SECTION V

4.1.7 PARTICULAR TECHNICAL SPECIFICATIONS

FOR

OVERHEAD LINES AND CABLES

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4.1.7 PARTICULAR TECHNICAL SPECIFICATIONS FOR OVERHEAD LINES

4.1.7.1 66KV, 33KV & 11KV LINES

4.1.7.1.1 GENERAL

The Bidder shall examine the scope of works in this section in close connection with the other documents and particulars forming these Bidding Documents.

Special attention shall be paid to Technical Specifications, in which the general technical requirements are specified. The drawings enclosed in are for bidding purposes only.

If the Specifications and/or Drawings do not contain particulars of materials or goods that are necessary for the proper and safe completion, operation and maintenance of the equipment in question, all such materials shall be deemed to be included in the supply.

In the event of any conflict between the Drawings and the Specifications, the latter shall prevail.

In the event of any conflict between scaled dimensions and figures on the Drawings, the figures shall prevail.

Should the Bidder find discrepancies in or omissions from these Specifications or from the other Documents, or should he be in doubt as to their meaning, he should immediately contact the Project Manager for interpretation, clarification or correction thereof before submitting his Bid. Such action shall, however, in no case be considered as a cause for altering the closing date of the Bid.

The scope of work covers supply of equipment, engineering and design, manufacture, testing before shipment and packing seaworthy or otherwise as required, delivery of all equipment CIP site, construction and installation and commissioning.

Where the new line share the route with existing lines, the scope of work shall include all the necessary works/modifications that will be required to accommodate the lines along the same route. The hardware/fittings and conductors of the existing lines shall be re-used.

The term "transfer" in this scope of works shall mean supply of new hardware/fittings, new concrete poles, stays, conductor, insulators as well as construction work in existing line routes. It also includes moving all equipment, such as distribution transformers, autoreclosers, switches and links, capacitor banks etc., mounted on the present poles over to the new poles. In addition, all existing poles, conductors and hardware/fittings shall be recovered and handed over to the KPLC stores at locations nearest to the installation sites.

<u>Cross arms:</u>
Steel cross-arms shall be used in all cases including transfer (where applicable). Steel cross arms shall meet international accepted standards in addition to KPLC specifications for steel structures and line fittings.

<u>Concrete Poles:</u>
Concrete poles shall be used in all 66kV, 33kV and 11kV overhead line construction. All poles shall meet design class of 50SC (10m, 11m and 12m) poles and 75SC (14m and 15m) poles and KPLC Pre-stressed concrete poles particular specifications

<u>Lattice and Monopoles Towers</u>
Lattice or monopole towers shall be used for construction of 132 kV lines. The towers shall meet BS 8100, BS EN 50341 and BS EN 10163 and other internationally acceptable standards.

Optical Ground Earth Wire (OPGW)
OPGW (Optical Ground Earth Wire) shall be used in all 33kV lines and above. Standard size for KPLC is 48 cores single mode Optic fibre. Where Overhead line transitions to Underground cable, an Underground Fibre Optic cable will be laid together in the trace of the power cable.
OPGW earthing shall be done after every fourth pole.

Line conductor
The 11kV and 33kV Overhead line conductors shall be 150mm2 ACSR.
The 66 kV overhead conductor shall be 300 mm2 AAAC.
The 132 kV overhead conductor shall be 175mm2 Lynx or any other conductor specified in definite scope of work section.

Conductor Joints and terminations
All joints and terminations shall be of compression type for conductors of 150mm2 and above.

4.1.7.1.1.1 Nature and Extent of Work

The work covered by this Specification forms part of the KPLC's Distribution capacity enhancement Project and is for design, survey, supply, installation and commissioning of new Overhead Lines as specified herein and in the Attachments. The overhead lines will form part of KPLC's transmission and distribution network system.

The new lines may run in parallel with existing overhead lines, but due to constraints in wayleave in some areas/section of the lines, the existing lines shall be transferred to the new line. Where existing line is on wooden poles the wooden poles shall be replaced with Concrete poles.

The works to be carried out by the Contractor in accordance with the Specification and Condition of Contract and shall comprise and not limited to the following:

(a) Three-phase overhead lines having the particulars set out in the Scope of Works, Technical Schedules and Drawings attached to the Specification,
(b) the lines being complete with the survey, line conductors, insulators and fittings, poles and cross arms, Earthing (where required) and connections and all other fittings necessary to have a complete distribution line.

4.1.7.1.1.2 Design

The following drawings shall be submitted by the Contractor according to the time schedule for approval:

- Detailed route maps
- Longitudinal profiles
- Tables showing the capacity of the poles and towers related to wind and weight span for the actual conductor sizes
- Sag tables for the actual conductor types for stringing conditions and included compensation for creep
- Erection drawings for each pole and tower line formation showing, insulator sets, fittings, cross arms etc.
- Pole and/or Tower foundation.

4.1.7.1.1.3 Factor of Safety

The minimum factor of safety at assumed maximum simultaneous working loading shall be as follows:

i) Line conductors based on ultimate strength

Max tension	3.0
Everyday stress	5.0

ii) Insulator and fittings, based upon electro-mechanical test and minimum failing load

Insulators and insulator fittings	2.5
Dead-end clamps and conductor fittings	2.5

iii) Steel structures, bolts and other steel pole members based on elastic limit of tension members and on crippling loads of compression members:

Steel Structures (Including steel cross arm)	2.5
Bolts, nuts and washers	2.5

iv) Supports, stays and cross arms subjected to the longitudinal transverse and vertical loads resulting in the lading conditions stated above:

Wood supports and cross arms	3.5
Concrete structures	2.5
Steel supports and cross arms	2.5
Stay assembly and fittings	2.5
Foundation – Concrete	2.5

4.1.7.1.1.4 Working Conditions

The maximum assumed working conditions shall be as follows:-

i)	Minimum temperature of line	5^{o}C
ii)	Ambient temperature of line conductor	35^{o}C
iii)	Maximum temperature of line conductors	80^{o}C)
iv)	Wind pressure on the whole projected area of conductors	400N/m2
v)	Wind pressure on projected are of insulator	400N/m2
vi)	Wind pressure on projected are of support	400N/m2
vii)	Altitude above sea level:	0 – 2200 meters.

4.1.7.1.2 CLEARANCES AND SPANS

4.1.7.1.2.1 Medium overhead lines minimum clearances at operating temperatures:-

i)	Lines not exceeding 11kV across or along road:	5.8m (19ft)
ii)	Lines not exceeding 11kV over private land:	5.2m (17ft)
iii)	Lines not exceeding 33 kV over private land:	5.8 m
iv)	Lines not exceeding 66kV over private land:	6.2m (20ft)
v)	Lines not exceeding 132kV over private land:	7.0m

4.1.7.1.2.2 Additional Clearances

i)	11 kV line conductor to any part of the building:	2.7m (8ft. 8 inch).
ii)	33 kV line conductor to any part of the building:	5.0m
iii)	66 kV line conductor to any part of the building:	7.5 m
iv)	132kV line conductor to any part of the building:	10m

4.1.7.1.2.3 Special Clearances

a) Railway crossing clearances

i) All types of line including guard nets 8.1m (30ft)

ii) The minimum clearance of any pole or structure from the centre of a tract shall be the height of the pole above ground plus 2.1m (7ft).

iii) Where the tract is in a cutting, no such pole shall be closer to the edge of the cutting than a distance equal to the height of the pole.

iv) Angles of crossing Medium voltage, not less than 60°

b) Kenya Posts and Telecommunications Installation Clearances

i) Guard net – 1.3m (4ft)
Up to 66kV conductors using cradle guard – 1.8m (6ft)

ii) Angles of crossing Medium voltage, – not less than 60°

c) Installation near Airport Clearances

i) Guard net – 1.3m (4ft)
Up to 66kV conductors using cradle guard – 1.8m (6ft)

ii) Angles of crossing Medium voltage, – not less than 60°

d) Kenya Pipeline Clearances

i) Guard net – 1.3m (4ft)
Up to 66kV conductors using cradle guard – 2.1m (7ft)

ii) Angles of crossing Medium voltage, – not less than 60°

4.1.7.1.2.4 Environmental Requirements

The Contractor shall undertake to complete all works in accordance with statutory requirements including those of:

i) i) The Kenya Wildlife (Management and Conservation Act) Applicable for all works inside National Parks.

ii) ii) The Kenya Agricultural Act - Concerning protection against soil erosion.

iii) iii) Public Health Act – Concerning with noise, water and air quality as they relate to human health.

iv) iv) Chief Authority Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.

v) v) The County Government Act – Section 145 for preservation or protection of wildlife and Section 163 regarding noise disturbance controls.

vi) vi) Kenya Forestry Act – Concerning the regulation of timber cutting and wasteful destruction of trees and avoidance of damage to the public road or other community facilities.

The Contractor shall take reasonable precautions to avoid damage to land, property, crops, etc. and shall ensure that the work is adequately supervised so that damage is reduced to the minimum. All surplus material shall be removed after erection and site shall be left in a clean and tidy condition, to the satisfaction of the Purchaser.
Where the Contractor considers that damage cannot be avoided if the work is to proceed normally, he shall notify the Employer accordingly. The Employer will coordinate and facilitate assistance with the landowner concerned during negotiations for compensation. The Contractor will be responsible for compensation in respect of damage and the Contractor shall proceed with the work within the limits indicated by the Purchaser.

Where temporary removal of bound, wall or similar obstacles is necessary for the purpose of foundation installation or support erection, the cost of removal and subsequent reinstatement shall be deemed included in the Contract rates for foundation and support erection.
Where it is necessary to provide scaffolding over roads, railways or telecommunication lines in order not to interfere with the passage of traffic, this shall be carried out by the Contractor at such times as may be convenient to the Authority concerned. Flagman and approved types of danger and warning notices shall be provided by the Contractor to ensure safety of the public.

4.1.7.1.3 WAY LEAVES

Way leaves shall be provided by the Purchaser to enable the Contractor to carry out the Works. In order to provide way leave the Purchaser has to obtain approvals from Government and other statutory authorities and also consents from owners and occupiers of property which will be affected by the lines.
The procedure for obtaining approvals and consents is dependent on preliminary profile survey, as described below:

a) Representatives of the Purchaser will accompany Contractors staff during preliminary survey. The Purchaser's representatives will issue notices to and liaise with landowners and occupiers in order to establish rights of entry for survey and agreement to limited cutting of vegetation as specified.
b) Upon approval by the Purchaser of preliminary survey the Purchaser will initiate procedures for obtaining way leave, and when necessary approvals and consents have been granted the Purchaser will arrange for trees etc. to be cleared from the line route as specified.
c) Upon approval by the Purchaser of the position of support centre pegs the Contractor shall submit access maps as specified and the Purchaser will obtain the necessary rights of construction access for the Contractor.
d) Way leaves procedures as described above will take place concurrently with profile survey, approval of centre pegs, etc. The Contractor shall allow in his programme for a period of up to two months from approval of preliminary lines to the grant of right of access for its construction.
e) Any conditions for the way leave should be made known to the Contractor.
f) The way leave procedures shall lead the construction programme for each section of the Contract.

4.1.7.1.4 STANDARDS

Unless another standard is mentioned in this Specification, all materials used and provided under this contract and all services performed must be in accordance with the latest amendments of the Standards of the International Electro-technical Commission (IEC) or British Standards (BS), applicable Kenyan Standards and the attached Material Specifications.

Suppliers who do not normally manufacture to IEC or BSI Standards may offer equipment in accordance with other recognized national Standards provided that they draw attention to any essential differences between their Standards and IEC/BSI Standards and Subject to the satisfaction of the Employer that the quality, finish and performance of the equipment complying with such standards shall be comparable to that complying with IEC or BS.

4.1.7.1.4.1 Units of Measurements

SI units (System International) shall be used in all the technical schedules and drawings.

4.1.7.1.5 MATERIALS

Each of the several parts of the line shall be of such construction and design as to give long and continuous service with high economy and low maintenance costs.
All material used and equipment provided under this contract shall be new and of the best quality and workmanship and shall be of the highest class throughout with the designs and dimensions of all parts such that mechanical and electro-mechanical stresses which they are subjected shall not render them liable to distortion or damage under most severe conditions encountered in service. Repair of any defective parts shall not be permitted without the sanction in writing of the Project Manager.

The detailed design shall be carried out in manner to facilitate inspection, repairs and simplicity of operations and maintenance. All materials shall ensure satisfactory operations under the atmospheric conditions prevailing in the area where the lines are to be built, irrespective of season and under such variations of load and voltage as may occur under working conditions of the system. Line supports, conductors, insulators and fittings shall be such as to minimize the risk of damage due to deterioration, or damage in service of any part of the line. The design shall incorporate any reasonable precaution and provision for the safety for those concerned in the maintenance of the Contract Works and all associated works supplied and executed under other contracts.

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

4.1.7.1.5.1 Line Supports and Foundations

The network shall be supported on concrete and steel structures.
The wood poles shall meet specifications set in Kenya Power and Lighting Co Ltd: Specification for Wood Pole and Kenya Standard KSO2-516: Poles for power and telecommunications lines. The concrete poles shall meet the specifications set in Kenya Power and Lighting Co. Ltd; Specifications for Concrete Pole Kenya Standard DKS 1933.

The poles can be of single pole type or H-pole type, with or without stay wires, with insulator chains or pin or post insulators, depending on the actual conditions and the approved design.

4.1.7.1.5.2 Physical and Mechanical Properties of Wood poles (Not Applicable)

The wood poles (Eucalyptus Salina) used shall have the following properties.

Nominal length	10	11	11	12	12	14	14
Category	Medium	Medium	Stout	Medium	Stout	Medium	Stout
H(mm)	1.8	1.8	1.8	1.8	1.8	2.0	2.0
D_c(mm)	220	230	295	240	305	248	310
D_m(mm)	150	160	200	160	200	160	200
D_g(mm)	220	230	295	240	305	270	335
D_e(mm)	175.9	185.6	234.8	189	238.1	199.4	248.4
F(kN)	5.90	4.94	13.05	4.03	10.37	3.45	8.23
Ultimate load (kN)	8.64	8.73	18.42	8.89	18.24	10.46	20.02
Crippling load (kN)	59.4	58.6	149.8	51.2	128.9	45.9	110.3

H Ground position from butt
d_c Critical diameter
d_g Minimum groundline diameter (mm)
d_m Minimum top diameter (mm)
d_e Effective diameter
f Load per mm of deflection at point of application of load

Note that the mechanical properties used in the mechanical calculations are those stated in the Kenya Standard KSO2-516.

4.1.7.1.5.3 Strength and Species

Wood poles shall be of eucalyptus timber and shall belong to the strength groups Light, Medium or Stout as specified. The treatment shall be creosote pressure-treated wood, or Chromated copper arsenate (CCA).

4.1.7.1.5.4 Pole Caps

Pole caps of approved type shall be used.

4.1.7.1.5.5 Safety

All poles shall have a DANGER/HATARI warning plate, placed at a visible point in the pole at a height of 1.7m and legible from a distance of at least 2m.

4.1.7.1.6 EXCAVATION

The hole for the pole shall be excavated to a minimum of 1.8m for the 11m pole. If the base of the hole is not firm ground, the hole shall be excavated until firm ground is reached, otherwise the pole has to be placed on a flat rock block, min. 40 x 40 cm or a timber raft, min 80 x 80cm. depending on the conditions.

