture by expansion or loosening by contraction. The cement shall not give rise to chemical reaction with metal fittings and its thickness shall be as small and uniform as possible. Proper care shall be taken to correctly centre and locate individual parts during cementing.

9.3.4 Caps and Pins

Insulator caps and bases of malleable cast iron shall be manufactured from a suitable grade of MCI complying with the requirement of BS EN 1563 for spheroidal graphite, or BS EN 1562 for whiteheart and pearlytic. Ductile cast iron of suitable grade may be used for caps and bases.

Insulator end fittings of forced or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS EN 515, 573, 586, 603, 604 or BS EN 1559, 1676, 1706 and/or BS EN 1676 or equivalent respectively.

9.3.5 Security Clips

Security 'R' clips shall be of austenitic stainless steel capable of complying with the requirements of relating to inter-crystalline corrosion tests of BS 970: Part 1 and BS EN 10084, 10085, 10087, 10095, 10250 and PD 970. 2.5% extra Security clip shall be provided.

9.3.6 Zinc Sleeve

Zinc sleeve shall have a total impurity not greater than 0.2 percent and shall comply with the requirement of BS EN 1179 or IEC 61325 or equivalent.

Insulator end fittings of forced or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS EN 515, 573, 586, 603, 604 or BS EN 1559, 1676, 1706 and/or BS EN 1676 or equivalent respectively.

9.4 WORKMANSHIP

9.4.1 Insulator Units

The dimensions of all insulator units, together with materials and grades and other pertinent information shall be shown on the contract drawings. Contract drawings shall be submitted to the Engineer. **This is a Hold Point.**

Particular regard shall be paid to those dimensions which involve interchangeability, correct assembly and those for which gauges are specified. Where appropriate insulator caps and pins shall comply with the requirement of IEC 60120, IEC 60372 and IEC 60471.

Porcelain shall be sound, thoroughly vitrified and free from defects and blemishes which might adversely affect the life of the insulator units.

Cement used in the construction of an insulator unit shall not fracture by virtue of expansion, nor loosen by contraction and proper care shall be taken to locate the individual parts correctly during assembly. The cement shall not give rise to chemical reaction with metal fittings nor the zinc collars. The cement thickness shall be as uniform as possible.

All insulator caps and bases are to be free from flaws, blowholes and shall be of a close-grained quality.

Insulator pins shall be round, free from cracks, surface flaws, lamination and other defects.

The zinc sleeve shall not be porous and all mould lines shall be removed. The cement level shall be approximately at the mid-point of the sleeve.

All the material shall be of the latest design and conform to the best modern practices adopted in the extra high voltage field. Suppliers shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for 400 kV/ 230 kV /132kV Transmission lines (as applicable) and will give continued good service.

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

The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.

Metal caps shall be free from cracks, seams, shrinks, air holes, burrs and rough edges. All surfaces of the metal parts shall be perfectly smooth with no projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

All ferrous parts shall be hot dip galvanized to give a minimum average coating of Zinc equivalent to 600 gm/sq.m. and shall be in accordance with the requirement of relevant IEC standard and shall

satisfy the tests mentioned in relevant IEC. The zinc used for galvanizing shall be of Grade Zn 99.95. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash, rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test.

Before ball fittings are galvanized, all die flashing on the shank surface of the ball shall be carefully removed without reducing the dimensions below the design requirements.

The design of the insulators shall be such that the shell shall not engage directly with hard metal. The design shall also be such that when units are coupled together there is no contact between the shell of one unit and metal of the next adjacent unit. The design of the shell ribs shall be such that the security clip of the insulator can be engaged and disengaged easily with hot stick without damaging the shell ribs.

Insulator units after assembly shall be concentric and co-axial within limits as permitted by the relevant IEC Standards.

9.4.2 Identification and Marking

(i) All insulator units shall be marked to ensure a system of traceability. Each unit shall be clearly and indelibly marked as follows on the insulating component according to the requirements of IEC 60383-1:

(a) Electromechanical failing load
(b) Name or trade mark of the manufacturer
(c) Year of manufacture.

(ii) For porcelain insulator, the marking shall be on porcelain. The marking shall be printed, not impressed and shall be applied before firing.

(iii) One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap of each insulator porcelain disc of particular strength for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance.

9.4.3 Installation Criteria

The manufacturer shall where necessary provide comprehensive instructions in a suitable format regarding, the handling and installation of insulator units.

9.4.4 Erection

The Contractor shall provide the Engineer with a method statement giving sequential details of the proposed erection method. The method statement shall be submitted to the Employer, the requisite period before insulator set erection commences. **This is a Hold Point.**

Care shall be exercised in the handling and erection of insulator units to prevent scratches, chipping or cracking of the insulation medium.

The Engineer shall be reasonable entitled to request the removal and destruction of any insulator units from a string which they notice has been severely handled or knocked during erection. All units which are scratched, chipped or abraded shall be removed and replaced. Insulator units and fittings shall be laid on plastic sheets prior to erection and any foreign matter shall be removed prior to installation.

The Contractor shall ensure that insulator units are not strained or damaged in any way during, erection.

All bolt threads shall be coated with an approved grease immediately before erection.

9.5 PROTECTIVE TREATMENT

All insulator caps, bases and pins shall either be inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in the appropriate grade of stainless steel, shall be protected by hot dipped galvanising to comply with the requirements of BS ISO 1461. All manufacturing processes shall be completed prior to galvanising.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179 or equivalent.

All galvanised materials shall be stored on packing, clear off the ground and away from all materials that might stain or corrode the galvanising. Black steel packing, or bins shall not be used.

9.6 QUALITY CONTROL

9.6.1 General

Type, sample and routine tests shall be undertaken on all insulator units and type tests on insulator sets in accordance with the requirements of this Specification. Details of the test requirements are summarised in Table 9.1.

Acceptance criteria for Thermal Mechanical Performance Test and Electromechanical Failing (EMT) load test shall be governed by the following, formula, irrespective of sample size:

$$3 \leq C = \frac{X - SFL}{\acute{o}}$$

where, C = Acceptance Constant
X = Mean value of failing load
SFL = Specified EMT load
ó = Standard deviation

Test result of each sample shall not be less than the specified EMF load. The results (mean value and standard deviation) of Thermal-Mechanical Performance Test shall not differ from the results of the ordinary Electro-Mechanical Failing Load Tests.

In addition electrical puncture shall not occur before ultimate fracture.

Contract drawings previously submitted to the Employer shall be available at the time of testing.

The Contractor shall give the Employer the requisite period of notice prior to undertaking the tests, and shall submit to the Employer a test program and procedures. **This is a Hold Point.**

9.6.2 Type Tests

(i) Insulator Units

Type test for cap and pin insulator units shall be in accordance with all the requirements of IEC 60383-1. It is not required to perform type tests on insulator units during Contract execution as the type tested insulators shall be supplied by the manufacturer.

Methods of tests shall comply with the requirements of the above standard, unless otherwise specified in the following clauses.

Bidders are required to submit the type test reports in their bid, which will be evaluated during evaluation of bids. Bidders are requested to refer to Section 6, Volume 1 of 3 of the bid document in this regard.

9.6.3 Type Tests - Insulator Sets

9.6.4 Type Tests - Radio Interference & Corona

Radio interference type tests shall be under-taken both on single insulator units followed by a complete insulator set test. All radio noise measurements shall be made at a frequency of 1.0 MHZ (9 kHz band width), using a radio interference measuring set having a response conforming to CISPR Publication 1. The test circuit shall conform to IEC 60437 and shall be calibrated in-situ to determine any circuit losses. The set shall be adjusted to indicate correctly, or alternatively an appropriate correction (in dB) shall be added to the measurement. Ideally the measurement shall be made using a 300 ohm load resistance. All readings shall be converted to dB above 1μV across 300 ohms, taking into account any corrections necessary.