Minimum hole depth for wood poles shall be defined in the table:-

Pole Height H (m)	Size	Hole Depth Minimum (m)
10	Medium	1.6
11	Medium	1.8
11	Stout	1.8
12	Medium	2.0
12	Stout	2.0
14	Medium	2.2
14	Stout	2.2
15	Stout	2.4
17	Stout	2.6

The hole shall be dug to the required depth. Any holes left overnight must be covered in such a way that they do not pose any danger to persons or animals. A suitable method of warning shall be used to identify positions of the holes.

4.1.7.1.7 ERECTION

The butt of the pole is laid over the hole with the length in the direction of the line. A skid board is placed against the hole to facilitate the entry of the butt when the pole is raised and prevent earth breaking into the hole during the process of erection.

Erection of the poles shall be done using any of the following methods:

i) Erection ladders
ii) Truck mounted hydraulic lifts
iii) Guy ropes shall be used to prevent accident and to hold pole in a true vertical position. The pole is gradually raised to the vertical position and the butt guided into the hole.

4.1.7.1.8 POLE DRESSING

Partial dressing can be done while the poles are lying on the ground; in this case care must be taken during erection to avoid the fittings being damaged. The fitting of the insulator shall be done after the pole has been erected.

4.1.7.1.9 BACK FILLING

After erecting the pole and positioned it vertically, the pole shall be secured in this position by help of stones blocks placed in 2 or 3 layers, one layer at the bottom of the hole, and one to two layers at the top. The stones shall fill out the area between the pole and the wall and will secure that the pole remains vertical during the pole's lifetime.

Between the layers of stone and above the top layer, the excavated soil can be used as backfill material if the origin soil is appropriate for tamping.
The soil should be wet and backfilled slowly and each layer thoroughly tamped until the tamp makes a solid sound as the earth is stuck. Each tamping layer should not exceed 150 mm. If small stones or gravel are readily available, these should be mixed with the soil used in backfilling.

In areas where the ground is unsuitable for firm erection of poles i.e. swampy areas with black cotton soil etc the pole has to be placed on a flat rock block or on timber raft as described under **Clause 4.1.7.1.6**. It may also be necessary to change out the soil material around the pole.

4.1.7.1.10 DESIGN, MATERIALS AND CONSTRUCTION OF CONCRETE POLES

The concrete poles shall be designed and manufactured in accordance with Kenya Standard DKS 1933.

The poles shall be round, Prestressed or Reinforced Concrete Poles as per DKS 1933.

The materials used shall be in conformity with the design standard (DKS 1933) and shall be selected to suit intended application.

The pole shall be so designed that its strength in transverse direction shall be sufficient to take the load due to wind on conductors, fittings and the pole.

In accordance with Annex A of DKS 1933, the aggregates used in the manufacturer pf the pole shall be free from veins and adherent coating and free from injurious amount of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky, sconaceous and elongated pieces shall be avoided.

The surface of all reinforcement shall be free from loose scale, oil, grease, clay or other material that may have deleterious effect on the bond between the reinforcement and concrete.

The mix design, mixing and compaction of the concrete shall be such that the necessary strength in the pole is obtained after curing in accordance with DKS 1933.

Concrete shall be compacted by vibration, centrifugation or other efficient means. Hand compaction shall not be permitted.

The finished pole shall have a smooth external surface that is free from honeycombing.

A quarter (¼) of the poles supplied for each consignment shall incorporate an integral Earthing system comprising a non-stressed internal Earthing copper conductor (at least 70mm² stranded conductor) running the length of the pole and the ends of the conductor shall be left projecting from the pole to a length of 100mm at 200mm from top and 150mm below ground level. Manufacturer may offer alternative suitably designed Earthing termination for consideration.

4.1.7.1.10.1 Physical and Mechanical Properties of Concrete Poles

The concrete poles shall conform to the following standard sizes:

Nominal Length (m)	Top Diameter (mm)	Working Load (kN)	Ultimate Load (kN)	Strength Class (as per DKS 1933)	Minimum Depth in Ground (m)
10	190	2.5	5	50	1.8
11	190	2.5	5	50	1.8
12	190	3.0	6	50	1.8
13	190	3.0	6	50	2.0
15	190	3.0	6	50	2.1

The required safety factor is 2.5 and pole taper for the Pre-stressed Concrete Pole shall be at least 13mm per meter.
Poles shall be supplied complete with suitably designed fittings for conductor and stay wire characteristics.

4.1.7.1.10.2 Marking

Each concrete pole shall be marked permanently by impressing on the pole (or by use of a permanently secured plate) at a position 1.5m above the pole Ground line with the following details:

- Manufacturer's name
- Date of manufacture (mm/yy)
- Length of pole (meters) and Tip dimensions (mm)
- Ultimate/Working load/Strength Class
- Type of pole
- Weight of pole
- Standard to which the pole complies
- The words "PROPERTY OF KPLC"

Ground line reference mark shall be conspicuous on the pole.

Where a plate is used it shall be made of stainless steel, securely affixed to the pole. In all cases the lettering shall be not less than 5mm high legibly impressed.

4.1.7.1.10.3 Bolts Nuts and Washers

All bolts and nuts shall confirm to BS 4190 and shall preferably have screwed threads of I.S.O. form. Nuts and heads of all bolts shall be of the hexagonal type. All bolts and screw rods shall be galvanized including the threaded portion. Al nuts shall be galvanized with the exception of the threads, which shall be oiled.

4.1.7.1.11 INSULATORS AND FITTINGS

4.1.7.1.11.1 Insulators

Insulation between conductors and support shall be polymeric for tension, suspension, pin and post insulators, and shall comply in all respects with IEC 305, 383 and 120, 1109 and 815 or such other standard as may be approved and with the requirements set out in this Specification and in the Technical Schedules.

Insulators polymeric type from approved manufacturers who shall have had at least ten years' experience of supplying complete insulator units to international purchasers. Technical particulars and service histories must be submitted for the type of insulator offered. Insulator units shall where possible be interchangeable with units already in use on the Employer's system.

All insulators shall be designed with a view to service in a tropical climate in an area subject to lighting storms, at an altitude of about 2200 m above sea level.

Glass Insulator strings, where specified in scope of work, shall consist of minimum quantity of 12 units for 132kV, 6 units for 66kV, 3 units for 33kV and 2 units for 11kV at 146 mm Centre distance between each disc. The actual numbers and types of discs shall be selected to suit the requirements set out in the technical schedules.

Locking devices for the insulator units themselves and for associated ball and socket and fittings shall be of stainless steel and shall comply with IEC 372. The assembly shall be such as to allow easy removal for replacing of insulator units or fittings without the necessity to remove the insulator string from the crossarms.

All ball and socket joints on insulator sets shall be lightly coated with approved grease before erecting.
Each insulator shall be marked with the name or trademark of the manufacturer and the year of manufacture in accordance with IEC Publication 60383. In addition, each insulator shall be marked with the specified electromechanical or mechanical failing load in conformity with IEC Publication 60383.

4.1.7.1.11.2 Insulator Fittings

Fittings shall comply with BS.3288: Part 1 or such other standard as may be approved and shall be so designed that replacement of string insulator units and the arcing protection system can easily be performed during maintenance or repair under outage or live-line conditions.

All clamps shall be as light as possible and shall be designed to avoid any possibility of deforming the stranded conductors and separating the individual strands.

Bolts and nuts shall be in accordance with an approved specification. Bolt threads shall be coated with approved grease immediately before packing. Split pins for securing attachment of fittings of insulator sets shall be of stainless steel and shall be packed by washers of approved size and gauge.

All insulator strings shall be attached to crossarms by means of shackles or swivels. Hooks shall not be used.

4.1.7.1.11.3 Pin Insulators

Pin insulator shall be used for intermediate line poles and for small angles up to 20°.

On pin insulators, the conductor shall be bound in on top of the groove, using two suitable stirrups in each case. The bind shall be formed of a single layer of closely wound wire, extending at least 25 mm beyond the stirrups. The bind shall be wound on opposite directions, on each side of the insulator.

With aluminium conductor, the bind shall be formed of two stirrups, with 2.5mm diameter aluminium binding wire. In addition, aluminium amour tape shall be used, wrapped in a direction opposite to that of the conductor lay. The amour tape shall cover the portion of the conductor that is in contact with the insulator, and extend at least 40 mm under the bind.

4.1.7.1.11.4 Tension and suspension Insulators

These Polymeric Insulators shall be used where increased tensile strength in the conductors is envisaged i.e. flying angles, section and terminal poles.

The table below gives creepage distance requirement in relation to pollution.

Type of pollution	Creepage distance
Low	18-22 mm/kV
Medium	25-31 mm/kV
Extreme (Coastal/industrial area)	35 mm/kV

Where there is severe lightning activity, high insulation and creepage values are necessary

4.1.7.1.11.5 Post Insulators

In high pollution areas (Coast region) 33kv line shall use Post insulators for 66 kV line and 11kv lines shall use 33kv line post insulators.
All insulators to be used shall be composite polymeric insulator unless stated in the general technical specifications.

4.1.7.1.11.6 Cross Arms

The following types of cross-arms shall be used for 33kV and lower voltage lines depending on the limiting factor. 66kV lines and above shall not use Cross Arms, instead they shall use composite post insulators.

4.1.7.1.11.6.1 Steel Cross Arms

Steel crossarms shall be used in all cases as required.
Steel Crossarms shall be used extensively in the line making different formations. The choice of the formation will be determined based on the following:

i) Environmental conditions
ii) Landscape
iii) Available space

The steel cross arm shall be suitable for continuous operation outdoors in tropical areas at altitudes of up to 2200m above sea level, humidities of up to 90%, average ambient temperature of +30ºC with a minimum of -1ºC and a maximum of +40ºC and saline conditions along the coast.

4.1.7.1.11.6.2 Materials

Structural steel used, shall be grade 43A as specified in the BS 4360: “Specification for weld able structural steel”.

The tensile strength and yield stress of the steel shall be not less than 430/510 N/sq. mm and 255 N/sq. mm respectively.
Angle sections shall be as per BS 4848
Channel sections shall be as per BS4

4.1.7.1.11.6.3 Welding

Welding where specified shall be by metal-arc welding and shall be as per BS 5135.
After welding and before galvanising, welds shall be thoroughly cleared to remove slag and spatter, preferably by sand blasting.

All materials before and after fabrication shall be straight and free from twists. The material shall be free from blisters, scale and other defects.

All dimensions specified shall be subject to the following tolerances, unless otherwise stated.

(i) Dimensions up to and including 50 mm: ±1 mm
(ii) Dimensions greater than 50 mm: ±2 mm

Erection clearance for cleated ends of members connecting steel to steel shall not be greater than 2mm at each end.
Bolt holes shall not be more than 2mm greater than the diameter of the bolt for bolts up to 24mm diameter.

Cutting may be by shearing, cropping, sawing or machine flare cutting. Sheared or cropped edge shall be dressed to a neat finish and be free from distortion where parts are to be in metal contact.

All holes shall be drilled in one operation and burrs shall be removed. Holes shall not be formed by a gas cutting process. All matching holes for bolts shall register with each other so that a gauge 2mm less in diameter than the diameter of the bolt shall pass freely through the assembled members in a direction at right angle to such members.

4.1.7.1.11.6.4 Galvanizing

All materials to be galvanized shall be of the full dimensions shown or specified and all punching, cutting, and the removal of burrs shall be completed before the galvanizing process commences.
All galvanizing shall be done by the hot dip process with spelter, not less than 98% of which must be pure Zinc and in accordance with BS 729.

The Zinc coating shall be uniform, clean, smooth and as free from spangle as possible.
Galvanized steel structures shall be treated after galvanizing with Sodium Dichromate Solution.

Galvanizing	**Steel Structures for Inland installations**
Minimum Average Coating Weight	610 g/m²

Bending of flat straps shall be carried out cold.

4.1.7.1.11.6.5 Standard Sizes

The standard sizes of the different Cross Arms shall be as shown on the table below:-

Application	Standard Length (mm)	Cross Section		
		Height (mm)	Width (mm)	Thickness
11kV Inter pole. Upto 150mm^2 conductor.	1626	70	70	9.5
11kV Section/Angle/Terminal Upto 60^o 150mm^2 conductor.	2290	125	70	9.5
33kV Inter pole	2400	100	76	9.5
33kV Section/Angle pole/ Terminal	2400	125	76	9.5

4.1.7.1.11.6.6 Markings

The cross arms shall be marked legibly and indelibly with the words “Property of KPLC”.

4.1.7.1.11.6.7 Line Formation

The following is a recommendation for the use of the different common line formations:

i) Line poles for deviations 0°-10°, Steel cross arm will be used for horizontal and delta formations.
ii) Line poles for deviation 20°-60°,, double cross-arms or vertical flying angle shall be used.
iii) Line poles for deviations greater than 60°,, vertical sections shall be used.

4.1.7.1.11.7 Stay, Stay Insulators and Stay Blocks

4.1.7.1.11.7.1 Stay

Stay wires shall be in conformity with the attached Specification for Stay Wires and Guy Grips.
The dimension of stay wires used shall be in accordance with the actual load taking into consideration the Safety Factor given.
The stay wires shall with first-class workmanship be fastened to the pole to assure that they are keeping the pole in a vertical position during the pole’s lifetime.

4.1.7.1.11.7.2 Stay Insulator

A sling type strain insulator shall be inserted in each stay 1.6m from the top.

4.1.7.1.11.7.3 Stay Block

A reinforced concrete stay block buried to the depth of 1.6m shall be used as the stay anchor.

4.1.7.1.11.8 Conductor

Phase conductor to be used shall be Aluminium Conductor Steel Reinforced (ACSR) or All Aluminium Alloy Conductors (AAAC) and shall consist of steel strands together with aluminium strands or aluminium strands. The specific conductor to be used shall be described in the definite scope of work.

The outermost layers of the conductors shall be stranded with right hand lay. There shall be no joints in the individual wires of the outer layers of the aluminium wire.

The requirements for the conductors are specified in the attached Specification for Aluminium Alloy Conductors and Specification for Aluminium Conductor Steel Reinforced.

4.1.7.1.11.8.1 Conductor Characteristics

The conductors shall conform to the following:

a) Physical characteristics

Nominal Al. area (mm^2)	Code Name	Steel No./mm^2	Alum. No/mm^2	Overall dia. (mm)	Calculated Al. equ. Area (mm^2)	Total cond. Area (mm^2)	Weight Kg/Km	Copper Equiv. Area (sq.in)
150	Wolf	7/2.59	30/2.59	18.1	154.3	195.0	727	0.15
175 ACSR	Lynx	7/2.59	30/2.79	19.53	183.4	226.2	842	0.19
300AAA	Upas		37/3.53	24.71		362.1	997	0.3

b) Electrical characteristics

Nominal Al. area (mm^2)	Tensile Strength kgs	Resistance at 20 °C Ohm/Km	Current Rating Amp	Inductive reactance ohm/Km Spacing	
				30cm	50cm
150	6880	0.1844	430	0.235	0.266
175	7880	0.1576	470	-	-
300	10600	0.09155	610	-	-

The current ratings are based on the following operating conditions:

- Ambient temperature : 35°C
- Maximum conductor temperature : 80°C
- Intensity of solar radiation : 0.089 w/cm^2

4.1.7.1.11.8.2 Joints, Clamps and Connectors

Conductor fittings shall be designed in accordance with BS.3288. The electrical conductivity and current capacity of each joint or clamp shall be not less than those of the equivalent length of conductor.

Dead end clamps and tension joints shall be of the wedge clamp type and shall be so as not to permit slipping of or cause damage to or failure of the complete conductor at a load less than 85 per cent of the ultimate strength of the conductor. (Refer to the safety factors: 3.0 for conductors, 2.5 for clamps/fittings))

The design of joints and any tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly. All external nuts shall be locked in an approved manner. There shall be no relative movement within the clamp between individual layers of the conductor itself.
Mid span joints shall comply with the mechanical requirements of the Specification for line conductor joints and clamps. Compression dies shall be of a common size and dimensions for each fitting for a given size of conductor. Not more than one mid span joint will be allowed in one span in one conductor.
Parallel Groove (PG) clamp can be applied to joint conductors where there is no mechanical load.

4.1.7.1.11.8.3 Conductor Terminations.

Ball ended hook, Socket clevis and Socket tongue shall be suitable for use on Aluminium conductor steel-reinforced (ACSR) of outer diameter between 7.0mm and 25mm (25 sq. mm and 150 sq.mm) and standard disc insulator of ball and socket type with the ball pin diameter of 16mm.

Ball ended hook, socket clevis and socket tongue shall be of malleable iron or ductile iron, hot dip galvanised to BS 729.

Tension clamp shall be bolted type and shall be suitable for use on aluminium conductor steel-reinforced (ACRS) of outer diameter between 7.0mm and 25mm (25 sq.mm and 150 sq.mm).

The clamp body and keeper piece shall be of high strength and heat-treated cast aluminium alloy.

The clamp cotter bolts, and U-bolts shall be galvanised steel and the pin shall be stainless steel.

The clamp shall have slip strength of not less than 85% of the rated ultimate strength of conductor it is intended for use with.

4.1.7.1.11.8.4 Joints (Non-tension)

Parallel groove clamp (PG Clamp) shall be suitable for use on aluminium conductor steel-reinforced and all aluminium conductors of outer diameter in the range of 7.00 mm to 18.2 mm for ACSR conductors 25mm for AAAC conductors (300 sq. mm).

(a) The groove of the PG clamp shall correctly fit the conductor it is intended for use with. It shall have adequate cross sectional area and length.
(b) The PG clamp shall be of electrolytic, high strength, corrosion resistant aluminium alloy.

4.1.7.1.11.8.5 Suspension Clamps

Suspension clamps shall be suitable for use on aluminium conductor steel-reinforced (ACSR) of up to 18.2 mm diameter (150 sq. mm) and All Aluminium Alloy Conductor (AAAC) of up to 25mm diameter (300sqmm) shall be of the following types.

(a) Clevis ended hook type and pivoted type (similarly known as envelope type and trunnion type respectively).
    (i) The clamp body and keeper piece shall be of high strength, heat-treated cast aluminium alloy.
    (ii) The clamp cotter bolts, hangers, brackets and U-bolts shall be of galvanized steel and the cotter pin shall be of stainless steel.

(b) Angle suspension clamp type (similarly known as side opening type).

    (i) The clamp shall be suitable for use on turning angles from 10 to 120 degrees.
    (ii) The clamp body and keeper shall be of malleable iron or ductile iron; hot dip galvanised to BS 729.
    (ii) The clamp cotter bolts and bolt shall be galvanised steel and the cotter pin shall be stainless steel.

4.1.7.1.11.8.6 Connectors

The connectors shall be suitable for use on stranded bare conductors and shall correctly fit the conductor it is intended for use.
The connector shall have adequate cross-sectional area and dimensions and shall have current carrying capacity at least equal to the capacity of the conductor it is intended for.

(a) Aluminium connectors
  (i) Aluminium connectors (line taps) shall be suitable for connecting stranded aluminium conductors
  (ii) The connector shall be manufactured from electrolytic, high strength aluminium.

(b) Copper connectors
Copper connectors shall be suitable for connecting stranded copper conductors.

(c) Bi-metal connectors
  (i) Bi-metal connectors shall be suitable for connecting stranded aluminium conductors to stranded copper conductors.
  (ii) The bi-metal connector shall be designed to provide an effective corrosion barrier between the dissimilar metals (aluminium and copper).

4.1.7.1.11.8.7 Drums

Drums for conductors shall be stoutly constructed of good quality timber or steel and clearly marked with length and type of conductor in a manner not easily removable. Drums shall be securely battened around the perimeter and shall be lined with approved impervious material to prevent contact between the contents and both the drum itself and any chemicals with which the drum has been treated.

All timber drums and battens shall be protected from deterioration on site by termite or fungus attack by an approved impregnation treatment at the works before dispatch. Such substance shall not be harmful to the conductor.
All drums shall have spindle holes of adequate diameter and be stoutly reinforced with steel plate.
The cut ends of the conductor shall be properly secured to the flange of the drum and shall be treated in an approved manner to prevent the ingress of moisture during transit or storage.
The Contractor shall deliver all empty drums to the employer's store. All drums are non-returnable and shall remain the property of the Employer.

4.1.7.1.11.8.8 Markings of Drums

The following particulars will be indelibly stencilled on both flanges of every drum:
(i) Contract title and reference number
(ii) Manufacturer's name
(iii) Direction of rolling
(iv) Lifting instructions and limitations.
(v) The words "Property of KPLC"

An aluminium nameplate shall be fixed to each drum clearly showing the following:-
i) Conductor materials and stranding
ii) Length of conductor
iii) Net weight
iv) Gross weight
v) Manufacturers batch number
vi) Manufacturers drum number
vii) Winding date
viii) Approximate measurements

4.1.7.1.11.8.9 Conductor Stringing

All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

Every precaution is to be taken to prevent damage to the conductor. Clamps and other devices used for handling the conductor during stringing shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor. Conductor grooves in sheaves and tensioner shall be lined with neoprene or rubber.

Conductors shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

Conductor drums shall be closely examined before conductor pulling commences and all nails and other things that could damage the conductor shall be removed.

4.1.7.1.11.8.10 Re-Conductoring

Where applicable before the re-conductoring commence, the Contractor shall inspect the line and check that the clearances to ground, trees, houses, roads etc. meet the requirements. He shall also check that:

- The capacity of poles, cross arms and stay wires is sufficient for the new conductor
- The quality of poles, cross arms and stay wires is satisfactory
- The pole heights are sufficient for the new conductor
- The poles are in vertical position

Where the existing installation does not meet the above requirements, change out of material or aligning work of poles have to be carried out.

When re-conductoring, the Contractor has to handle all tilted poles with outmost care. Before loosen the existing conductors, the poles have to be secured with stay wires. Climbing the poles has to be done by use of ladders placed against the tilted direction.

All tilted poles has to be corrected to a vertical position before the stringing work of the new conductors starts. Poles that do not meet capacity- or quality-wise meet the new requirements have to be changed out.

After aligning the poles, the top of the pole shall not be out of the vertical axis by more than the top pole diameter.

All clamps, fittings and details not suiting the new conductors or quality-wise not meet the requirements, shall be changed out.

4.1.7.1.11.9 Safety

Personnel shall be required to use necessary protective gear, which conform to applicable codes.
Personnel working near high voltage areas shall be required to use non-slip footwear, gloves, safety glasses, helmets, etc. They shall also be required to observe stipulated safety clearances.

Fire prevention and safety programmes shall also be observed.

4.1.7.1.11.10 Operation Devices and Protection Systems

Operation devices consisting of single and three pole disconnectors shall be installed at locations specified by the designer. The disconnectors shall be easily accessible during normal conditions. They will be fixed in such a way that they cannot be closed by the action of gravity. Their characteristics shall be capable of meeting the maximum rated current of the circuit.

4.1.7.1.11.10.1 Isolation

4.1.7.1.11.10.1.1 Air break Switches

Air break switches shall be used to interrupt small currents (up to 10% of rating of ABS).

4.1.7.1.11.10.1.2 Protection against over Voltages

Protection against overvoltage will consist of surge diverters at locations specified by the designer.

4.1.7.1.11.10.1.3 Protection against Overcurrent

The network comprises main line and spurs.
Circuit breakers shall be installed at the beginning of the main line at the primary substation.

Short circuit fuses shall be installed at the beginning of the primary spur.
Autoreclosers and Sectionaliser shall be located as specified by the designer.

4.1.7.2 PARTICULAR TECHNICAL SPECIFICATIONS FOR TRANSMISSION LINES

4.1.7.2.1 DESIGN REQUIREMENTS

4.1.7.2.1.1 Philosophy of Design

The philosophy of design contained within this specification is based upon deterministic principles whereby the applied loading multiplied by the appropriate safety factor must be less than the ultimate strength of the component.
In tendering the Contractor will be deemed to have concurred as a practical manufacturer with the design and layout of the works as being sufficient to ensure reliability and safety in operation freedom from undue stresses and satisfactorily performance in all other essentials as a working plant.
The transmission lines shall be designed with high reliability and low cost of maintenance as the primary consideration in accordance with the relevant sections of the specification.
The design shall incorporate all reasonable precautions and provisions for the safety of those concerned in the erection and subsequent maintenance of the contract works.

4.1.7.2.1.2 Units of measurement

In all correspondence, technical schedules design calculations and drawings the metric (SI) units of measurement shall be used. Angular measurements shall be degrees with 90^0 comprising a right angle.

4.1.7.2.1.3 Design Calculations

All sets of calculation shall be complete, bound titled and given a unique drawing number
The binding shall be such as to allow the easy introduction of subsequent pages if necessary.
Bound into each set shall be fully detailed index. Following this shall be a design information sheets which incorporates the following details: -

a) The design concept shall be summarized
b) Full details of manual design papers or other aids referred to in the text shall be given with photocopies of relevant sheets if appropriate.
c) Full loadings shall be reiterated with their deviations if appropriate
d) Design stresses shall be reiterated
e) Code or standard references should be quoted and equation written out in full for initial calculation

Should the Contractor be required to re-submit amended calculations or additional sheets the following annotation shall be adopted:-

a) Amended sheets should retain the same sheet number but have a lower case revision letter suffix i.e. sheet 14 when amended becomes 14a then 14b.
b) Additional sheets that needed to be inserted shall be given the sheet number they are added to plus an upper case letter prefix i.e. additional sheets to page 60 become A60, B60 and if subsequently amended A60a etc.

Where a computer program is used for design calculations a full explanation in the English language shall be provided to assist the Employers approval of the calculations for each and every program used. Details must include name of program author source, comprehensive description of theoretical basis including all references to relevant documentation, checks undertaken on program and list of projects on which the program has been used.

4.1.7.2.2 DRAWINGS

4.1.7.2.2.1 General Requirements

- Drawings shall be to scale fully detailed and all dimensions shall be in Metric Units. General arrangements drawings submitted shall be to scale of not less than1 to 50 and all detail drawings not less than 1 to 20. Profile drawings shall normally be drawn to a vertical scale of 1 to 200 and a horizontal scale of 1 to 2,000.
- Drawings sheets shall conform in size to BS 3429, mainly A0, A1, A2, A3, and A4. A3 drawings shall be used as much as possible for construction drawings.
- The sheet size is to be stated on the drawing within or adjacent to the title block.
- Drawings shall conform to BS 308 or equivalent.
- The scale used shall be stated on the drawing as a ratio together with linear scale at a convenient position along the margin of the original drawing sheet.
- The physical draughting requirement in respect of line density, strength, contrast, contrast, spacing and character legibility shall be met to ensure drawings are suitable for microfilming in accordance with BS 5536 and the specification for micro-copying of drawings to BS 4210.
- All drawings shall bear in English, serial number of the project, drawing number, which shall be unique to this project and scale. The system of numbering and layout of the title block will be to the approval of the Employer. The title block shall include the name and address of the Employer. The revision notes shall detail the nature of each revision. The revision shall be enclosed in a cloud with the revision letter indicated.

4.1.7.2.2.2 Computer Generated Drawings

The submissions generated drawings by electronic transmission or any other electronic form shall be subject to agreement by the Employer.

4.1.7.2.2.3 Contract Drawings List

At defined interval the Contractor shall submit the requisite number of copies of the contract drawing list.
The list shall contain the following information:

a) Drawing number,
b) Drawing title
c) Revision status
d) Approval status

All changes since the previous issue shall be clearly indicated and when agreed only the front (index) revised sheets need to be submitted.

4.1.7.2.2.4 Contract Record Drawings

The Contractor shall submit to the Employer:

a) A final issue of the contract drawing list indicating which of the drawings design calculations, methods statements etc that they propose to issue as final contract drawings. These drawings shall be updated to incorporate all modifications made during erection and commissioning.
b) Requisite number of prints of each schedule, including where appropriate the supply and installation material manual.
c) Requisite number of drawings including design calculations schedules including the supply and installation material manual in diskette format in either WPG or DXF format.
d) Requisite number of polyester/transparency film copy of each drawing, including design calculations, profile and route maps.

The distribution of the contract record drawings will be advised by the Employer.

4.1.7.2.2.5 Route Maps

During the progress of the work the Contractor shall record on profiles, supply and install material manuals (SIMMs) and on a set Survey Maps of approved scale such particulars as will allow an accurate reference to be made afterwards in case of any faults or projected modifications to the line.
The map and/or profile sheet shall show the exact position of every support with approved reference marks. The maps shall be supplemented or profiles marked by sketches where necessary to delineate boundary position of support which cannot be clearly indicated on the maps.
The date included on the maps profile sketches and SIMMS shall be submitted to the employer to whom facilities shall be given for examining such records during the progress of the work.

4.1.7.2.2.6 Sag Templates

The Contractor shall supply the specified sets of templates in strong stable colourless plastic or similar material not less than 3mm thick. Engraving shall be on the back face of the templates. The templates shall be for the specified equivalent spans.

Each template shall be accurately shaped to provide the sag curve; the same curve shall be engraved on the template at a distance below representing the minimum allowable vertical clearance to normal ground. A further sag curve in still air at minimum temperature shall also be shown. Each template shall be clearly endorsed with the sagging basis, conductor particulars equivalent span and unless otherwise specified to a scale of 1:200 vertical and 1:2000 horizontal.

Templates shall be supplied to the Employer before the submission of the profiles. Failure to do so may result in delay which will be responsibility of the Contractor.