The single unit test voltage shall be that which would appear across the live end unit in the complete set test and shall be determined by an initial voltage distribution measurement.

Before final readings of the radio noise are taken it is permissible to wipe the unit with a dry clean cloth, and to condition it at not more than 50% above the test voltage for upto 2 minutes. This may be repeated if the first measurement exceeds the first level.

The maximum permitted radio noise levels per insulator unit shall not exceed the values stated in Appendix 9.A2.

The number of units tested shall be either 1.5 times the number of units in a complete string or six units whichever is the greater. The choice of set make up to be tested shall be that likely to give the highest voltage across the live end unit with the shortest arc gap. Three pairs of units shall be selected from those previously tested as single units (the noisiest units).

Each pair shall comprise the live end and penultimate live end unit of a single string or the pair of live end units for a duplex string, each pair shall be tested in turn in the set.

The radio noise test voltage and limits shall be in accordance with IEC 60437. None of the tests shall give rise to radio noise levels exceeding the specified limits. Each set shall also be tested for visible corona extinction. Light shall be excluded from the laboratory and the observer's eyesight allowed time to become accustomed to the dark. The voltage shall be increased until corona appears on the string. The voltage shall be gradually reduced until all discharges on the string are extinguished. The extinction voltage shall be measured, and shall not exceed 0.8 times the nominal system voltage plus 5%. All appropriate action shall be taken to eliminate discharges from test equipment, thereby avoiding spurious corona observations and radio inference readings.

9.6.5 Type Tests - Pollution

Artificial pollution tests (salt fog method) in accordance with the requirements of IEC 60507 shall be undertaken.

The salinity of the salt solution and the power frequency withstand voltage shall be in accordance with Appendix 9.A3.

9.6.6 Power Arc Tests

(a) Power Arc Test for complete Insulator Set

Power arc tests to simulate the effect of short circuit current shall be undertaken on the complete insulator set if requested by the Engineer.

The power arc current shall be in accordance with Appendix 9.A2.

The function of the insulator protective devices shall not be greatly affected by the power arc.

(b) Power Arc Test for Insulator Unit

Power arc test shall also be performed to prove the ability of the insulator units to withstand the heat generated by power arc. This test shall be performed in the following manner.

Nine (9) insulator units of each type shall be chosen for the power arc test. Tests shall be conducted on the above chosen insulator units in three (3) strings of three (3) insulator units each. Strings shall be mounted vertically without arcing horns or conductors. The current and duration of power arc shall be 12kA (symmetrical r.m.s) and 0.1 sec or 6kA (symmetrical r.m.s) and 0.2 sec.

No shed breakage shall occur during the power arc test. Peeling-off or burn out of glaze on the insulator surface and partial rib chip shall be permitted. If two or more insulator units string break in the power arc test, this insulator design is considered to have failed to meet the specifications. In case one insulator unit fails in the test, re-test on another nine (9) insulator units shall be conducted in the same manner. Failure of anyone unit in the re-test means that the insulator design has failed to meet the specification.

9.6.7 Impulse Voltage Puncture Tests

Impulse voltage puncture tests shall be undertaken in accordance with the requirements of IEC 61211.

9.6.8 Residual Strength Tests

Residual strength tests on string insulator units shall be undertaken in accordance with the recommendations of IEC 60797. With all the outer shed material removed, the insulator stubs shall be capable of withstanding 80% of the rated minimum failing load for 1 minute. The test shall be continued to destruction (where it is practicable) to obtain a representative value of the actual falling load, and allow the modes of failure to be determined.

The mean failing load X and the standard deviation s shall be calculated and the ratio

$$k = (X - 1.645\ s)/ \text{Rating}$$

shall be deduced where k is the acceptance constant. The acceptance constant k should be greater than or equal to 0.65.

9.6.3 Sample Tests

The Contractor shall, give the Employer the requisite period of notice prior to undertaking Sample Tests. **This is a Notification Point**.

Sample tests for string insulator (cap & pin) insulator units shall be undertaken in accordance with the requirements of IEC 60383-1, see also Table 9.l.

Sample tests in respect of radio noise shall be undertaken in accordance with ANSI C 29.2-1992. Radio noise level shall be less than 50 μV at applied voltage of 10kV on single units. The sample size shall generally be 0.5% of the batch offered for acceptance.

The number of sample to be checked regarding the metallurgical bond of the zinc sleeve to the pin shall be in accordance with IEC 61325.

The metallurgical purity of the zinc shall be established by chemical analysis to ensure that any impurities do not sensitise the zinc to intergranular corrosion.

The zinc sleeve of each sample tested for mechanical strength shall also be inspected according to IEC 61325, to ensure no radial and circumferential cracking has occurred.

Three insulators shall be selected at random from each lot of the order and their straight head design checked against the straight head design of the manufacturer's cross-section drawing.

9.6.4 Routine Tests

Routine tests for string insulator (cap and pin) insulator units shall be undertaken in accordance with the requirements of IEC 60383-1, see also Table 9.l.

9.6.5 Galvanising

Tests for galvanised insulator caps, bases and pins shall be carried out at the works to ensure compliance with the requirements of ISO 1461. Details of the test results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also be made available to the Employer upon request.

9.6.7 Test Certificates

All metallic materials used in the manufacture of insulator caps, bases and pins shall be covered by test certificates stating their mechanical, chemical and where specified the impact properties and clearly showing the cast numbers to prove compliance with the requirements of this Specification and BS EN 1563, BS EN 1562, BS 970 and BS EN 10084, BS EN 10085 etc., BS EN 515, 573, 586, 603, 606, BS EN 1559, 1676, 1707, BS EN 1172, 1652, 1653, 1654, BS EN 1179 as appropriate.

Test certificates for metallic materials and bolts shall be made available to the Employer upon request.

Test certificates covering Type and Sample tests shall be made available to the Employer upon request.

9.6.8 Certificate of Conformity

When requested copies of the following certificates/records shall also be forwarded:

(a) Routine test records

(b) Metallic material test certificates

(c) Galvanizing test records

(d) Ingot zinc certificates

(e) Metallurgical purity test records for zinc sleeve.

9.6.9 Installation

The Contractor shall be responsible for checking that all insulator sets are complete and that all bolts, split pins and security clips have been correctly installed. A record of this work shall be kept by the Contractor and made available to the Employer upon request.

9.6.10 Bid Drawings

(i) The Bidder shall furnish full description and illustration of the material offered.

(ii) The Bidder shall furnish along with the bid the outline drawing of each insulator unit including a cross sectional view of the insulator shell. The drawing shall include but not limited to the following information :

(a) Shell diameter and ball to ball spacing with manufacturing tolerances

(b) Minimum Creepage distance with positive tolerance
(c) Protected creepage distance
(d) Eccentricity of the disc
(i) Axial run out
(ii) Radial run out
(e) Unit mechanical and electrical characteristics
(f) Size and weight of ball and socket parts
(g) Weight of unit insulator disc
(h) Materials
(i) Identification mark
(j) Manufacturer's catalogue number

(iii) After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given above, in four (4) copies to Employer for approval.