4.1.7.2.3 MATERIALS SUPPLY AND INSTALLATION MANUAL

As soon as final support positions are approved, the Contractor shall provide the requisite copies of the A4 size Supply Install Material Manual (SIMM).
Each support position shall be represented by one of the manuals with the following information recorded:

a. Provisional and final support numbers.
b. Profile and record map reference drawing numbers.
c. Span
d. Wind span
e. Weight Span
f. Angle of deviation
g. Support type, leg and body extensions and General Arrangement (G.A.) drawing reference numbers
h. Foundation type and G.A. drawing reference number
i. Earthing details and G.A. drawing reference number
j. Insulator set details and G.A. drawing reference number
k. Sag adjustment setting and linkage requirements – (where appropriate)
l. Phase conductor jumper details including spacer and general arrangements drawing reference number – (where appropriate)
m. Earth wire set details and G.A. drawing reference number
n. Earth wire vibration damper G.A. drawing reference number
o. Aircraft navigator (obstruction aids) drawing reference number – (where appropriate)
p. Fibre optic junction boxes and cabling G.A. drawing reference number – (where appropriate)

In addition, the following schedules shall be included: -

i. Phase conductor and OPGW sags and tension (erection and final)
ii. Suspension insulator sets off-sets
iii. Location and spacing of all phase conductor spacers dampers – (where appropriate)
iv. Location of all phase conductor and earth wire tension and non-tension joints
v. Location and spacing of all aircraft warning spheres (where appropriate)
vi. Location of all fibre optic joint boxes – (where appropriate)

The appropriate reference drawing numbers shall also be included. Preliminary copies of SIMMs shall be available prior to any site work commencing, together with materials summaries. This is Hold Point.

4.1.7.2.3.1 Maintenance Manual

The Contractor shall provide at the specified period before the end of the construction period of the contract, a maintenance manual covering the following information: -

a) Type, code numbers and description of all plant erected, together with names and addresses of manufacturers
b) Methods of assembly of all fittings
c) Method of replacing any part of the plant including the use of maintenance holes provided on the support access provisions and where appropriate the application of “live - line’ maintenance techniques.
d) Recommendations of preventive maintenance including frequency of inspection.
e) List of recommended maintenance equipment with a description of its use and limitations
f) Type and application of temporary Earthing equipment.
g) Personal safety equipment requirement and any risk assessment required.

The above information must be specified to this contract and entirely in the English language. Drawings and diagrams shall be used where necessary to enable the Employer/Purchaser to properly maintain the whole of the works.
The manual shall be suitably bound within a hard cover and all materials used shall be reasonably hard wearing.

The manual shall be submitted to the Employer. This is Hold Point.

4.1.7.2.3.2 Samples And Models

If the nature of the works makes it desirable the Contractor/ supplier may be asked to submit or prepare for the Employer such samples, patterns and models as the Employer may reasonably require for the purpose of design approval at the expense of the Contractor/supplier.

4.1.7.2.3.3 Photographs

The Contractor shall make all arrangements to provide progress photographs of all tests and such sections of the work in progress as directed by the Employer. Each photograph shall be suitably entitled, in digital format. The photographs shall be the property of the Employer and no copies of the photographs shall be released without the authority of the Employer.

The Contractor will normally be required to provide every month at his own cost the specified number of sets of un-mounted progress photographs suitably inscribed of potions of the work in progress throughout the period of construction. Any variation to these quantities will only be with the permission of the Employer.

4.1.7.2.4 TRANSPORT, ACCESS AND SERVITUDE

4.1.7.2.4.1 Wayleaves

4.1.7.2.4.1.1 General

Way leaves and access facilities, subject to the requirement of landowners and occupiers, will be provided by the Employer to enable the Contractor to carry out the erection of the contract works. Such facilities will not necessarily include facilities for storing materials nor necessarily include access for wheeled vehicles.
The Contractor shall satisfy themselves that the necessary rights of entry and access have been obtained before
The contractor shall indicate to the employer such pipes or other obstructions telephone telegraph and power lines which infringe the clearance specified or otherwise fail to satisfy the requirement of the specification.
The necessary agreement for the removal of obstruction such as trees and for the permanent removal or guarding of pipes telegraph telephone and power lines, will be obtained by the Employer.

4.1.7.2.4.1.2 Way leaves Schedule

Before the Contractor commences work on any property, he shall obtain the way leaves schedule from the Employer, including details of any special requirement of the occupiers concerned. This is a hold Point.

4.1.7.2.4.2 Access to Site, Notice of Entry

4.1.7.2.4.2.1 Access Routes – General

The Employer may indicate to the Contractor the general route for access to each or any position as agreed by the Employer, otherwise the Contractor shall make all necessary arrangements (other than questions of way leaves) with the occupier.
Subject to the provisions of the preceding paragraph before commencing work, the Contractor shall at his own expenses do what is necessary to make the access suitable for his use and shall take all reasonable precautions to avoid damage, including if required erection of temporary fences or gates where permanent fences, hedges or gates have been removed. The Contractor shall not be entitled to any additional payment in the event of a particular access being difficult.
The Contractor shall be responsible for maintaining agreed access routes in a usable condition without undue widening for the duration of the contract. The occupier shall not be put to any inconvenience in gaining access to his land or buildings. No unauthorized access routes shall be taken by the Contractor.

4.1.7.2.4.2.2 Commencement of work

Before beginning on any property, the Contractor shall be responsible for obtaining confirmation from the Employer that way leaves are in order and any agreed accesses have not been altered and for giving not less than 48 hours' notice to the occupier that work is to begin. Work shall proceed on any land within the requisite period of such notice being given to the occupier.

4.1.7.2.4.2.3 Suspension of work

Where work is to be suspended without the expectation of it being resumed within the specified period, the Contractor must notify the occupier of such intention and shall similarly give the occupier prior notification of the resumption of work. The purpose of this Clause is to assist in maintaining good relations between the occupier, the Contractor and the Employer and to keep the occupier informed of what is going to happen on or across his land.

4.1.7.2.4.2.4 Compliance with occupier's requirements

At all times during the execution of the works, the Contractor shall ensure compliance with all such reasonable requirements of the occupier as are brought to the Contractor's notice by the Employer. The Contractor shall not be entitled to any additional payment in respect of his compliance with the reasonable requirements of the occupier.

4.1.7.2.4.2.5 Notice to Authorities

Before the Contractor carries out the stringing of conductors along or across power or telecommunication circuits, public roads, etc, he shall give the requisite notice to the appropriate Authorities of the time and date when he proposes to perform the work and shall send a duplicate copy of each notice to the Employer.

4.1.7.2.4.2.6 Route Clearance

For details of the clearance requirements for survey, access routes, line route, support locations and conductor stringing, reference shall be made to **Clause 4.1.7.2.4.6** on route selection and clearance

4.1.7.2.4.2.7 Access Roads

For details of the access road requirements reference shall be made to **Clause 4.1.7.2.4.6** on route selection and clearance

4.1.7.2.4.3 Crossing Of Obstacles

4.1.7.2.4.3.1 General

The Contractor shall, at his own expense, make any necessary arrangements and take the necessary precautions where the route crosses buildings, telecommunication, power or pipelines, orchards, gardens, railways, antiquities or other obstructions or ground over or across which erection cannot be carried out in the normal manner or has to be avoided. These arrangements must be submitted to the Employer. This is a Hold Point.

Where a support is set across a fence, hedge, bank or wall, the Contractor shall remove and reinstate the fence, hedge, bank or wall at his own expense and he shall be responsible at his own expense for making good to the satisfaction of the Employer, owners and tenants concerned, all land, property, roads, drains, fences, walls hedges, gates and the like which he has damaged or disturbed during the execution of the contrast works and shall remove all surplus material after erection. The Contractor shall take proper precautions to prevent the straying of and damage to livestock until after the backfilling of excavations and permanent reinstatement of fences, walls, hedges, gates and the like are completed.

4.1.7.2.4.3.2 Public Utilities

The Contractor shall ensure that the erection of the contract works does not cause damage to or interference with existing telecommunication, power or pipelines.
Where appropriate Authorities affected deem it necessary for the protection of their employees, property, or the public, or for the assistance of traffic, to provide flagmen and watchmen, the cost of such provision shall be borne by the Contractor. Where required by the appropriate Authorities work shall be carried on outside normal hours and at the Contractor's own expense.
The Contractor shall also be liable to make good at least to the original condition or compensate the owners, operators and users or any public undertaking in respect of any damage however caused to their property, lands or roads arising out of or in consequence of the execution of the works.

4.1.7.2.4.4 Scaffolding

The Contractor shall provide all necessary scaffolding and the like for the crossing of telecommunications or power lines, roads, railways building or other obstacles. The Contractor shall advise the Employer in each instance of the scaffolding he proposes to use. Drawings of the proposed scaffolding shall be submitted to the Employer, and the appropriate regulatory authorities. This is Hold Point.

4.1.7.2.4.4.1 Live Line Scaffolds

The scaffolding which is used to cross specified low, medium and high voltage power lines shall be of such dimensions and allow such clearances that the power lines being crossed may remain in commission during construction of the new transmission line. It may only be possible to have shutdowns on the lines to be crossed for sufficient periods of time to top out and net the scaffolds. Such restrictions in building and use of the scaffolds will not be grounds for claiming additional costs. Design and construction of the live scaffold shall not be inferior to the minimum standards outline in the following clause.

4.1.7.2.4.4.2 Live Line Scaffold-Construction

The scaffold shall be designed to withstand the maximum design wind speed, except that a reduced return period will be accepted. Consideration shall also be given due to impact loading, due to dropping of the upper phase conductor.
The scaffold shall, unless otherwise approved by the Employer, consist of 3m wide 300mm squire mesh nylon nets attached to steel wire ropes running perpendicular to the lower line route, carried by metal scaffolding at 3m intervals. The nets shall be attached to the catenary wires by means that do not require the presence of any persons on the net or the catenary wires whilst the lower line is alive. An additional movable 3m by 50 mm mesh walk net laid over the 300 mesh nets may be used whilst the lower line is dead.
Normally, steel or aluminium tubular scaffolding to BS 1139 and BS 6323 should be used. The use of pre-formed units or frames shall be subject to the Employer's approval.

The mechanical construction shall be in accordance with BS 5950. Reference shall also be made where appropriate to BS 5973.
The design of the scaffold shall have due regard to the requirements of safety with particular respect to accidental contact with live conductors during construction, use and removal.
The scaffold, including foundations, shall be designed and constructed to ensure stability during the process of erection and removal, and also at times when work has caused for any reason including adverse weather conditions. The foundations shall be suitable for the ground concerned.

The base width of any tubular steel supporting structure shall not be less than 25 percent of its height. Lighter materials (e.g. Aluminium) shall be used with caution. Adequate diagonal bracing shall be provided.
The scaffold shall extend at least 5m either side of the outermost conductors of the upper line. A maximum of 2m of this distance may be provided by means of catchers.
Catchers shall be provided at each end of each scaffold support. The catcher may be vertical or inclined to a maximum angle of 45^0 from the vertical. They shall be capable of withstanding the specified impact loads without excessive distortion that would permit a falling conductor to approach or touch a live line.

The upper parts of the scaffold shall be provided with soft wood rubbing boards or otherwise protected in an approved manner to prevent damage to the conductors resting on or being drawn over the guard. Soft wood poles may be used for this purpose. The height of these boards shall be sufficient to prevent the conductor damaging the nylon net. To avoid

damaging the conductors no object other than non-metallic lashing or the catchers shall protrude above the rubbing boards.

Sufficient endless or double ended lead lines for hauling over pilot wires shall be placed over the scaffold prior to re-energization of the lower line.

The side supports shall have working platforms to facilitate the required running of conductors and prior wires. Working platforms shall be provided with handrails, toe boards and notices warning of the danger of live conductors. The heights of handrails shall be 1m and the toe boards 230 mm. Each working platform shall have a notice plate indicating the "Safe Climbing Height".

The scaffold shall be fitted with danger plates at intervals of not more than 6m along the anti-climbing device with at least one plate on each face of the structure.
The scaffold shall be constructed to prevent unauthorized access or climbing by the use of barbed wire anti-climbing devices, fences or other means approved by the Employer.

The scaffolding shall be lit with red warning lamps from ½ hour before sunset to ½ hour after sunrise if erected within 2m from a highway or footpath without an intervening fence. The scaffold the Contractor shall provide or arrange for the supply and maintenance of these lamps (e.g. with the line Contractor).
If the scaffolding is constructed adjacent to a roadway, a guard constructed from steel drums filled with soil or a soil bund shall be provided and suitably lit.

Where possible the resistance to earth of the scaffold shall be less than 10 Ohms. Special consideration by the Employer and the lower line operator shall be given in cases where this is not attainable with a reasonable number of driven earth rods.

Bonding the scaffold to the earthing systems of either the live-line, or the line under construction is not normally acceptance. In the former case a nearby line fault could cause the scaffold to become live. In the latter case a fault between the live-line and the scaffold could cause components of the line under construction to become alive, particularly as its earthing system may not be complete.

The earth rods should normally be driven into the ground around the outside and approximately 1 m from the scaffold structure. The rods should be securely connected electrically and mechanically to the scaffold structure by flexible copper or aluminium leads with minimum across-sectional areas of 64 mm^2 or 100 mm^2 respectively.

Drawings of the scaffold complete with details of the clearance plates and earthing arrangement, together with supporting calculations shall be submitted to the Employer and appropriate regulatory authorities. This is a Hold Point.

4.1.7.2.4.5 Damage

4.1.7.2.4.5.1 General

The Contractor shall take all reasonable precautions to avoid damage to land, property, roads, crops, fields drain, fences walls, hedges, gates, trees and the like and shall ensure that the work is adequately supervised so that any damage is reduced to the minimum. Save as otherwise provided, the Contractor will be liable for all damage arising by or in consequence of the works except unavoidable damage to crops and shall pay compensation or make good at the option of the Employer.

4.1.7.2.4.5.2 Contractor's Responsibility

The Contractor's liability for loss or damage shall extend to any such loss or damage resulting from the employment of a Subcontractor. This does not relieve the Contractor of his liability for all actions of his Subcontractor.

4.1.7.2.4.5.3 Livestock

Adequate provision shall be made by the Contractor to prevent the straying of or injury to livestock during the execution of the work and until the permanent reinstatement of fences, wall, hedges, gates and the like is completed.
The Contractors shall be liable for any injury to or loss of livestock due to failure to comply with the above requirements.

4.1.7.2.4.6 Route Clearance

Where clearing is required, the following requirements shall be observed:

a) Tree and tall scrub shall be cleared to a distance of 15m on either side of the centre line of the route. Trees and bushes shall be cut down to a height of not more than 1.25m above ground level. In addition, tall trees outside the cleared area, of such height that could fall within 3m of the conductors, shall be trimmed by the Contractor. No tree may be felled without the express permission of the Employer. This is a Hold Point.

b) Felled trees and scrub shall be removed from a path 2.5m wide and running as far as possible continuously along the route. The Contractor shall grub up tree stumps and roots from this track and leave a graded way for negotiation by Land Cruiser or similar four-wheeled drive light vehicle for patrolling and maintenance by the Employer.

c) The Contractor shall clear a 4 m wide agreed construction track from public roads, of all trees, stumps, scrub and vegetation to tower positions as required by the Employer. Such tracks need not be surfaced but shall be graded and shall include culverts to prevent wash-way.

d) All felled trees and tree trimmings shall remain the property of the landowner.

4.1.7.2.5 SURVEY AND GEOTECHNICAL INVESTIGATIONS

4.1.7.2.5.1 Route Selection

The Employer will indicate to the Contractor either on maps or during visits to the sites the proposed route of the transmission line, with approximately positions of the angle and terminal support and the position of such intermediate supports as it may have been desirable to determine during preliminary way leaves negotiations. The Contractor shall give the Employer the requisite period of notice prior to commencing the survey. This is Hold Point.

4.1.7.2.5.2 Contractor Survey

4.1.7.2.5.2.1 Access for Survey

The Contractor's surveyors shall in all cases announce himself to the occupier/landowner immediately before entering any private property for the purpose of survey.

4.1.7.2.5.2.2 Accuracy

Profiles shall be produced as a result of a precision ground or aerial survey, the accuracy of which shall be such that the vertical tolerance between levels forming the profile and

actual ground level shall not exceed 300 mm, and the measured to an accuracy of not less than 0.2 percent. All levels shall be related to the specified national datum.

4.1.7.2.5.2.3 Profile Drawings – Size & Scales

Computer plotted profiles on plain plastics drawings sheets will be accepted by the Employer.

The profile shall either be drawn on a mixture of a melinex type material or as otherwise approved with printed grid lines of increasing thickness in 1, 5, 10 and 50 mm squares and shall be drawn on the reverse side of the melinex to the grid lines.
However, the format of the profile shall not differ from the details specified in the following clauses.
Unless specified to the contrary the scale of the profile shall be:

- 1:2000 horizontally and
- 1:200 vertically

The profile shall be plotted with the direction of the line route left to right on profile sheet. In general, individual profile sheet shall commence and finish at tension supports but where this is not practicable and continuation sheets are found to be necessary the ground line is to be drawn so that there is an overlap of at least 300 mm between adjacent sheets. The chainage of each section between tensions structures shall start at zero, be on 50mm printed grid line and not less than 150mm from the left-hand margin. Each section shall normally be started on a new sheet. The date of survey of each section shall be added.
If more than one section is drawn on one sheet a gap shall be left in the ground line of not less than 150mm.

4.1.7.2.5.2.4 Profile Drawings – Details

The following details and information are to be included on the profile drawings:

a. At each angle position “tie– in” sketch shall be provided on the profile sheet. This sketch shall show clearly the location of the support using as reference where possible points which can be located on the ground and on the 1:5,000 or closest available scale of survey map. The direction of the line and angle of deviation are to be shown stating also whether the deviation is left or right. Where reliable maps of reasonable scale and accuracy are not available for locating and plotting support positions survey methods acceptable to the Employer shall be employed to establish grid co-ordinates supports and ground features shall be related to these.

b. Where ground slope across the line route exceeds 1 in 25 the level of ground left and right of the centre line shall be recorded at specified horizontal offset distances where the side slope is uniform. Where the slope breaks upwards beyond this distance levels will be recoded up to a specified horizontal offset distance. The offset levels shall indicate on the profile as broken and/or chain lines and the distance off-line started.

c. The profile shall show all changes of level of 300 mm or more along the route centre line and along the off-set lines. All features such as hedges, fences, graves, ditches, roads, railways, rivers, buildings, canals, telephone and railway lines and all power lines shall be shown. Route numbers or name of roads shall be stated or, if unclassified the destination. Railways are to be given the destination, number of tracks, whether or not electrified and the level at the top of rail stated.

d. The chainage is to be shown at each 300 m and at every geographic feature or obstruction. Chainage shall also be given to all pegs.

e. The specified Datum shall be the basis for all levels and the levels above the specified Datum shall be shown at 10 m vertical interval at the beginning and end of each profile sheet. Levels shall be shown at each peg on line and at every obstruction or geographical feature.

f. The visual nature of the ground shall be noted whether cultivated, woodland, etc, with special reference to marsh soft ground or rock and other relevant information such as soil instability.

g. All buildings or high obstruction within 30 m of the centre line shall be shown dotted at their measured height with the distance left or right of line indicated.

h. Where the ground contour rises to a point which would be less than 100 mm from the top of the profile sheet, the ground line shall be terminated and continued on a new sheet with an overlap of 300 m of line route.

i. The following detail shall be shown for crossing of power lines: -
   - Voltage and type of construction
   - Ground levels at point of crossing and support structures.
   - Height of top conductor and earth wire at point of crossing and at point of support.
   - Distance from crossing point to support structures along route of line to be crossed.
   - Angle of crossing.
   - Temperature at time levels were taken (state date and time);
   - Support structures members.

j. Along the bottom of the profile sheet a route map shall be drawn, to the same scale as the horizontal scale of the profile, showing all relevant details, within a distance of 30m each side of the route centre line. All items covered by **Clause 4.1.7.25.24 paragraphs (a) and (i)** above as appropriate shall be included

k. On tower spot locations, local profile for each tower shall be provided. Stub length and foundation depth design shall refer local profiles as much as possible.

4.1.7.2.5.2.5 Support Location on Profiles

The Contractor shall submit to the Employer the requisite copies of the profile drawings upon which shall be indicated the proposed location and type of each support, spans, section lengths, (i.e. distances between tension supports), equivalent spans, wind and weight span, phase conductor swing angles, difference in level between adjacent phase conductor attachment points and the sag templates used. This is a Hold Point.
In addition, the relevant position of the bottom or lowest phase conductor at the specified maximum conductor temperature, together with another line parallel to the phase conductor at the minimum statutory ground clearance, shall be shown on the profile.

4.1.7.2.5.2.6 Check Survey

The Contractor shall carry out a check survey. Profile drawings/preliminary profile will be made available to the Contractor, who will be required to check the profile survey and survey and design final route for approval.

The Contractor is required to check thereon the proposed support positions and submit the profile to the Employer. Profile details and support locations shall be in accordance with the preceding clauses. Check survey shall include Contractor notes on final route selected and shall be approved by Employer; approved centre shall be the transmission line approved design centre.

Design and construction set out will be based on this without changes, and any deviation shall be reported immediately to the Employer with the proposal for restoring design centre.

4.1.7.2.5.3 Geotechnical Investigation

4.1.7.2.5.3.1 General

Geotechnical investigations shall be undertaken in accordance with the technical requirements detailed in the following clauses.
Where required by the Employer, the Contractor or his appointed geotechnical consultant shall undertake the specified slope stability analysis and design. The Contractor shall give the Employer the requisite period of notice prior to commencing the geotechnical investigation. This is a Hold Point.

4.1.7.2.5.3.2 Level 1

Level 1 geotechnical investigations shall be based on a visual-tactile examination or disturbed soil samples for the determination of both soil classification and strength.

4.1.7.2.5.3.3 Level 2

Level 2 geotechnical investigations shall be based on in-situ testing for the determination of the soil strength and visual tactile examination of disturbed samples for the determination of soil classification

4.1.7.2.5.3.4 Level 3

Level 3 geotechnical investigations shall be based on in-situ testing (as level 2) for the determination of the soil strength and the recovery of disturbed soil samples for the subsequent laboratory testing. Laboratory soil classification tests for non-cohesive soils shall be article size distribution, moisture content and relative density, whilst those for cohesive soils shall be moisture content and Atterberg limits.

4.1.7.2.5.3.5 Level 4

Level 4 geotechnical investigations shall be based on a combination of in-situ testing (as level 2) and the recovery of disturbed/undisturbed soil samples for the subsequent laboratory testing.

4.1.7.2.5.3.6 Soil and Ground Water Samples

Where specified, soil and ground water samples shall be obtained for determination of the chemical content i.e. organic matter, sulphate, pH and chloride content.

4.1.7.2.5.3.7 Geotechnical Investigation Criteria

Geotechnical investigation shall be undertaken to the following criteria:

a) Geotechnical investigation shall be undertaken as near as possible to the tower site. For test foundations the investigation shall be undertaken as near as possible to the test site and shall take account of the theoretical failure surface of the foundation.

b) Time lapses between the investigation and foundation installation shall take into account any noticeable effect on the geotechnical properties due to rainfall or seasonal variations in the groundwater level.

c) Depth of investigation shall be:
   i. For trial pits 2m; or
   ii. the foundation depth plus 1.5 times the maximum base width dimension for concrete pad and chimney or steel grillage foundations; or
   iii. 3m or 5 times shaft diameters (whichever is greater) below the foundation depth for drilled shaft, piled foundations; or
   iv. at least 2m into rock or hard dense stratum (N_{SPT} > 50) if this occurs before the recommended depth; or
   v. for uplift or lateral foundation tests not less than 1m below the base of the test foundation.

d) SPTs (standard penetration tests) should be undertaken at the top of each stratum and then at 1m intervals in soil or weak rock.
e) PMTs (Pressure meter tests) should be undertaken in each stratum or as required.
f) CPTs (Cone Penetration Tests) should be taken continuously over depth of investigation
g) VSTs (Vane Shear Tests) should be undertaken at top of each stratum and then at 1m intervals.
h) Soil/rock description should be based on disturbed samples taken in each stratum and thereafter at 1m intervals.
i) Highest ground water level and variation in water level

4.1.7.2.5.3.8 APPENDIX 6.A.1

Geotechnical Investigation

Geotechnical Investigation Level	Frequency
Level 1 and 2	Every tower site
Level 3	Every tower site
Level 4	Every tension, Angle and terminal tower
Electrical resistivity	Every tower site

Ground water samples shall be taken at every tension/angle/Terminal and 5% suspension monopole position for chemical analysis.

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4.1.7.2.6 CONDUCTORS AND FITTINGS

4.1.7.2.6.1 Power Conductor – "LYNX" – ACSR 175mm^2

The power conductor shall be Aluminium Conductor Steel Reinforced (ACSR)-175 mm^2 codename "Lynx" and shall comply with IEC 60889. The outermost layer of the conductors shall be right-handed lay (z-lay). The Aluminium shall be of the highest purity commercially obtainable and shall not be less than 99.5%. The Contractor shall submit certificates of analysis giving the percentage and nature of impurities in the metal from which the wires were made. There shall be no joints in the individual wire of the outer layers of aluminium wires. All steel core wires unless specified to the contrary shall be hot-dipped galvanized to comply with the requirements of IEC 60888.

Unless specified to the contrary all conductors shall be uniformly covered with neutral grease as per IEC 61089. The minimum fill factor of grease shall not be less than 70 percent. Each layer of wire except the outer layer shall have, both lengthwise and peripherally, an even and continuous coating of grease. Wax thickened greases shall be applied at a temperature above the dropping point and shall be substantially free from contaminants.
The grease shall protect the conductors from corrosion in service, not corrode the steel or aluminium, be compatible with any wire drawing lubricant that might be applied on the

conductor, not flow nor exude from the conductor during storage, transport, erection or service at temperatures of up to 100 degrees celsius. In addition, the grease should have adequate resistance to oxidation and conform to relevant current health and safety requirements.

4.1.7.2.6.1.1 Technical Details of Lynx ACSR Conductor

Nominal section	:	175 mm^2
Conductor strand	:	30/7 (2.79 mm)
Tolerance of diameter: Aluminium	:	± 1.0%
Steel	:	± 2.0%
Minimum tensile strength after stranding : Aluminium	:	17.2 kg/mm^2
Steel	:	128.5 kg/mm^2
Minimum coating weight of zinc	:	240g/m^2
Calculated section		
Aluminium	:	183.40 mm^2
Steel	:	42.80 mm^2
Total	:	226.20 mm^2
Outside diameter	:	19.53mm
Unit weight of conductor	:	0.842kg/m
Ultimate tensile strength (UTS)	:	8,140kg
DC resistance at 20 deg. C	:	0.1576 Ohm/km
Approx current carrying capacity	:	540 A

4.1.7.2.6.2 Alternative Conductor for Coastal Region ACCC 223mm^2

Coast region is heavily polluted and prone to high corrosion due to its high humidity environment.
KPLC prefers use of Aluminium conductor composite core conductor i.e. 223mm^2 ACCC for this project. This conductor is resistant to heavy pollution and corrosion, and is ideal for coastal areas
General requirement and technical specifications for ACCC conductor is provided in the attachment for KPLC materials and equipment specifications.

4.1.7.2.6.2.1 Conductor Sag Design

Sags shall be computed under the following conditions:

Most severe design conditions:	Max. Wind pressure under min temperature
Max. wind pressure on conductor	385 N/m^2
Max air temperature	35^0 C
Min. air temperature	10^0 C.
Min. conductor temperature	0^0 C
Max. conductor temperature (continuous loading)	75^0 C
Max. conductor temperature (fault conditions)	200^0 C
Average conductor temperature	40^0 C
Factor of safety	
- Max. Working tension to UTS	more than 2.5
- Everyday stress to UTS	more than 5.0
Young's modulus of aluminium	6,300kg/mm^2
Young's modulus of steel	21,000kg/mm^2
Linear expansion coefficient	17.8X $10^{-6}/^0$C

4.1.7.2.6.3 Drums

The conductors shall be supplied on impregnated drums of approved materials constructed so as to enable the conductors and OPGW to run smoothly and those as spare materials shall be supplied on steel drums of approved materials for storage for long duration.
Length of conductors on one drum shall not be less than 2,000m.

4.1.7.2.6.4 Joints And Repair Sleeves

Tension joints of the conductors shall be of compression type and shall be free from slipping off, causing damage to or failure of the complete conductors, OPGW or any parts thereof at loads less than 95 per cent of the ultimate breaking strength of the conductors and OPGW.
Electrical conductivity and current carrying capacity of the tension joints for the power conductors shall not be less than those of equivalent length of the conductors.
The cut ends of steel wires and steel component inside the joint shall be protected from the weather in an effective and permanent manner.

Aluminium sleeves shall have plugholes for injecting compound.
All tension joints shall be supplied with aluminium fool-proof gauges or anti-displacement pins for correct positioning, adequate quantity of filling compound in injectors and aluminium collars for gap filling.

Full details of the joints including an illustration of practices for filling the air gap between sleeves, method of correct positioning of steel sleeves, gauges for ascertaining the compressed size, etc. shall be submitted with the tender.

Repair sleeves for the power conductors shall be of the compression type and the conditions stated above for the tension joints shall apply to the repair sleeves where applicable.

4.1.7.2.6.5 Accessories For Power Conductors and OPGW

In order to prevent fatigue of power conductors and earth wires due to repeated vibrations caused by breeze, the following countermeasures shall be applied.

a) Trunnion type suspension clamps
b) Vibration dampers
c) Armour rods.

4.1.7.2.6.5.1 Trunnion type suspension clamps

Suspension clamps shall be of trunnion type, made of aluminium alloy and as light as possible. They shall be designed to avoid any possibility of deforming the stranded conductors and earth wires and of separating the individual strands and shall be free to pivot in the vertical plane containing the conductors and earth wires.

Suspension clamps except jumper suspension sets shall have a suitable dimension for clamping the conductor with preformed armour rods; and shall not permit the complete conductor with armour rods to split at load less than 2,250kg for ACSR. Particular attention shall be paid to the elimination of corona emission from all parts of the suspension clamp.

4.1.7.2.6.5.2 Vibration Dampers

Vibration dampers shall be of Stockbridge type for both conductors and OPGW. The dampers shall be applied in all conductors and OPGW in every span except slack spans into the substations. The dampers shall be designed to be attached to the conductors and OPGW in a manner, which will prevent damage thereto and free drop of the weight in service. Clamping bolts shall be provided with domed self-locking nuts designed to prevent corrosion to the thread.