(iv) After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

TABLE 9.1 - TEST REQUIREMENTS

Test	String Insulator Units Cap & Pin (Type B)	Insulator Sets
Type Tests:		
Verification of dimensions	X	X
Dry lightning, impulse w. voltage	X	X
Wet power frequency w. voltage	X	X
Thermal mechanical performance	X	
Mechanical or EMF load	X	
Radia Interference Voltage (RIV)	X	X
Pollution performance		X
Power arc	X	X
Impulse voltage puncture	X	-
Zinc sleeve	X	-
Residual strength	X	-
Sample Tests:		-
Verification of dimensions	X	-
Verification of locking system and displacement	X	-
Temperature cycle test	X	-
Mechanical or EMF load	X	-

Test	String Insulator Units Cap & Pin (Type B)	Insulator Sets
Porosity	X	-
Galvanising,	X	-
RIV	X	-
Impulse Voltage puncture	X	-
Zinc sleeve test	X	-
Head design test	X	
Routine Tests:		
Visual inspection	X	
Mechanical	X	
Electrical	X	

Notes: 'X' – Required test

APPENDIX 9.A1/1

INSULATOR TYPES & USES (132KV OVERLAND PORTION)

Insulator Set Type	**Suspension**	**Tension**	**Low Duty Tension**	**Jumper Suspension**
Nominal System Voltage	{…….....132kV…….. .....……}			
String Configuration	Single	Single	Single	Single
Reference Drawing				
Insulator Unit type	{.....…….....Cap & Pin type disc insulator.....}			
Coupling Type as per IEC 60305	{…….....…… Ball & Socket …….....…….}			
Insulating Material	{…….....…… Porcelain …….....…….}			
Security Clip type	{…….....…….R …….....…..}			
Zinc Sleeve	{…….....Required…….....…..……..}			
Head design	{…….....Straight Head…….....……..}			

INSULATOR TYPES & USES (132KV RIVER CROSSING PORTION)

Insulator Set Type	**Suspension**	**Tension**
Nominal System Voltage	{…….....132kV…….. .....……}	
String Configuration	Twin	Twin
Reference Drawing		
Insulator Unit type	{.....…….....Cap & Pin type disc insulator.....}	
Coupling Type as per IEC 60305	{…….....…… Ball & Socket …….....…….}	
Insulating Material	{…….....…… Porcelain …….....…….}	
Security Clip type	{…….....…….R …….....…..}	
Zinc Sleeve	{…….....Required…….....…..……..}	
Head design	{…….....Straight Head…….....……..}	

APPENDIX 9.A2/1

ELECTRICAL & MECHANICAL CHARACTERISTICS

132KV OVERLAND PORTION

Parameter **Insulator Set Type**		**Suspension/ Jumper Suspension**	**Heavy Suspension**	**Tension**	**Upright Low Duty**	**Inverted Low Duty**
Pollution Category		{…….....….Medium II…….....……}				
Nominal Creepage	mm	{…….....…….2900…….....……}				
Insulator type		{…….....……Cap & Pin type disc insulators……}				
Insulator Unit Reference		U70BL	U120B	U120B	U70BL	U70BL
Glaze colour		Brown	Grey	Grey	Brown	Brown
Unit Puncture Voltage	kV	110	110	110	110	110
Number of Insulator Units per string		10	10	11	11	11
Dielectric material		{…….....……Porcelain…….....……..}				
Max. Insulator String length without fittings	mm	10x146	10x146	11x146	11x146	11x146
Dry Lightning Impulse Withstand voltage	kV	{…….....…… 650 …….....……..}				
Wet power frequency Withstand voltage	kV	{…….....…...…... 275 ….....……}				
Power Arc for insulator set -Current -Duration Power arc for string insulator units : Current for duration kA for s	 kA s 	 {…….....…….. 31.5 .....……} {…….....…….. 0.5 ….....……} {…..... 12 for 0.1 or 6 for 0.2 .....……}				
Arc Gap Nominal	mm	1120	1120	1120	1000	1000
RIV level per unit	δB	{…….....…….. 42 .....……}				
RIV level per set	δB	{…….....…….. 30 …….....……}				
Mechanical/ Electromechanical Failing load	kN	70	120	120	70	70

APPENDIX 9.A2/2
ELECTRICAL & MECHANICAL CHARACTERISTICS
132KV RIVER CROSSING PORTION

Parameter **Insulator Set Type**		**Suspension**	**Tension**
Pollution Category		{…….....….Medium II…….....……}	
Nominal Creepage	mm	{…….....…….2900…….....……}	
Insulator type		{…….....……Cap & Pin type disc insulators……}	
Insulator Unit Reference		U120B	U160BL
Glaze colour		Brown	Grey
Unit Puncture Voltage	kV	110	110
Number of Insulator Units per string		2x10	2x11
Dielectric material		{…….....……Porcelain…....……..}	
Max. Insulator String length without fittings	mm	10x146	11x170
Dry Lightning Impulse Withstand voltage	kV	{……650……..}	
Wet power frequency Withstand voltage	kV	{……....275…..……}	
Power Arc for insulator set -Current -Duration Power arc for string insulator units : Current for duration kA for s	 kA s 	 {……...31.5...……} {…….……..0.5….……} {……12 for 0.1 or 6 for 0.2…….}	
Arc Gap Nominal	mm	1120	1120
RIV level per unit	δB	{…….42…...……}	
RIV level per set	δB	{……..30…….……}	
Mechanical/ Electromechanical Failing load	kN	2x120	2x160

APPENDIX 9.A3

TYPE TEST - POLLUTION IEC 60507

Salt Solution Salinity	Not Required

APPENDIX 9.Bl

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

Clause Reference	Document Description	Comment
9.4.1	Insulator Units - Contract Drawings	
9.4.3	Installation procedures	Where necessary
9.4.4	Contract Drawings	
9.6.1	Insulator units - Type test certificates	If tests waived
9.6.1	Insulator sets - Type test certificates	If tests waived
9.6.1.	Type test - Programme & Procedure	
9.6.1.	Details of support simulations	
9.6.10	Galvanising, test results	If requested
9.6.10	Ingot zinc certificates	If requested
9.6.11	Material test certificates	If requested
9.6.11	Insulator units - Type test results	
9.6.11	Insulator units - sample test results	
9.6.11	Insulator units - Routine test results	If requested
9.6.12	Certificates of Conformity	
9.6.13	Installation records	If requested

APPENDIX 9.Cl

NOTIFICATION AND HOLD POINTS

Clause Reference	Notification Points	Hold Points
9.4.1		Contract Drawings
9.4.4		Method Statement
9.6.1.		Insulators -Type Tests
9.6.4		Type tests - Support Simulation details
9.6.8	Insulator – Sample Tests	

APPENDIX 9.Dl

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of Specification are listed below:

IEC 60120:	Dimensions of ball and socket couplings of string, insulator units
IEC 60305:	Characteristics of string, insulator units of cap and pin type
IEC 60372:	Locking devices for ball and socket coupling of string insulator units -Dimensions and tests
IEC 60383:	Insulators for overhead lines with a nominal voltage above 1000V
Part 1:	Ceramic or glass insulator units for ac systems Definitions, test methods and acceptance criteria
Part 2:	Insulator string and insulator sets for ac - Definitions, test method and acceptance criteria
IEC 60437:	Radio interference tests on high voltage insulators
IEC 60471:	Dimensions of clevis and tongue couplings of string insulator units
IEC 60507:	Artificial pollution tests on high-voltage insulators to be used on a.c. systems
IEC 60672:	Specification for ceramic and glass insulating materials
IEC 60797:	Residual strength of string, insulator units of glass or ceramic, materials for overhead lines after mechanical damage of the dielectric
IEC 60815:	Guide for selection of insulators in respect of polluted conditions
IEC 61211:	Insulators of ceramic material or glass for overhead lines with a nominal voltage greater than 1000V - Puncture testing
IEC 61325:	Insulators for overhead lines with nominal voltage > 1000 V
ISO 1461:	Specification for hot-dipped galvanizing coating on iron and steel articles
BS EN 10084:	Specification for wrought steel for mechanical and applied Engineering purposes
BS EN 10085	
BS EN 10087	
BS EN 10095	
BS EN 10250	
PD 970	
BS EN 515:	Specification for wrought aluminium and aluminium alloy
BS EN 573	
BS EN 586	
BS EN 603	
BS EN 604	
BS EN 1559:	Specification for Aluminium and aluminium alloy ingots and casting for general engineering purposes
BS EN 1676	
BS EN 1706	
BS EN 1172:	Specification for Rolled Copper and Copper Alloys: Sheet, strip and foil
BS EN 1652	
BS EN 1653	
BS EN 1654	
BS EN 1563	Spheroidal graphite cast iron
BS 4190:	Specification for ISO metric hexagon bolts, screws and nuts
BS 5252:	Framework for colour co-ordinations of buildings
BS EN 1562	Specification for malleable cast iron
BS EN 1179:	Specification for Zinc & Zinc Alloys
BS EN 1676:	Aluminium & aluminium alloys - Alloyed ingots for re-melting
CISPR:	Publication 1 Specification for CISPR radio interference measuring apparatus for the frequency range 0.15 to 30 MHz.