The nominal weight of damper shall be 12 pounds (5.44kg) for the conductors and 4 pounds (1.81kg) for the OPGW. The numbers of the dampers to be installed per span shall be:

a) 2 pieces per conductor or OPGW for spans up to 600 m and,
b) 4 pieces for the spans longer than 600 m.

First and second dampers will be positioned at 1.1m and 2.2m for power conductors and 0.6m and 1.2 m for OPGW respectively from the centre of suspension clamps or from the mouth of tension clamps.

4.1.7.2.6.5.3 Armour Rods

Preformed armour rods shall be applied to all suspension points of the power conductors except jumper suspension points.

Suspension clamps for those conductors protected by armour rods shall be suitable for the enlarged conductors.

4.1.7.2.6.5.4 Corona and Radio Interference

The design of all line conductor fittings, vibration dampers, etc., shall avoid **sharp corners** or **projections** which would produce high electrical stress in normal working. The design of adjacent metal parts and matching surfaces should be such as to maintain good electrical contact under service conditions. Particular care shall be taken during manufacture of conductors and fittings and during subsequent handling to ensure smooth surfaces free from abrasion.

4.1.7.2.7 LINE INSULATION

The transmission line for the project is aligned on an elevation level of 1500-2500m above sea level. The area has high humidity levels, tropical sunshine and prone to medium pollution by agricultural activities.

Silicon-rubber long-rod type Composite Insulators of the approved type shall be used to support the power conductors of the Transmission line. All insulator units will be composed of top and bottom arcing rings to equalize the voltage distribution over the insulator. The top shed of the insulators shall also have a larger diameter to prevent waste from birds and animals tracking down along the insulator.

4.1.7.2.7.1 Insulators Design

The 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 insulators should withstand wind pressures of up to a maximum of 385N/ m2.
The design of insulator units shall be with end over mould or such as to avoid local corona formation and no significant radio interferences shall be exhibited. The long rod Insulator units shall comply with the requirements of IEC 61109.

4.1.7.2.7.2 Fittings

All fittings to make each composite insulator set complete for beneficiary use shall be supplied and included in the rate for each insulator unit. Such bolts, nuts, washers, cotter pins and retaining pins with necessary spares as may be necessary for the use for erection shall be deemed to be included in the appropriate items.

Ball and socket couplings shall be in accordance with the requirements of IEC 60120/16. Sockets shall have “R” type security clips in accordance with the requirements of IEC 60372.

Clevis tongue couplings shall be in accordance with the requirements of IEC 60471.
All ferrous fittings shall be made of steel, ductile iron or malleable iron hot dip galvanized, and shall have sufficient strength for abrasion and weariness produced by repeated vibration. Cotter pins shall be made of non-ferrous metal or stainless steel and designed as the self-locking type.

The arcing ring shall be provided for the top and bottom of each insulator string and shall be of such design and shape that it reduces the voltage across the part of the insulator adjacent to the conductor for each insulator string, to a value which prevents visual corona formation on the metal caps and pins of the insulators and shall minimize the Radio / Video interference voltage from complete insulator and hardware assemblies when operated at the voltage up to 420 KV.

The arcing rings shall be of such design that when added to suspension and tension assemblies, the resulting flash-over values of the complete insulator string shall not be reduced below the percentage indicated hereunder, of corresponding flash over values with the rings omitted.

The percentages are:
a) Wet 50 Hz: 100%
b) 1.2 / 50 Impulse: 96%

The rings shall be of hot dip galvanized steel or Aluminium tube having outside diameter as required for corona control and minimum thickness of 2.5mm. Both inner and outer surfaces shall be galvanized to the required specifications (BS 729). The details of the rings, brackets and methods of mounting shall be of such design that the rings may be readily replaced under ‘hotline’ maintenance.

The horizontal distance between corona rings at suspension rings at suspension insulator strings shall be kept as small as practicable to accomplish the required reduction in Radio/ Video Interference (RVI).

All the accessories and the fitting offered against this specification shall be subjected to corona test. The corona shall not take place and shall extinguish at the voltages specified i.e. when a voltage of the specified value applied (Phase to Neutral i.e. RMS) the corona shall appear and shall disappear again at the specified value of voltage.

4.1.7.2.7.3 Pollution

The design of insulator units should take into account the principles contained in the IEC 60815 for medium pollution environment. For this project the minimum creepage value of 25mm/kV shall be applied (Creepage distance of 3700 mm).

4.1.7.2.7.4 Zinc Collars

The insulator unit cap and pin shall be fitted with zinc-collared pins to prevent cracking due to pin corrosion caused by the effects of pollution and high humidity in the project area.

4.1.7.2.7.5 Insulator Protective Device

The design of insulator fittings including corona shields shall comply with the following requirements:

a) Shall effectively protect the insulator unit and fittings from damage caused by power arcs.
b) Shall effectively improve the voltage distribution along the insulator unit.
c) Shall effectively improve the corona performance of the insulator unit.
d) Shall be designed in such a way as not to subject to breakage fatigue due to wind induced vibration.
e) Shall withstand the specified mechanical load
f) Shall be suitable for live line maintenance

4.1.7.2.7.6 Materials

The silicon rubber composite insulator shall comply with requirements of IEC 61109. The tension bearing material shall be E-CR Fibre Glass and the housing and sheds made of HTV silicone rubber.
Insulator caps and pin 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 white heart and peralitic.

Insulator end fitting of forged or cast aluminium alloy shall be manufactured from a suitable grade of aluminium alloy complying with the requirements of BS 1472 or BS 1490 and/or BS EN 1676 respectively.
Security ‘R” clips shall be of phosphor-bronze composition in accordance with the requirements of BS 2870 and supplied in the half-hard condition with a minimum harness of 155 VPN

Zinc collars shall have a total impurity not greater than 0.05 percent and shall comply with the requirement of BS EN 1179.

All insulator caps, bases and pins shall either be inherently resistant to atmospheric corrosion or a 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 729.

4.1.7.2.7.7 Tests

Type, sample and routine tests shall be undertaken on the insulator units in accordance with the IEC 61109.

4.1.7.2.8 Minimum Clearances

Minimum Clearance of Live Parts to towers shall be as per **Appendix 9.A.2**

4.1.7.2.9 APPENDIX 9.A.1

Specifications for the Composite Insulators

No	Specifications	Suspension	Tension
1	Maximum System Voltage (kV)	145	145
2	Pollution Category	Medium Category -II	Medium Category -II
3	Dielectric	Silicon rubber	Silicon rubber
4	One-minute power frequency withstand voltage, 50 Hz, wet. (kV)	275	275
5	Lighting impulse withstand voltage, 1,2/50 pos. (kV)	650	650
6	Power arc current	25 kA, 0.5 sec	
7	Minimum creepage distance (mm)	3700	3700
8	Specified mechanical load, tension (KN)	70	100
9	Minimum Arc Gap (mm)	1250	1250
10	Material fittings	Steel h.d.g	Steel h.d.g
11	Material of rod	E- CR Glass	E- CR Glass
12	Material of housing and sheds	HTV- Silicone	HTV Silicone
13	Socket	IEC 60120/16	IEC 60120/16
14	Ball	IEC 60120/16	IEC 60120/16
15	Arcing Rings material	Steel h.d.g	Steel h.d.g
16	Arcing rings	IEC 61284	IEC 61284

APPENDIX 9.A2

Minimum Clearances of live parts to towers

The minimum electrical clearances of live parts to earthed monopole structures shall be as follows:

Minimum clearances		
a) In still air (vertical position)	:	1370 mm
b) Under 15^0 swing of suspension insulator set or jumper conductors		:1370 mm
c) 20^0 swing of suspension insulator set or jumper conductors	:	1350 mm
d) 30^0 swing of suspension insulator set or jumper conductors	:	1200 mm
e) 45^0 swing of suspension insulator set or jumper conductors	:	1220 mm
f) 60^0 swing of suspension insulator set or jumper conductors	:	1070 mm

APPENDIX 10.A2

Minimum Ground clearances of lowest conductor on tower

Above general terrain	17.1m
Above main roads	17.5m
Above other Power lines	13.2m
Above other Telephone lines	13.2m
Above railways, SGR	1 8.5m

4.1.7.2.10 TRANSMISSION LINE TOWERS (TUBULAR STEEL MONOPOLES)

4.1.7.2.10.1 Types of Monopole tower

Monopoles shall be self-supporting and galvanised steel tubular type with body extensions. The body extensions shall be in sections of 1m and 3m in length.

The following monopole tower types shall be designed for the project in order to meet various tower positions and loadings economically.

(a) Type-S: Use at tangential positions or angle points up to 5 degrees of horizontal deviation, provided with suspension type insulator sets.

(b) Type-L : Use at positions of light angle between 5- 15 degrees of horizontal angle deviation with tension type insulator sets.

(c) Type-M: Use at positions of medium angle between 15-30 degrees of horizontal angle deviation with tension insulator sets.

(d) Type-H: Use at positions of heavy angle between 30-60 degrees of horizontal angle deviation with tension insulator sets.

(e) Type-HS: These are heavy suspension towers to be applied to zero degree line horizontal angle deviation, with tension type insulator sets.

(f) Type-T : Use at positions of line termination or ≥ 90 degrees of horizontal angle deviation with tension type insulator sets.

4.1.7.2.10.2 Monopole tower design general arrangement

Towers shall have the general arrangements and configurations to carry 132 kV double circuits and 33kV double circuits. They shall be designed to resist the specified ultimate system loading. Minimum clearances between live parts and supporting steelwork and between the phase conductors and ground or other obstacles shall be as specified in Appendix 10.A2. All monopole towers shall be designed for Mult circuit use i.e. to carry 33kV double circuits below 132kV double circuit lines.

All monopole tower 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 single member should be limited to that within the normal lifting capability of the proposed erection equipment.
Main members of monopole polygonal steel monopoles shall be formed of the maximum single lengths appropriate to the body extensions and shall not without the Employer's approval incorporate additional spliced sections.

For lattice steel towers a fully triangulated system of bracings shall preferably be adopted. If full triangulation is not adopted, the overall stability and secondary bending stresses must be considered in the design.

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.

Cross arm design for polymeric insulators shall be so arranged that they can be disconnected in the plane of the longitudinal face of the support without disturbing any section forming part of the monopole body.

For Lattice towers Cross-arms shall be so arranged that they can be disconnected in the plane of the longitudinal face of the support without disturbing any members forming part of the support body. The cross-arms should be designed to take and be compatible with the AB CHANCE Live Line maintenance tools and equipment.

The monopoles shall be installed using anchor bolt on a pad and chimney foundation, or other types of Pile foundations as described in the tender document depending with the condition of each site
All the monopole foundations shall be constructed with Sulphate resistant Portland or pozzolana Cement with minimum strength of 42.5KN/m2.

All monopoles along or adjacent to roads shall be protected against damage from heavy trucks by concreted steel guards, 1.2m high, 100 mm diameter, and a spacing of 800mm.

All monopoles close to existing walls shall be placed away from the existing wall foundations, and the walls affected by the construction of the monopole foundations shall be reinstated to match the original state by the contractor at no additional cost.

Any permanent structures to be demolished for purposes of monopole foundation construction shall be replaced by contractor at no additional cost.

Appropriate bird guard protective devises shall be installed to keep away birds from roosting directly over the insulator units.

Where applicable approved anti-climbing spiked wire mesh or race wire shall be installed at appropriate height to deter Monkeys and Baboons from climbing the towers.

4.1.7.2.10.3 Monopole tower design and technical Specifications

The towers shall be a self-supporting single-pole tubular steel monopole, designed for Mult circuit use in urban areas.
Main circuit design shall be double 132 kV top and 33 kV double circuits mounted below. It shall also have provision to carry 48 cores OPGW cable and ground Earth wire at top for lightning protection of the double circuit transmission line.

4.1.7.2.10.3.1 Tower design reference:

Towers design and manufacturing shall meet following IEC, BS, IEEE, ASTM and other internationally acceptable standards;

- Structural design - IEC 60826 and 60652, ASCE10 and 48, IS875 and 1893
  -
  Material and fabrication- ASTM A123/A123M, ISO 1461, ISO12944 and AWS D1.1-
  ASCE Manual of practice N0.74: guidelines for Electrical Transmission line structural loading

- Hot-dip galvanized - BS EN 10025 / IEC 60826.
- Seismic load design - IS 1893 / IEC 60826
- Wind Load Design - IEC 60826 / IS 875

4.1.7.2.10.3.2 Tower minimum requirement:

The tower shall meet below minimum general requirements and technical specifications

i. Mult circuit Single-pole tubular steel monopole tower, Hot-dip galvanized as per BS EN 10025 / IEC 60826.
ii. Minimum tower height shall be 30.0 m above ground to ensure required conductor clearances for both voltage levels. Maximum height shall be guided by site conditions
iii. Tower body extensions shall be 1m, 3 m and 6m with adequate provision for 33 kV cross-arm attachment.
iv. Minimum tower foundation diameter shall 1.5 with M36 high-tensile steel Anchor boltsM36, high-strength steel.
v. Steel Grade: This shall be S355J2G3 for standard sections and S420 for high-load zones such as crossing the sea and long spans.
vi. Steps / Ladder: Galvanized steel step Bolts with spacing of 300 and Ladder with cage for heights above 20 m.
vii. Lightning protection & Earthing: Lightning rod 2 m above the OPGW cable, and earthing shall have integrated provision for foundation earthing with a resistance of ≤ 5Ω.
viii. Foundation reinforcement bars shall meet requirement of Fe500 TMT steel.
ix. Base Plate shall be min. 40 mm thick steel with a diameter of 1.8 m, hot-dip galvanized and treated.
x. The minimum Pole Section diameter shall be. Bottom: 800 mm OD, Wall thickness: 20 mm; Middle section: 600mm, wall thickness 16mmm, Tapers to 400 mm OD, wall thickness 12 mm at top depending on height
xi. Cross-Arm material shall be Galvanized steel tubular / I-section with a minimum length of 2 m for 132kV and 1.2m for 33kV circuit. Polymeric insulators shall be used.
xii. Cross-arm shall be furnished with hoisting lugs to facilitate line construction and maintenance
xiii. Corrosion Protection: Hot-dip galvanizing with min. zinc coating of 120 micron and epoxy paint coating
xiv. Identification and Marking- Towers shall have tower ID plate and phase markings, for inspection & safety identification
xv. Minimum Conductor Clearance shall be: 33 kV: min 15.0 m Phase-to-ground

4.1.7.2.10.3.3 Tower height design

Height of monopole and lattice towers shall be determined in the under-mentioned way:

H = Gc + Sg + Li + Hc + Hg

Where,

H = total height of tower
Gc = Necessary ground clearance of power conductors above ground or other objectives.
Sg = Maximum conductor sag
Li = Length of a suspension insulator set, but nil for a tension type tower.
Hc = Vertical spacing of upper conductor cross -arm spacing
Hg = Vertical spacing between upper conductor cross-arm and overhead OPGW.

The Monopoles shall be provided with flagged body extensions in 3m step [3m, 6m, 9m and 12m] to a standard height for maintaining necessary conductor ground clearance mentioned in **Appendix 10. A2** on various ground profiles. However, maximum body extension shall be 6 m.

4.1.7.2.10.3.4 Design Span

The design of all towers shall provide for the following basic, wind and weight spans:

This design span table shall be submitted with the bids.

Type of Tower	S	L	M	H	HS	T
Basic span (m)	350	350	350	300	500	250
Wind span (m)	350	350	350	250	450	250
Weight span (m)	500	450	400	300	300	300
Uplift Weight (KN/Phase)	25	50	60	110	150	250

The term basic span means the horizontal distance between centres of adjacent supports on the level ground which the height of standard towers is derived with the specified conductor clearances to ground in still air at maximum temperature.

The term wind span means half the sum of adjacent horizontal span lengths supported on any one tower.
The term uplift weight means the weights of conductors and overhead OPGW supported upwards at any one tower for reinforcing strength of cross arms.

4.1.7.2.10.3.5 Minimum design Loads

For structural loading shall refer to ASCE Manual and Report on Engineering Practice No. 74 "guidelines for electrical transmission line structural loading".
The following minimum loads shall be applied in the design of towers, actual site environmental loads (wind) with appropriate factors of safety will be used for detailed design.

(a) Wind Loads
- On power conductors and overhead OPGW : 385N/m^2 (on the projected area of conductor or wire)
- On tower structures :690N/ m^2 (on the projected area of structure members)
- On insulator sets : 385N/ m^2

(b) Maximum working Tensions of Conductor and OPGW
- Power conductor Lynx : 22,500 N
- Overhead ground wire OPGW : 14,100 N

(c) Vertical Loads
- Tower structures : actual weights of tower structures including accessories
- Power conductors : Weight of conductors of specified weight span with accessories
- OPGW : weight of specified weight span with accessories

- Erection Loads : such loads as workers' weights on tower members, reaction of temporarily backstays during stringing operation, etc

(d) Horizontal Angle Effect
-Power conductors and overhead OPGW : horizontal component of maximum working tension of conductors and

OPGW due to the specified horizontal angle deviation.

The towers shall be designed for the following wind and weight spars.

Type of tower	S	L	M	H	HS	T
Wind Span [m]						
- Normal working condition [m]	350	350	300	250	450	250
- Broken wire condition [m]	200	150	150	100	300	250
Weight Span [m]						
- Normal working condition [m]	350	400	400	300	550	250
-Broken wire condition [m]	250	200	200	150	300	250
Uplift weight for cross arms (KN)	20	35	50	100	140	250

4.1.7.2.10.3.6 Design Conditions

(a) Assumed Normal Loading Condition:
The assumed maximum simultaneous working loading on towers shall be as follows:

(i) Vertical loads : as above-mentioned.
(ii) Transverse loads : wind loads horizontal angle deviation effects
(iii) Longitudinal loads : wind loads and erection loads but together with maximum working tensions of power conductors and overhead earth wire for their termination for Type-T tower.

(b) Assumed Broken-Wire Condition
Under the condition, any one power conductor or an earth wire is assumed to be broken at their maximum working tensions in addition to the loads under the normal condition. In the case of Type-S tower, the pull will be assumed to be reduced to 70% of the specified maximum working tensions.

(c) Factor of Safety:
The following factors of safety for tower structures shall be applied in the design.

(i) More than 2.5 for the synthetic maximum load under the normal loading condition.
(ii) More than 1.25 for the synthetic maximum load under the broken-wire condition.

Those factors of safety shall be proved under tower loading tests on the proto-type towers in the manufacturer's testing station, and there should be no failure or permanent distortion during the tests.

4.1.7.2.10.3.7 Design of Towers

Monopole steel structures shall be designed with geometric configurations based on structural strength, electrical, economic, and safety requirements. Member forces caused by the design factored loads shall be determined by established principles of structural analysis.

Each type of towers shall be designed so that no failure or permanent distortion shall occur when tested with applied force equivalent to 2.5 times the maximum simultaneous working loadings specified in the **Clause 4.1.7.2.10.3.6** [Normal Working Loading] and also equivalent to 1.25 times the maximum simultaneous working loadings resulting from the assumed broken wire condition. Design loads shall consider:

a) Minimum legislated levels
b) Client specifications including factors of safety,
c) Expected climatic conditions,
d) Line security provisions,
e) Design life of not less than 50 years,

f) Construction and maintenance operations.

The ultimate design stress, obtained from the working stress multiplied by the factor of safety of 2.5 under the normal condition and 1.25 under the broken wire condition, in tension members shall not exceed the yield point of materials. The ultimate design stress, obtained from the working stress multiplied by the above-mentioned factor of safety, in compression members shall not exceed a figure obtained from an approved formula to be entered in Tender based on the yield point of materials. Alternately, formulas in the American Society of Civil Engineers standard for the design of self-supporting lattice steel transmission structures ASCE 10- 97. Structural loading shall refer, ASCE Manual and Report on Engineering Practice No. 74 guidelines for electrical transmission line structural loading.

Tower design report shall consist of full structural analysis report showing correctness of dimensional detail calculations, tower profile/layout drawings, shop detail drawings, erection drawings and bills of materials. Shop detail drawings shall be approved by the producing utility Engineer of Record (EOR) regarding compliance with the purchaser's specifications and the strength requirements of the design.

Designed tower full size prototype proof test shall be conducted and approved before tower materials shop production and delivery to site.

4.1.7.2.10.3.8 Materials and Fabrication.

The towers shall be fabricated from high tensile steel of the finest quality or other approved materials, of which mechanical properties shall comply with Grade Fe 430 and Fe 510 specified in ISO 630-1980 or equivalent. Steel Grade shall be S355J2G3 for standard loading and S420 for heavy loading design applications

No member of the tower shall be less than 6mm in thickness and 50mm in width of the base plates for the monopole towers

For lattice towers No member of the tower shall be less than 6mm in thickness and 50mm in width of flange for leg members of towers and main members of the cross-arm, and 5mm and 45mm for the web and nominal members respectively. The slenderness ratio shall not exceed 150 for the leg and arm members, 200 for the web members and 250 for the nominal members as compression member and 350 for tension only member.

All the connection shall be made by mild and/or high tensile steel bolts and nuts. No bolt shall be less than M12. All bolts and nuts shall be provided with approved spring washers. Antitheft bolts shall be used from ground level to the tower anti-climb level.

Bolt holes shall not be more than 1.5 mm larger in diameter than the corresponding diameter of bolts. Holes shall be drilled for the members not less than 13 mm in thickness. For the members having thickness below 13 mm, holes may be drilled or punched, but the former is preferred.

Holes shall be drilled to join the flanged sections of the monopole, and bolt and nuts punching is not allowed

All the steel members or monopole sections shall have clearly identifiable part numbers which enable quick identification of similar parts. The letters 'KPLC' should also be inscribed on each member by punching or any other suitable method, with more than one inscription for parts of length greater than 0.5m.

All burs shall be removed completely by reaming and smoothing before hot-deep galvanising.

4.1.7.2.10.4 Tower Accessories

The following accessories shall be provided for every tower.

(i) **Anti-climbing device and climbing steps**: All towers shall be provided with the anti-climb device on each leg or section at height of 3 m to 5 m above the highest ground level at all tower locations. The device installed on the step-bolted legs shall be provided on all towers. Gates shall be designed to open upwards only and shall be secured with galvanised bolts and nuts. No padlocks are required.

Each tower shall be provided with step-bolts of an approved type on diagonal sides of the tower at a spacing no more than 380mm, starting immediately above the anti-climbing device and continuing to the earth wires.

Holes for removal step-bolts below the anti-climbing guards shall be provided at no more than 380mm centres on the step legs for lattice tower.

(ii) **Danger, Number and Helicopter patrol plates**: Danger plate which shows warning sign for tower climbing of other people than maintenance crew will be provided on all towers.

Number plates which show tower number set serially from Kipevu to Mbaraki will also be installed on every tower.
On the top of every section tower, and every 10^{th} tower, additional number plates will be provided to aid helicopter patrol over the transmission line. Lettering and size of plates shall be to the Employer's requirements and should be both sides of the number plate for clear identification when patrolling from either end.

All plates shall be of anti-corrosive material. If enamelled iron plates are used, the whole surface of each plate including the back and edges shall be properly covered and resistant to corrosion. On all plates the colours shall be permanent and free from fading. With enamelled plates, washers or fibre or other approved material shall be provided back and front of the securing bolts.

(iii) **Tower Earthing**: No separate earth conductor from top to bottom of towers is required and earthing continuity will therefore depend on surface contact between bolted members.

All structures shall be provided with means for connecting earthing devices at or around nominal ground level, on each leg and for connecting earth wire bonds to each top crossarm or earth wire peak.

Each leg of towers will have an earthing rod underneath its foundation to act as basic grounding required by good transmission line Engineering. Basic grounding shall be constructed in such a way that isolation from the tower and concrete foundation is possible to allow earthing survey if required during line service life.

Maximum earthing resistance of a tower is targeted on 10 Ohms, and in case of higher resistance than 10 Ohms, additional horizontal counterpoise earthing system will be added in the ground longitudinally to the line route with more than 50 cm depth. The rate entered in the schedule of prices shall include for all necessary fittings and shall be adjusted at the variation rate for increased or reduced fittings.

(iv) **Aircraft Warning Devices**: Due to the activity of aircraft in the vicinity of certain parts of the transmission line, it shall be necessary to mount warning spheres on earth wires at some locations. Aircraft warning spheres shall be capable of being clamped securely to overhead earth wire. The sphere itself shall be of plastic or fibreglass construction of at least 0.5m in diameter and coloured orange or yellow as required by local regulations. The Contractor is to enter rates against appropriate item in the schedule of prices for the above and he will be advised early in the contract of actual requirements.

(v) **Bolts:** Where appropriate all metal parts hall be secured with bolts and nuts with single spring washers. When in position the bolts shall project through the corresponding nuts by at least three threads, but such projections shall not exceed 10mm. No screwed threads shall form part of a shearing plane between members.

In order to safeguard the tower members from theft; special anti-theft bolts shall be applied from ground level up to 1 metre above the anti-climbing device. The bolts shall be approved by the Employer. The bolts are of the type that shears once the full torque has been applied.
The nuts of all bolts attaching phase conductor insulator set, earth wire sets, maintenance brackets/plates shall be locked in an approved manner preferably by locknuts.

The bolts of any one diameter in a tower shall be one grade of steel. Section members shall be joined in such a way that electrical continuity is maintained to ground.

(vi) Rectangular and Auxiliary Cross Arm

The type H, HS and T towers may be provided with rectangular arms where horizontal angle exceeds 45degrees.
The prices of the rectangular arm set shall be included in the prices for the towers.

(vii) Spare Towers

Two (2) sets of spare suspension tower of emergency type and two (2) set of the emergency type angle tower used in the line shall be provided. Spare Base plate shall also be provided, sufficient for the four (4) emergency type towers. Spare web bracings shall also be provided, sufficient for five (5) standard towers up to the anti-climbing device level in case of lattice tower.

4.1.7.2.10.5 Materials

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, segregations 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 for tower design:

a) Mild steel shall be either grade S235JRG2

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

4.1.7.2.10.6 Workmanship

All steel lattice members shall be cut to jig and all holes in steelwork shall be drilled or punched to jig. All steel parts shall be carefully cut and holes located so that when the members are in position the holes will be opposite each other before being bolted up. The drilling, cutting, punching and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulty in the erection of structures on site. High tensile steel members shall be bent hot. Care shall be taken not to punch holes too close to the edge of members.

Means shall be provided to enable the Employer to carry out such checking of members, as he may consider necessary. Built-up sections, when finished, shall be true and free from all kinks, twists and open joints and the materials shall not be strained in any way.

In order to check the workmanship, not less than 1 per cent, of the members or sections corresponding to each type of tower or crossarm shall be selected at random and assembled to form complete latticed supports, cross-arms or monopole sections in the presence of the Employer representative at the manufacturer's factory.

4.1.7.2.10.7 Tower Marking

Each steel monopole pole shall be marked permanently by embossing on a permanently secured corrosion resistant plate at a position 1.5m above the pole Ground line with the following details.

a) Manufacturer's name

b) Date of manufacture (mm/yy)

c) Length of pole (meters) and Tip dimensions (mm)

d) Ultimate/Working load/Strength Class

e) Weight of pole f) Standard to which the pole complies

g) The words "**PROPERTY OF KPLC"** The plate used shall be made of stainless steel, securely affixed to the pole. In all cases the lettering shall be not less than 5mm high legibly impressed.

4.1.7.2.11 CIVIL WORKS FOR TRANSMISSION LINE

4.1.7.2.11.1 FOUNDATIONS

4.1.7.2.11.1.1 General

Monopole steel towers foundations shall be mainly concrete Pad/Spread type foundations. Design of these concrete pad foundations for the monopoles shall be performed based on the requirements and assumptions set out below, and the details of the design and drawings for each type of foundations shall be submitted with the bid.

Lattice towers shall require mostly Concrete pad and chimney type foundations. The design of the concrete foundations of the towers shall be performed based on the requirements and assumptions set out below, and the details of the design and drawings for each type of foundations shall be submitted with the Tender.

Such design of foundations for the towers are subject to modifications to suit the site conditions as indicated in writing by the Project manager during execution of the Contract without any price adjustment to the items of the foundation.

4.1.7.2.11.1.2 Concrete Block/Pad/spread Foundation

The types of the concrete foundations and natures of earth to be considered shall be as follows:

Types of concrete foundation Assumed natures of earth yield bearing capacity		L	M	H
- Vertical	[ton/m^2]	60	40	20
- Lateral	[ton/m^2]	30	20	10
Mass	[kg/m^3]	1,600	1,500	1,400
Angle of frustum (Lattice tower)[degree]		30	20	10

All Structural Concrete shall be reinforced with steel bars to structural design details. Deformed steel bars are preferable for the reinforcement.

The abbreviations L, M and H of the concrete foundation types shall mean as follows: -

L : Light concrete foundation
M : Medium concrete foundation
H : Heavy concrete foundation

The angle of frustum of earth shall mean the angle vertical of earth frustum to resist the uplift force.
Natures of concrete to be considered shall be as follows: -

Assumed natures of concrete

Allowable strength:

-Compressive	[kg/m^2]	60
-Tensile	[kg/m^2]	6.0
-Shearing	[kg/m^2]	6.0

Mass:

-Concrete without reinforcement	[kg/m^3]	2,300
-Concrete with reinforcement	[kg/m^3]	2,400

Allowable strength on:

-Galvanized steel action	[kg/m^2]	3.6
-Round reinforcing bars	[kg/m^2]	7.2
-Deformed reinforcing bars	[kg/m^2]	12.0

Each type of foundation shall be designed based on the following formula:

[1] Against compression load

$$\frac{q}{F} \geq \frac{C+G+Ws}{A}$$

Where:
- *q* : *Yield bearing capacity of earth [ton/m^2]*
- *F* : *Factor of safety*
- *C* : *Compressive load [ton]*
- *G* : *Weight of concrete [ton]*
- *Ws* : *Weight of earth above foundation pad [ton]*
- *A* : *Area of foundation pad [m^2]*

[2] Against uplift load

$$G + \frac{Ws'}{F} \geq T$$

Where,
- *T* : *Uplift load [ton]*
- *Ws'* : *Weight of earth in frustum [ton]*
- *F* : *Factor of safety*

[3] Against lateral load

$$\frac{q' \times A'}{F} \geq Q$$

Where,
- *Q* : *Horizontal load [t]*
- *q'* : *Yield lateral bearing capacity of earth [ton/m^2]*
- *A'* : *Projected area of foundation chimney and pad [m^2]*

The factor of safety shall not less than 2.5 under the normal working conditions and 1.25 under the broken wire conditions.