POWER GRID COMPANY OF BANGLADESH LIMITED

BIDDING DOCUMENT
FOR THE PROCUREMENT OF
PACKAGE-1: DESIGN, SUPPLY, ERECTION, TESTING & COMMISSIONING OF 132KV TRANSMISSION LINES AND SUBSTATIONS ON TURNKEY BASIS

LOT-1: TRANSMISSION LINES

SECTION 10

INSULATOR AND CONDUCTOR FITTINGS

SECTION 10

INSULATOR AND CONDUCTOR FITTINGS

CONTENTS

SECTION 10

INSULATOR AND CONDUCTOR FITTINGS

10.1 SCOPE

10.1.1 Types and Uses

The type and arrangement of all insulator and earthwire sets inclusive of all insulator and earthwire set fittings, suspension clamps, conductor tension fittings and insulator protective devices shall be approved.

Reference shall be made to Appendix 10.A1, A2 and A3 for details of the specific requirements.

10.2 DESIGN

10.2.1 General

All insulator and conductor fittings shall be designed so as to:

(a) avoid damaging the conductor under all service conditions;

(b) withstand the mechanical loads relevant to the installation-service-maintenance conditions, the design service current including short circuit effects, the service temperature and environmental effects;

(c) be free from visible and audible corona discharge and radio interference at the voltage levels specified, except those designed exclusively for use on earthwires;

(d) minimise the number of parts and the possibility of incorrect assembly and installation;

(e) ensure that individual components are secured against becoming loose in service, and all threaded fasteners shall be locked;

(f) Compression fittings after compression shall not permit relative movement between the individual layers of the conductor.

(g) from material, which have sufficient strength, ductility and environmental resistance to withstand the static and dynamic loading.

Where appropriate insulator and conductor fittings shall be in accordance with the requirements of IEC 61284. Ball and socket coupling shall be in accordance with the requirements of IEC 60120. Socket fitting shall be designed for 'W' type security clips or 'R' type security pins in accordance with the requirements of IEC 60372 as appropriate, clevis tongue couplings shall be in accordance with the requirements of IEC 60471.

All factory formed helical fittings shall be performed with a right hand lay and shall completely enclose the conductor except for small gaps required to ensure that all rods make good contact with the conductor over their entire length.

10.2.3 Live-Line Working

Where live-line working is specified in Appendix 10.A1 the design of the fittings shall take into account the following requirements:

(a) both suspension and tension insulator sets shall include either clevis fittings, or yoke plates incorporating cut-outs correctly dimensioned suitable for live-line working;

(b) the minimum distance between the attachment point and the shoulder for clevis fittings shall not be less than 125 mm, where no yoke plate is adjacent;

(c) clevis and tongue and clevis-clevis connections shall be provided with 'R' type security pins;

(d) insulator protective devices attached to yoke plates shall utilise captive bolts.

10.2.4 Sag Adjusters

All tension insulator sets shall incorporate sag adjusters for adjusting the sag of either Individual phase conductors or sub-conductors forming a phase conductor bundle. The total range of linear adjustment and individual steps shall be as specified in Appendix 10.A1.

When specified low-duty tension insulator sets shall incorporate a turnbuckle for adjusting the sag of the complete downlead. The turnbuckle where appropriate shall comply with the requirements of BS 4429 and shall be fitted with locknuts. The total range of linear adjustment shall be as specified in Appendix 10.A1. The turnbuckle shall be fitted in the earth end of the low duty tension insulator set.

10.2.5 Insulator Protective Fittings:

The design of insulator protective fittings including corona shields shall comply with the following requirements:

(a) shall effectively protect the insulator units, and the fittings from damage caused by power arcs;

(b) shall effectively improve the voltage distribution along the insulator string;

(c) shall effectively improve the corona performance of the insulator set;

(d) shall be designed in such a way as not to be subject to breakage fatigue due to wind induced vibration;

(e) shall withstand a specified mechanical load.

For details of the materials, workmanship and quality control requirements for insulator protective fittings reference shall be made to Sub-clause 10.3, 10.4 & 10.6 of Section 10 of this Specification.

The end of all arcing horns shall be formed into smooth hemispheres. The end of tubular arcing horns shall also be sealed.

10.2.6 Electrical and Mechanical Characteristics

The insulator and earthwire set fittings, suspension clamps, conductor tension fittings and insulator protection devices shall have the electrical and mechanical characteristics specified in Appendix 10.Al, A2 and A3.

10.2.7 Suspension Clamps

Suspension clamps shall be designed to meet the following requirements:

(a) so that the effects of vibration both on the conductors, or the earthwire and on the clamp themselves are minimised;

(b) to avoid localised pressure or damage to the conductor or earthwire, and shall have sufficient contact surface to avoid damage by fault currents;

(c) shall be free to pivot in the vertical plane of the conductor/earthwire and shall have a minimum range of movement of plus or minus 30 degrees;

(d) shall have a slipping capacity between specified minimum and maximum slipping loads so as to meet the requirement of Sub-clause 10.6.4 of Section 10 of this specification;

(e) suspension clamp assemblies shall have sufficient strength and durability to prevent deterioration in service;

(f) The mouth of the suspension clamp shall be rounded and slightly flared, with a minimum radius of curvature in the vertical plane of 150 mm.

10.2.8 Earthwire Suspension Clamps

Where specified earthwire suspension clamps and all suspension clamps for use with earthwire with embedded optical fibre cable and ADSS optical fibre cable shall be of the armour grip type, generally in accordance with the requirements of Clause 10.2.5, except that they shall be capable of being used in conjunction with factory formed helical armour rods and neoprene liners.

10.2.9 Counterweights

When specified counterweights shall either be fitted below the suspension clamp by extension of the clamp-keeper retaining bolts, by attachment to the yoke plate, or by replacement of the complete assemblies for multi-bundled conductors for use with pilot suspension insulator sets.

Where the complete clamp assembly is replaced, the counterweight shall be fitted with permanently bonded aluminium liners and all retaining bolts, nuts and washers shall not protrude beyond the cylindrical section of the weight.

10.2.10 Connectors and Joints

Connections and joints shall be designed to meet the following requirements:

(a) that after installation the initial contact area of the fitting to the conductor or earthwire does not raise stresses which may lead to failure under aeolian vibration or other conductor oscillation conditions;

(b) localised pressures which may cause excessive cold flow of the conductor or earthwire shall be avoided;

(c) to minimise internal voids and to prevent the ingress of moisture during service;

(d) full tension joints (dead ends and midspans) shall not permit slipping of, or cause damage to, or failure of the complete conductor or any part thereof at a load less than 95% of the rated ultimate strength of the conductor;

(e) non tension joints and connectors shall not permit slipping of, or cause damage to the conductor at a load less than 25% of the rated ultimate strength of the conductor;

(f) those connectors and joints with auxiliary eyes intended for use during construction or maintenance shall be marked with the specified minimum failing loaded stated by the manufacturer.

10.2.11 Tee Connector

Tee connectors shall be as specified either interlocking compression type or bolted type.

10.2.12 Full Tension Joints (Dead End)

Full tension joints (dead end) shall be of the following types:

(a) Compression

Compression dead ends shall have either integral jumper terminals or jumper terminal flags for use with bolted jumper palms. Integral jumper terminals shall either be straight or 30 degree line type.

(b) Bolted

Bolted dead ends shall be designed to ensure that once the bolts have been tightened to the manufacturer's recommended torque, no slackening of the clamp can occur.

(c) Wedge

Wedge clamps shall be designed with the attachment straps. The body and the wedges shall be of forged aluminium alloy. The body shall be hinged and the design shall incorporate dovetail interlocking wedges and body. The performance of the clamp shall be unaffected by manufacturing tolerances in the wedges and the bodies. The design of the conductor guide

assembly shall ensure that it is possible to tighten the bolts with the wedge clamp straps assembled in their correct position.

(d) Factory Formed Helical

For details of the exact requirements reference shall be made to Appendix 10.A3.

Helical dead ends for earthwires or ADSS optical fibre cables shall be supplied complete with solid thimbles in accordance with the requirements of BS EN 1311-1.

10.2.12 Full Tension Joints (Midspans)

Full tension midspan joints shall be of the compression type, joints for metallic conductors shall include a longitudinal centring key. Joints for mono-metallic conductors shall include a central barrier stop to ensure correct longitudinal centring of the joint.

10.2.13 Non-Tension Joints

Non-tension joints shall be of the following types:

(a) Disconnectable

Disconnectable joints shall comprise two identical straight palms, and shall be supplied complete with bolt assemblies. Bolt assemblies shall consist of bolts and nuts, grade 8.8/8 in accordance with BS 4190 complete with load spreading washers.

(b) Non-disconnectable

Non-disconnectable joints shall be of the compression type.

(c) Jumper Palms

Jumper palms for connecting jumper loops to dead ends, or tee connectors shall be of the compression type with either straight or 30 degree lugs. Bolt assemblies shall be in accordance with requirements specified for disconnectable joints.

10.2.14 Repair Sleeves

Repair sleeves shall be either compression types, or factory formed helical type. The compression type shall be two part interlocking sleeve or key type. Reference shall be made to Appendix 10.A3 for the specified requirements.

Repair sleeve shall be designed to make good a conductor of which not more than one-third of the strands of the outermost layer have been severed.

10.2.15 Line Termination Fittings

Line termination fittings shall be either bimetallic or aluminium. Bi-metallic fittings shall be designed to prevent corrosion between dissimilar metals, they shall include both a waterproof barrier at the end of the compression termination and a waterproof joint adjacent to the substation equipment terminal.

Reference shall be made to Appendix 10.A3 for the specific requirements.

10.2.16 Armour Rods

Armour rods shall be of the factory formed helical type and comprise sets of individual rods compatible with the conductor. The rods shall completely enclose the conductor except for small gaps required to ensure that all the rods make good contact with the conductor over the entire length.

10.2.17 Jumper Weights

Jumper weights for multi-bundled phase conductors shall be fitted with permanently bonded aluminium liners, and all retaining bolts, nuts and washers shall not protrude beyond the section of the weight.

10.2.18 Tubular Jumpers

Tubular Jumpers where specified shall be supplied complete with integral compression jumper terminals. Earthing bars for tubular jumpers shall have captive locking bolts opposite to the hinge bolt. The earthing bar shall be of solid aluminium rod.

10.2.19 Earthwire Bonding Clamps

Earthwire bonding clamps for the connection of flexible earthwire bonds to the earthwire shall be explosively applied wedge tap assemblies C-type, in accordance with the requirements of BS EN 61238-1 Part 3. For OPGW termination positions the C-type connectors shall be complete with a lug. The lug shall have a 18 mm diameter hole.

10.2.20 Earthwire Bond

Earthwire bonds shall be manufactured from multi-strand, multi-wire fatigue resistant aluminium alloy to BS EN 50183, with a minimum nominal cross sectional area of 100mm². The overall bond and individual strands shall be thoroughly greased with an approved conductor grease (see Clause 11.3.2), before being covered by an extruded flexible PVC sheath, of minimum thickness 1.5 mm.

The bond shall be fitted with either a compression type lug or a compression type pin 20 mm diameter as appropriate. Compression lugs shall accommodate either M 16 or M 12 bolts.

10.3 MATERIALS

10.3.1 Insulator and Conductor Fittings

Materials used in the manufacture of insulator and conductor fittings shall be of:

(a) adequate strength for the intended application and service life requirements (including mechanical loads, vibrations, electrical currents and environmental effects) and free from defects which would affect the performance of the fitting;

(b) shall not be liable to intergranular or stress corrosion;

(c) the materials of compression fittings shall be capable of withstanding the cold working of the material due to compression;

(d) steel compression components shall have sufficient impact strength after compression;

(e) compatible with the conductor material, or capable of being used with an intermediate material such that there can be no deterious effects on the conductor, or fittings resulting from their use;

(f) the material shall not be adversely affected in the long term by a coating applied for corrosion protection.

All phase conductor fittings shall have aluminium or aluminium alloy only in contact with the phase conductor.

All mild and high tensile steel used in the manufacture of insulator and conductor fittings including suspension saddles shall comply with the requirements of BS EN 10025. Minimum steel grades shall be S275JR and S355JR for mild and high tensile steel respectively.

Tubular steel used in the manufacture of insulator protective fittings shall be medium steel complying with requirements of BS 1387. Forged steel fittings shall be made from steel of suitable grade, complying with the requirements relating to the inter-crystalline corrosion tests of BS 970: Part 1.

Malleable cast iron fittings shall be made from whiteheart or pearlitic MCI or spheroidal graphite MCI of a suitable grade complying with the requirements of BS EN 1562 or BS EN 1563 respectively.

Forged aluminium and aluminium alloy fittings shall be made from aluminium or aluminium alloy of a suitable grade, complying with the requirements of BS EN 515, 573, 586, 603 and 604.

Cast aluminium and aluminium alloy fittings shall be made from aluminium or aluminium alloy of a suitable grade, complying with the requirements of BS EN 1559, 1676 and 1706.

Twin-single bridging plates shall be manufactured from 99.9% pure EC grade aluminium.

Bolts and nuts shall be either ISO Metric Black Hexagon to BS 4190, and shall unless otherwise specified be threaded ISO Metric Course Pitch to BS 3643: Part 2, Tolerance Class 7h/8g, or ISO Metric Precision Hexagon to BS 3692.

Flat washers shall either comply with the requirements of BS 4320, Form E, Grade 4.6, or ISO Metric to BS 4320, 'bright series'. Spring washers shall be ISO Metric to BS 4464.

Split pins including 'R' type security pins shall comply with the requirements of BS 1574 and IEC 60372 respectively, and shall be of austenitic stainless steel capable of complying with the requirements relating to the intercrystalline corrosion tests of BS 970: Part 1 and BS EN 10084, 10085, 10087, 10095, 10250 and PD 970.

Security 'W' clips shall be of phosphor-bronze composition in accordance with BS EN 1172, 1652, 1653 and 1654, and supplied in half-hard condition with a minimum hardness of 155 VPN.

Non metallic materials used shall have:

(a) good resistance to ageing;

(b) capable of withstanding service temperatures without detrimental change of properties;

(c) adequate resistance to the effects of nitrogen oxides, ozone, ultra-violet radiation and air pollution over the whole range of service temperatures.

10.3.1 Oxide Inhibiting Compound

Compression fittings shall be filled with oxide inhibiting compounds prior to despatch from the manufacturers with the ends of the fittings temporarily protected. The quantity of oxide inhibiting compounds shall be sufficient to ensure the integrity of the fitting.

Where grease is used as an oxide inhibiting compound, it shall be of a neutral soft type with a high melting point, and shall be in accordance with the requirements of Clause 11.3.2.

10.4 WORKMANSHIP

10.4.1 General

The dimensions of all insulator and conductor fittings shall be shown on the contract drawings, together with material types and grades, protective treatment and any other pertinent information. Contract drawings shall be submitted to the Employer. **This is a Hold Point**. Particular regard shall be paid to those dimensions which involve interchangeability, correct assembly and those for which gauges are specified. Tolerances where appropriate shall be in accordance with the requirements of IEC 60372 or IEC 60471.

All castings shall be free from flaws, blowholes and shall be of a closed-grained quality. No repair of any casting shall be carried out without the approval of the Employer. **This is a Hold Point.**

The welding of all ferrous metals shall be carried out in accordance with BS EN 1011.

For river crossing suspension saddles all welding shall be undertaken in accordance with Clause 8.7.2. Inspection levels shall be level 4 or 5 as appropriate for fillet and butt welds, except that 100% of each welder's output shall be tested.

Ball ended fittings shall be free from cracks, surface flows, laminations and other defects.

Fittings shall be free from sharp edges, burrs and swarf, particular attention shall be paid to insulator protective devices to prevent corona in service. The faces of flat faced fittings shall be sufficiently parallel and flat to provide a suitable contact service and shall remain so after fabrication. In addition care shall be taken to remove any surface contaminates prior to packing, other than material introduced by the manufacturer as a protective measure.

The mouth of suspension and top (trunnion) clamps, counterweight, wedge and bolted jumper weight clamps shall be free of sharp radius of curvature, ridges or other irregularities which may lead to localised pressure or damage to the conductors, or the separation of individual strands.

Factory formed helical fittings shall have rounded ends, when used with ADSS optical fibre cable the ends shall be relieved.

10.4.2 Identification and Marking

All insulator and conductor fittings shall be marked to ensure a system of traceability for each component part of the fittings. Where practicable, and unless otherwise agreed between the Engineer and the manufacturer, fittings shall be clearly and indelibly marked with minimum 3 mm high characters as follows:

(a) Identification of fitting (reference number/specified minimum failing load);

(b) Maker's identification;

(c) Date of manufacture (month and year);

(d) Cast code - if appropriate;

(e) Conductor size or diameter range or code name - if appropriate;

(f) Fitting bolt installation torque - if appropriate;

(g) Compression die size - if appropriate;

(h) Length and direction to be compressed - if appropriate.

In the case of factory formed helical fittings, the information as required above shall be provided on tear-off labels; additionally they shall be marked with paint to an agreed colour code either at the cross-over point or at the centre of the fitting.

10.4.3 Installation Criteria

The supplier shall provide comprehensive instructions in a suitable format covering the selection and installation, including the installation torque of any bolt, compression die sizes and direction of compression.

Installation instructions shall include directions for the use of any additional materials to the fittings, including the selection of such materials and of the conductor preparation.

Joints and connectors intended for the restoration of electrical and mechanical properties of a conductor, shall have clearly defined manufacturer's instructions as to the extent of the damage which they are intended to repair.

10.5 PROTECTIVE TREATMENT

All parts of insulator and conductor fittings shall be either inherently resistant to atmospheric corrosion or suitably protected against corrosion, such as may occur in transit, storage and in service. All ferrous parts which will be exposed to the atmosphere in service, except those made in appropriate stainless steel, shall be protected by hot-dipped galvanising to comply with the requirements of BS ISO 1461. All manufacturing processes shall be completed prior to galvanising.

The ingot zinc used for galvanising shall comply with the requirements of BS EN 1179.

All external threads shall be cut or rolled before hot-dipped galvanised. Nuts to be galvanised shall be subsequently tapped 0.4 mm oversize with the threads oiled.

Where tubular steel insulator protective fittings are provided with galvanising vent-holes, these holes shall be effectively plugged after galvanising with zinc plugs.

The rough machined surfaces of bolted palm joints and aluminium line termination fittings shall be protected with a removable dry waterproof coating.

All galvanised materials shall be stored on packing, clear of the ground and away from all materials that might stain or corrode the galvanising. Black steel packing or bin shall not be used.

10.6 QUALITY CONTROL

10.6.1 General

Type, sample and routine tests shall be undertaken on insulator and conductor fittings in accordance with the requirements of this Specification. Type and sample test requirements are detailed in Table 10.1. Type tests specified in Table 10.1 shall be undertaken on a minimum of three samples, which shall be identical in all essential details, with the fittings to be supplied. Heat cycle tests shall be undertaken on four samples.

Contract drawings previously submitted to the Employer shall be available at the time of testing. The Contractor/Supplier shall give the Employer the requisite period of notice prior to undertaking the tests and shall submit to the Employer a test programme and procedures**. This is a Hold Point**.

In addition to the tests specified, when required by the Employer, electrical type tests shall be undertaken on complete insulator sets. For details of these tests reference should be made to Section 9 of this Specification.

Mechanical Tests:

10.6.2 Insulator Set and Earthwire Set Fittings

Each fitting shall withstand its specified minimum failing load for one minute, and shall be tested in a manner as far as practical to that in service. One sample shall if practical be taken to failure and the mode of failure recorded.

10.6.3 Insulator Protective Fittings

Insulator protective fittings shall be mechanically tested to withstand the specified loads for 1min without failure. A force of 1.8kN shall be applied to the tip of suspension arc horns, and 0.9 kN to tension arc-horns. The direction of the force shall correspond to that which would be applied by a linesman with the insulator set in service.

10.6.4 Conductor/Earthwire Suspension Clamps

(a) Tensile Test

The clamp supported by its trunnions as appropriate shall be installed at its recommended installation torque on a rigid bar of a suitable size and a tensile load equal to half its specified minimum failing load applied to 90 degrees to the conductor axis. The load shall be steadily increased, no failure shall occur at a load less than the specified minimum failing load.

(b) Conductor Slip Test

A length of conductor shall be fitted into the clamp and the clamp bolts tightened to the recommended torque. An axial tensile force shall be applied either to the conductor, or the clamp. The conductor shall not slip through the clamp below a load of 7kN or 5% of the nominal breaking load of the conductor, whichever is the greater value. The conductor shall slip through the clamp at a load not greater than 30% of the conductor minimum breaking load. The conductor shall not be damaged, other than some flattening of the strands.

10.6.5 Tension Joints, Tee Joints and Sleeves

The fitting shall be assembled in accordance with the manufacturer's instruction on conductors of the size and type with which it is to be used. The assembly shall be mounted in a tensile testing machine, the end fixings of the conductor shall be such as to prevent bird-caging or slipping of the individual strands. The length of conductor between fittings under test and any other clamp or joint in the test assembly shall not be less than 100 times the overall diameter of the conductor.

For factory formed helical tension terminations, the fitting shall be assembled in accordance with the manufacturer's instructions. A tensile load of 40% of the conductor breaking load shall be applied and maintained for 1min. The load shall be relaxed and the fitting removed. The fitting shall be reapplied and the test repeated, after subsequent removal and replacement the test shall be continued as detailed above.

For wedge clamps the test shall be carried out on a maximum size body and minimum size wedges and on a minimum size body and maximum size wedge. The maximum and minimum sizes shall be defined by the Manufacturer.

(a) The following additional requirement shall be applicable to wedge clamps:

- A 5kN load shall be applied to the assembly and the position of the wedges relative to the clamp body recorded.

- Loads of 20, 30 and 40% of the conductor's nominal breaking load shall be applied to the conductor and the relative position of the wedges recorded. After the application of each load the torque on the wedge and conductor guide bolts shall be removed and no conductor slip, shall occur. After 40% of the load when the wedge bolts are released to check for no slip, it shall then be confirmed that the wedges and body may be separated with the recommended extractor tool.

- The number of strands severed for repair sleeves shall be the nearest whole number to one-third of the total number of strands in the outermost layer and shall be severed at a uniform spacing along the conductor.

- A tensile load of 50% of the breaking load of the conductor shall be applied and the conductor marked so that any relative movement of the fitting can be easily detected. Without any subsequent adjustment of the fitting, the load shall be increased to 95% of the breaking load and then reduced to 90% and held for 1min. There shall be no movement of the conductor relative to the fitting due to slip during this period of 1min and no failure of the fitting.

For tests on OPGW and ADSS fittings there shall be no degradation in the fibre optic signal strength after the completion of the test. The signal strength shall be measured using an OTDR.

TABLE 10.1 TYPE AND SAMPLE TEST REQUIREMENTS

Note: T = Type Tests S = Sample Tests

Fitting	Name of Test					
	Mechanical	**Resistance**	**Heat Cycle**	**Corona**	**Bolt Torque**	**Conductor Damage**
Insulator set fittings	TS			T		
Earth set fittings	TS					
Insulator protective fittings	TS			T		
Suspension Clamps	TS			T	TS	TS
Earthwire suspension clamps	TS				TS	TS
Counter weights				T	T	T
L.P.I. Top (Trunnion) clamps	TS			T	T	T
Earthwire Top (Trunnion) clamps	TS				T	T
Tee Connectors						
(Compression)	TS	TS	T		TS	
(bolted)	TS	TS	T			
Tension Joints (deadends)						
Compression	TS	TS	T	T		
Bolted	TS		T	T	TS	TS
Wedge	TS		T	T	TS	TS
Helical	TS		T	T		TS
Tension joints (midspan)						
Compression	TS	TS	T			
Non-tensile Joints						
Disconnectable	TS	TS		T		
Non-disconnectable	TS	TS		T		
Jumper palms	TS	TS			TS	
Repair sleeves						
Compression	TS	TS				
Helical	TS	TS				
Line termination Fittings	TS	TS				
Armour rods						T
Jumper weights						TS
Tubular jumpers	TS	T		T		
Earthwire bonding Clamps						T
Earthwire bonds		TS				

10.6.6 Non-Tension Joints, Line Termination Fittings and Tubular Jumpers

A tensile load of 0.6kN shall be applied and the conductor marked so that any relative movement of the fitting can be easily detected. Without any subsequent adjustment of the fitting, the load shall be increased to 10% of the conductor's nominal breaking load and this load held for 1min. There shall be no movement of the conductor relative to the fitting due to slip during this period and no failure of the fitting.

10.6.7 Compression Fittings

All compression fittings after installation in accordance with the manufacturer's instructions shall remain straight after compression.

10.6.8 Resistance

The fitting shall be assembled in accordance with the manufacturer's instruction on a length of conductor. The electrical resistance shall be measured between two points on the conductor on either side of and immediately adjacent to, the fitting. The test shall be made with direct current. The current connections shall be at a distance of not less than 50 times the conductor diameter from the fitting. A micrometer having an accuracy of 0.1% with current reversal and averaging shall be used for measurement. The measured resistance shall not exceed 75% of the equivalent length of conductor.

10.6.8 Heat Cycle

Heat cycle tests shall be undertaken in accordance with the requirements of IEC 61284.

10.6.10 Current Pulse

In addition to the heat cycle test described in Clause 10.6.9, non-tension fittings shall be subject to the current pulse test undertaken in accordance with the requirements of IEC 61284.

The test assembly shall be so arranged that current is passed through the fitting from the main conductor to the jumper conductor on tension joints (dead ends) and from the main conductor to the tee conductor on the tee joints.

10.6.11 Corona and RIV

All fittings, other than those used exclusively for earthwire application shall be erected as in service, (which may necessitate representation of the tower body) and subjected to a visible corona and RIV test. The test shall be undertaken in accordance with the requirements of IEC 61284.

10.6.12 Bolt Torque

The bolts shall be tightened to twice the recommended torque on the conductor. No damage shall occur to the fitting or its bolts at less than this torque.

10.6.13 Conductor Damage

The fitting shall be installed on the conductor and where appropriate the bolts tightened to the recommended torque. In the case of factory formed helical fittings, these shall be checked to ensure that the rods make contact with the conductor over their entire length. The position of the fitting shall be marked and then removed from the conductor. No indentations in the outer strands of the conductor shall be present in the area of the fitting.

10.6.14 Sample Tests

Sample tests identical to type tests shall be undertaken as indicated in Table 10.1. In addition, verification of compliance with the 'contract drawings' and surface finish compatible with the reference fitting shall also form part of the sample test.

The Contractor shall give the Employer the requisite period of notice prior to undertaking Sample Tests. **This is a Notification Point**.

The number of samples selected for test shall be in accordance with the following requirements, where 'p' is the numbers of fittings to be tested, and 'n' is the number of fittings produced in a batch.

$p = 1$ when $25 < n \leq 50$

$p = 2$ when $50 < n \leq 75$

$p = 3$ when $75 < n \leq 100$

$p = 4$ when $100 < n \leq 500$

$p = 4 + 1.5n/1000$ when $n > 500$

If the randomly selected samples meet the test requirement, the batch(s) shall be deemed to comply with Specification. In the event of any sample not meeting this requirement, a further set of 'p' samples shall be tested. Should any further failure occur the whole batch(s) from the samples have been selected shall be liable to rejection.

10.6.15 Routine Tests

Unless otherwise specified routine mechanical tests shall be undertaken on insulator set and suspension clamp castings and those fittings in which a weld is subject to service load, insulator protective fittings and tension joints.

All fittings, tested shall be subjected to the routine test load of 50 percent of the specified minimum failing load. The application of the test load for 30 seconds shall not cause any permanent deformation or damage.

10.6.16 Galvanising

Tests for galvanising conductor and insulator fittings shall be carried out at the works to ensure compliance with the requirements of BS ISO 1461. Details of the tests results shall be made available to the Employer upon request.

Certificates relating to the ingot zinc used for galvanising shall also make available to the Employer request.

10.6.17 Test Certificates

All metallic materials used in the manufacture of conductor and insulator fittings shall be covered by test certificates stating their mechanical, chemical and where specified the impact properties and

clearly showing the cast numbers, to prove compliance with the requirements of this Specification and BS EN 10025, BS 970 and BS EN 10084, 10085, 10087, 10095, 10250, PD 970, BS EN 1562, BS EN 1563, BS EN 515, 573, 586, 603, 604, BS EN 1559, 1676, 1706, BS EN 1172, 1652, 1653, 1654, BS EN 1676 as appropriate.

Test certificates for metallic materials and bolts and nuts shall be made available to the Employer upon request.

Test results covering Type and Sample tests shall be made available to the Employer.

Test results covering Routine tests shall be made available to the Employer upon request.

10.6.18 Certificates of Conformity

When requested copies of the following certificate/records shall also be forwarded:

(a) Routine test records

(b) Metallic materials and nuts/bolts test certificates

(c) Galvanising test records

(d) Ingot zinc certificates.

APPENDIX 10.A1/1 – 132 kV OVERLAND PORTION

INSULATOR SETS – TYPES & USES

Insulator Fittings Type	**Suspension**	**Tension**	**Low Duty**	**Pilot Suspension**
Reference Drawing				
Set Configuration	Single	Single	Single	Single
No. Insulator strings	1	1	1	1
Min. separation between centres of parallel strings (mm)	---	---	---	---
Coupling Type	Ball & Socket	Ball & Socket	Ball & Socket	Ball & Socket
Security clip type	R	R	R	R
No. of sub-conductor	1	1	1	1
Sub-conductor spacing (mm)		-	-	-
Live line working	Not required	Not required	Not required	Not required
Sag adjuster type	-	Quadrant	Turnbuckle	-
Linear range (mm)	-	75 – 225	230	-
Increment (mm)	-	-	-	-
Overall set length (mm)	2000	2400	2350 (A) 2900 (B)	1950
Min. Failing load complete set Common to all conductor (kN) Common to individual Conductor (kN)	 70 70	 120 120	 70 70	 70 70
Insulator protective Devices Type - Live End - Earth End	 Single Point Single Point	 Single Point Single Point	 Single Point Single Point	 Single Point Single Point

Notes: (A) Upright
(B) Inverted

APPENDIX 10.A1/2 – 132KV RIVER CROSSING PORTION

INSULATOR SETS – TYPES & USES

Insulator Set Type	**Suspension**	**Tension**
Reference Drawing		
Set configuration	Twin	Twin
No. of insulator strings	2	2
Min. separation between centres of parallel strings (mm)	---	---
Coupling type	Ball & Socket	Ball & Socket
Security clip type	R	R
No. of sub-conductor	1	1
Sub-conductor spacing (mm)	---	---
Live line working	Not required	Not required
Sag adjuster type	---	---
Linear Range (mm)	---	---
Increment (mm)	---	---
Overall set length (mm)	2500	3000
Min Failing load of complete set:		
Common to all conductors (kN)	120	160
Common to individual conductor (kN)	2 X 120	2 X 160
Insulator Protective Devices:		
Type - Live End - Earth End	Raquet Single Point	Raquet Single Point

APPENDIX 10.A2/1 – 132 KV OVERLAND PORTION

EARTHWIRE/OPGW SETS – TYPES & USES

Earthwire/OPGW Set Type	Suspension	Tension
Reference Drawing		
Overall set length (mm)	350	700
Min. Failing Load Complete set (kN)	70	120

APPENDIX 10.A2/2 – 132 KV RIVERCROSSING PORTION

EARTHWIRE/OPGW SETS – TYPES & USES

Earthwire/OPGW Set Type	Suspension	Tension
Reference Drawing		
Overall set length (mm)	350	700
Min. Failing Load Complete set (kN)	160	210

APPENDIX 10.A3/1 – 132 kV OVERLAND PORTION

CONDUCTOR JOINTS & CLAMPS – TYPES & USES

Joint & Clamp Type	Phase	Earthwire	OPGW
Conductor	**636 MCM ACSR Grosbeak**	**7 x 3.25 S**	
Suspension Clamp-type	Trunnion Corona free	Trunnion	Armour Grip
Armour Rods	Preformed type-required for 132kV, 120kN suspension set; not required for other sets	-	Required
Counterweights (kgs)	50	-	-
Tension Joints :			
Dead end-type	Compression	Compression	Helical
Jumper terminal-type	Compression	-	-
Midspans-type	Compression	Compression	-
Repair Sleeves - type	Compression	Compr/Helical	-
Tee connectors-type	Compression	-	-
Non-Tensile Joints :			
Disconnectable	-	-	-
Non-disconnectable	-	-	-
Jumper palms –type	Bolted 0° & 30°	-	-
Line Termination fittings-type	-	-	-
Jumper weights (kgs)	-	-	-
Tubular Jumpers	-	-	-
Earthwire bonds – end fitting type	-	Lug-lug	Pin-lug Lug-lug

APPENDIX 10.A3/2 – 132 KV RIVER CROSSING PORTION

CONDUCTOR JOINTS & CLAMPS – TYPES & USES

Joint & Clamp Type	**Conductor**	**Earthwire**	
	ACSR Mallard	**7 x 4.25S Grade 1150**	**OPGW**
Suspension Clamp-type	-	Trunnion	Armour grip
Armour Rods	Required	Required	Required
Counterweights (kgs)	-	-	-
Tension Joints : Dead end-type Jumper terminal-type Midspans-type Repair Sleeves – type	 Compression Bolted Compression Helical	 Compression - Compression Compression/Helical	 Helical - - -
Non-Tensile Joints : Jumper palms –type	 Bolted 0° & 30°	 -	 -
Earthwire bonds – end fitting type	-	Lug-lug	Pin-lug Lug-lug

APPENDIX 10.B1

ENGINEERING DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

Clause Reference	Document Description	Comment
10.4.1	Insulator & Conductor Fittings - Contract drawings	
10.4.3	Installation procedures	
10.6.1	Insulator & Conductor Fittings – type test certificate	If requested
10.6.1	Type test-programme & procedures	
10.6.16	Galvanizing test results	If requested
10.6.16	Ingot zinc certificates	If requested
10.6.17	Metallic & bolt/nuts material test certificate	If requested
10.6.17	Insulator & Conductor Fittings – type test results	
10.6.17	Insulator & Conductor Fittings – sample test results	
10.6.17	Insulator & Conductor Fittings – routine test results	If requested
10.6.18	Certificates of conformity	

APPENDIX 10.C1

NOTIFICATION AND HOLD POINTS

Clause Reference	Notification Points	Hold Points
10.4.1 10.6.1 10.6.14	 Insulator & Conductor Fittings – sample tests	Contract drawings Insulator and Conductor fittings – type tests

APPENDIX 10.Dl

REFERENCE STANDARDS

The reference standards and other documents referred to in this Section of the Specification are listed below:

IEC 60120:	Dimensions of ball and socket couplings of string insulator units
IEC 60372:	Locking devices for ball and socket couplings of string insulator units Dimensions and tests
IEC 60471:	Dimensions of clevis and tongue couplings of string insulator units
IEC 61284:	Overhead lines Requirements and tests for fittings
BS EN 13411	Specification for thimbles for wire rope
BS EN ISO 1461	Specification for hot-dipped galvanising coating on iron and steel articles
BS 970:	Specification for wrought steel for mechanical and applied engineering purposes
BS EN 10084	
BS EN 10085	
BS EN 10087	
BS EN 10095	
BS EN 10250	
PD 970	
BS 1387:	Specification for screwed and socketed steel tubes and tubular and for plain end steel tubes suitable for welding or screwing to BS 21 pipe threads
BS EN 515:	Specification for wrought aluminium and aluminium alloy
BS EN 573	
BS EN 586	
BS EN 603	
BS EN 604	
BS EN 1559:	Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes
BS EN 1676	
BS EN 1706	
BS 1574:	Specification for split cotter pins
BS EN 1563:	Specification for spheroidal graphite cast iron
BS EN 1172:	Specification for rolled copper and copper alloys: Sheet strip and foil
BS EN 1652	
BS EN 1653	
BS EN 1654	
BS EN 50183	Aluminium alloy stranded conductors for overhead power lines
BS 3643:	ISO Metric threads
Part 2:	Limits and tolerances for course pitch series threads
BS 3692:	Specification for ISO Metric Precision hexagon bolts, screws and nuts
BS 4190:	Specification for ISO Metric hexagon bolts, screws and nuts
BS 4320:	Specification for metal washers for general engineering purposes. Metric series
BS 4429:	Specification for rigging screws and turnbuckles for general engineering, lifting purposes and pipe hanger applications
BS 4464:	Specification for Spring Washers for general engineering and automobile purposes. Metric series.
BS 4579:	Part 3 Performance of Mechanical and Compression Joints in Electric Cables and Wire Connectors
BS EN 1011:	Specification for arc welding of carbon and carbon manganese steel
BS EN 1562:	Specification for Malleable cast iron
BS EN 1676:	Aluminium and aluminium alloys - Alloyed ingots for remelting.
BS EN 1179:	Zinc and Zinc Alloys.
BS EN 10025:	Specification for hot rolled products of non-alloy structural steels and their technical delivery requirements.