The upper surfaces of the foundation pads shall be reinforced and sloped within 45 degrees to the horizontal. The minimum thickness of the edges of base pad shall be not less than 300mm.
The frustum shall be assumed to start from the top edges of the pad. Where frustums overlap each other, allowance shall be made for loss of uplift resistance.

Concrete shall cover any part of the top steelwork by at least 100 mm and shall extend above the ground for the minimum height of 350 mm. Additional 500 mm minimum chimney extension shall be provided to foots on lower side in sloping areas. The upper surface of chimney shall be sloped to ensure drainage of water.

The cleats shall be attached by bolting at the base of each stub to assist in transfer of leg load to the foundation pad. Minimum portion of stub loads in the design of cleats shall be assumed as 50 per cent.

4.1.7.2.11.1.3 Special Foundations

Besides the above mentioned concrete foundations, special foundations such as raft type foundation, rock anchor, piled foundation or others may be required. Final type of foundation to be applied for each tower shall be determined in accordance with results of soil investigation performed by the Contractor during route survey and soil investigation.

For the purpose of tendering, basic designs shall be submitted with the tender under the following assumptions, and prices for the special foundations shall be quoted based on the design.

[a] Raft type foundation

The foundation shall be designed with the following specifications: ultimate bearing capacity of 10ton/m^2, soil weight of 1.4 ton/m^3 and no angle of frustum of soil. Weights of reinforced concrete and soil shall be taken as entirely submerged. Other design conditions specified in this subsection will be applied.

[b] Rock Foundation with Anchors

A foundation constructed on or in rock using grouted rock anchors and concrete. The anchors provide high resistance to uplift and overturning forces. This type of foundation shall be generally rare in this project.

[c] Piled foundation

Piles used for the foundation shall be either pre-casted concrete pile with circular or square cross section or in-situ concrete pile.

[i] Pile data

Pile diameter or dimension

- Circular cross section	-	Φ300 mm.
- Square cross section	-	300 x 300 mm
- Pile depth below ground level	-	12 m
- Ratio or ultimate bearing/uplift capacity of pile	-	2.5: 1

[ii] Uplift

The mass density of concrete below ground level shall be assumed as 1,600 kg/m^3 to allow for hydrostatic effects and similarly soil as 960 kg/m^3. Additional weight of concrete shall be included as necessary to provide the specified resistance to uplifting under any condition. Where bored or driven piles are proposed having no specially made bulb or enlarged concrete foot to provide positive uplift resistance but relying on skin friction alone, at least 75% of the networking uplift force, and 50% of the net broken wire uplift force shall be provided in dead weight of concrete, whichever is the greater. The cost of such concrete shall be included in the piled foundation rate.

[iii] Compression

Mass density of concrete shall be assumed as 2,300 kg/m^3 on their technical acceptability and cast.

Contractors must justify assumptions of equal performance of their piling system with that proposed. No extra payment shall be made for access tracks necessary for heavy piling rigs.

Piles shall be embedded in a reinforced concrete cap of adequate dimensions and the caps tied with nominal reinforced concrete beams of a minimum size of 460 mm deep by 300 mm wide with at least eight 19 mm diameter main reinforcing bars per beam.

Piling shall be carried out using an approved procedure throughout. The actual length and numbers of piles required at any given location shall be approved by the Engineer on the basis of the final agreed design data.

[c] Other Foundations

Where special ground conditions exist which do not allow for any of the above designs in an original or modified, special types of foundations may be employed. They will be paid for on basis of submitted schedule rates for concrete, steel and excavations applying throughout, irrespective of special conditions.

Tower prices shall cover for all costs not covered by tower foundation work where admissible including the provision of access tracks and standings for piling equipment or building of bund for the Contractor's convenience in paddy fields or other flooded areas.

4.1.7.2.11.2 Foundation Works

4.1.7.2.11.2.1 Soil Investigation

The Contractor shall make tests of subsoil conditions at every tower site by means of an approved simple hand-operated borer [sampling] and sounding tool and indicate results on the approved soil test sheets together with ground water levels and proposed foundation type to be applied at the tower position.

The Contractor shall obtain the Engineer's approval for the foundation type in advance of the foundation works at each tower site. Particular note is to be made where any poor ground is encountered likely to require special foundations. The test results shall show firm evidence to prove reasons why the proposed type of foundation is selected from the specified foundation types. The cost of the sub-soil tests is deemed included in the rate for foundation work.

The Engineer may request the Contractor additional sub-soil tests at the bottom of excavated pits, if the Engineer judges its necessity for further confirmation on the proposed foundation types. The sub-soil tests shall be done at the earliest stage of the filed works to the urgency of having tower stubs and templates on site in order that foundation works can proceed with a minimum of delay. BS5930, soil investigation code will apply as a technical guide for reference.

4.1.7.2.11.2.2 Excavation and Backfilling

Where angle towers are fitted with unequal length cross arms at each side of the tower, the tower centre shall be offset to ensure that conductors are located as near as possible equidistant either side of the route centreline in adjacent spans.

The Contractor shall ensure that excavations are made to the correct depth and width. If excavations are taken deeper that the designed dimension the excess depth shall be backfilled with concrete at the Contractor's expense. If excavations are made wider than the designed dimension, such modifications to the design as the Engineer may require shall be made at the Contractor's expense.

For uplift foundations, undercutting or other approved method shall be applied as far as possible for allowing upward bearing of the foundation pad against undisturbed soil for a minimum width of 250mm all around. Alternatively, the concrete pad shall be cast to the edge of the excavation for a minimum height of 250 mm in order to gain assistance by adhesion to the original ground. In cases where the concrete block is cast in undercutting, the earth frustum assumed to resist uplift shall be considered to start from the bottom of the vertical

edges of the block. Otherwise, the frustum shall be assumed to start from the upper top of the block edges.

The backfill of all types of foundations shall be thoroughly rammed with mechanical rammers, and the ramming shall be carried out at intervals of not greater than 300 mm to ensure thorough consolidation of the backfill as the Engineer requires.

Foundation Concrete faces shall be painted with an approved bituminous paint to separate backfill from concrete before backfilling.

In no circumstances shall peat, black Cotton soil or equivalent materials be used as backfill for foundations. Where excavations are made in peat ground, backfilling to be foundations shall be made with a suitable soil or hardcore from an approved source at the Contractor's expense. Backfill shall be finished in such that the original ground contours are restored as nearly as possible, any subsidence of backfill shall be made good before the issue of the Taking-Over Certificate.

4.1.7.2.11.2.3 Anchor bolts setting

Base plates for the Monopole shall only be installed on the concrete foundation by use of high grade non-corrosive steel anchor bolts. The setting of the anchor bolts shall be done by use of factory designed template or probes. The Anchor bolts shall be of approved type and size capable of carrying the Monopole uplift and shear loads. The setting templates are not to be removed until 48 hours after the foundations have been completed, cured and backfilled.

The base plates shall be polygonal, manufactured from high tensile strength steel of approved and adequate cross-section as described in the preceding clauses. It shall be equipped with central alignment notches and anchoring holes from the factory for accurate setting of anchor bolts in respect of the following requirements:

a) Longitudinal centreline
b) Tower lateral centreline
c) Anchor Bolt elevations [with reference to datum]
d) Anchor bolts levelling
e) Inclinations of stubs

No concrete works shall be started before the setting template are confirmed to be in the right design positions, setting details recorded in setting out form.

4.1.7.2.11.2.4 Concrete Works

[a] Concrete for concrete foundation and pile shall have the minimum required breaking strengths as specified in the technical schedules. BS 5328 will refer when specifying concrete and BS 8110 in reference to structural use of concrete

[b] Cement used shall be Portland with minimum strength of 42.5 KN/m^2 or other approved composition obtained from an approved maker. Portland cement shall conform in all respects to BS-12.

[c] Aggregates shall be clean and free from dust, earthy or organic matter or salt. Coarse aggregate shall be approved grading to be retained on a mesh not less than 5mm square, and of a maximum size to pass a mesh not more than 40 mm square. Where specially approved in writing by the Engineer, coarse aggregate of uniform size which will pass a 25mm mesh may be used throughout. Fine aggregate shall be river sand and shall be coarse, sharp, clean and fee from dust, salt, clay, vegetable matter or other impurity and shall be screened through a mesh not more than 5mm in the clear.

It shall be well graded mixture of coarse and fine grains from 5mm gauge downwards. Aggregates shall conform in all ways to BS812 and KS 95:2003.

[d] Water shall be clean and free from all earth, vegetable or organic matter, salt, soil, oil, acid and alkaline substances either in solution or in suspensions. Quality shall be confirmed by lab test.

[e] At least four weeks before commencing any concreting work, the Contractor shall make trial mixes using samples of cement and fine and coarse aggregates.

The test specimens for the trial mixes shall be of cube type. Preliminary test specimens shall be taken from the proposed mixes as follows:

For each proposed mix a set of 6 specimens shall be made from each of 3 consecutive batches. Three from each set of six shall be tested at an age of seven [7] days and three [3] at an age of 28 days. The test shall be carried out in an approved laboratory.

Neither the mix proportions nor the source of supply of materials shall be altered without the prior approval of the Engineer except that the Contactor shall adjust the proportions of the mix as required, to take account of permitted variations in the materials, such approval shall be subject to the execution, to the Engineer's satisfaction, of trial mix procedures set out herein.

[f] Where directed by the Engineer, concrete cubes are to be taken and tested to verify the concrete strength during site concreting works. The Contractor shall provide the cube molds at site for the purposed, accordingly. The test specimens shall be 150 mm cubed and the mold shall be of metal with inner faces accurately machined in order that opposite sides of the specimen are plane and parallel. Each mold shall be provided with the metal base having a smooth machined surface. The interior surfaces of the mold and base should be lightly oiled before concrete is placed in the mold.

[g] The cost of concrete testing shall be deemed to be included in the Contractor's general schedule rates. Testing Lab shall be approved

[h] Requirements for testing concrete samples during construction are set out in **Clause 4.1.7.2.11.13.**

[i] The concrete shall thoroughly wet before backfilling commences. When shutters are to be struck, backfilling of excavation is not to take place immediately, and the concrete shall be kept continuously moist to avoid rapid drying.

[j] In the event that the Contractor proposes to use ready mixed concrete for foundation work, approval must first be obtained from the Engineer, who will inspect the batching plant and cement, sand and gravel used for concrete. No ready mixed concrete shall be used in foundation work if it has been mixed in the lorry during its journey for more than 45 minutes. At the discretion of the Engineer, ready mixed concrete may be used in foundations in excess of 45 minutes journey, if the cement is added to the drum at site and is thoroughly mixed prior to placing, or alternatively if the ready mixing lorry carried its own drum during the lorry's journey and not mixed for more than 45 minutes prior to placing. The Engineer's decision to reject any of the above methods of supplying ready mixed concrete shall be final.

[k] Throughout the line route, the Contractor shall at regular intervals and at the time of survey, obtain samples of subsoil and ground water, which he shall have analysed to ascertain if any agents be present which may have an adverse effect on concrete made

with normal Portland cement. The analyses shall be forwarded to the Engineer without delay together with any recommendations for the use of special cement.

The Engineer's decision as to the type of cement to be used will be final. The cost of obtaining soil and ground water samples is deemed to be included in the Contract Price. The cost of any special cement used will be paid at an appropriate rate to be agreed with the Engineer.

[l] Concrete shall be placed immediately after mixing. All concrete shall be thoroughly compacted by vibration during the operation of placing and shall be free from honeycombing and other defects. The upper surface of the concrete for all types of foundations shall be finished smooth and sloped in an approved manner to prevent accumulation of water. A concrete addictive of a type approved by the Engineer may be used.

4.1.7.2.11.2.5 Piling and Other Special Works

Pilling will be carried out using an approved procedure throughout. The actual length and numbers of piles required at any location will be approved by the Engineer on the basis of the final agreed design data and payment made for departures from the assumed tender design quantities on the basis of the difference of quantities times the Schedule variation rates. Piles shall be tested in accordance with **Clause 4.1.7.2.11.6** Tender Prices shall include for all necessary casings, pumping, and depreciation of piling machines, materials, transportation, testing and others.

Where special ground conditions exist which do not allow for any of the designs in an original or modified form, special types of foundations may be employed which will be paid for on the basis of schedule rates submitted. To this extent the submitted schedule of rates for concrete, steel and excavations shall apply throughout irrespective of special conditions.

4.1.7.2.11.3 Erection of Towers

Where tower members arrive on site with slight distortions due to handling in transit, they shall be straightened by the Contractor using approved means and offered to the Engineer for inspection and acceptance or rejection before erection commences.

In general, towers shall be assembled and erected with bolts finger tight only. Final tightening of bolts shall only take place when all members are in place. As far as practical, bolts shall be inserted with the nuts facing outwards or downwards.

Whenever wire slings or ropes are liable to abrade tower members, the members shall be suitably protected by heavy Hessian bags or strips, or by some other approved means.

The Contractor shall make use of temporary struts on panels prior to lifting, if in the opinion of the Engineer, there is likelihood of damage occurring to that panel during lifting. Where derricks are used for lifting panel they shall be securely guyed and shall be supported only at approved locations on the legs.
All monopoles shall be vertical under the stress set up by the completed overhead line to the satisfaction of the Engineer. The maximum acceptable deviation from vertical shall normally be 1%.

Proper precautions shall be taken to ensure that no parts of the monopoles or supports are unduly stressed or damaged in any way during erection. Drifting shall not be allowed.
Suitable ladders shall be used whenever necessary during erection, but such ladders and removal step bolts shall be removed when erection work is in progress.

Before assembly of members, joints shall be free of all earth, or any other substances which might prevent the correct alignment of members. After erection, all materials shall be cleaned of all foreign matter or surplus paint.

Spanners used during erection shall be well shaped and fit closely on the nut to avoid damaging nuts and bolt heads. Approved equipment shall be used for tightening the shear bolts which will be used from ground level up to one metre above the anti-climbing devices. After erection, the rest of the bolts up to the bottom cross arm shall have the threads smashed in an approved manner to prevent unauthorized removal.
Damage to the galvanised surfaces of bolts, tower steelwork or smashed bolts shall be repaired using zinc rich paint or similar and the cost of such repair is deemed to be included in the appropriate rates.

The Contractor must ensure that tower erection, steel handling and operation of equipment shall be such as to ensure the maximum safety of all personnel associated with the project as well as the public.

Lower parts of towers erected in the submerged area during wet seasons shall be protected from corrosion with an approved paint as ordered by the Engineer. The cost for the paint shall be quoted in the Price Schedule.

4.1.7.2.11.4 Grounding of Towers

Before placing foundation concrete, basic grounding earthing rods specified in **Clause 4.1.7.2.10.4** shall be erected to each foundation cleats. Installation shall ensure that earthing can be isolated from the tower and concrete foundation to allow earthing survey. Measurement of footing resistances of all towers shall be carried out with an approved instrument before stringing of an overhead OPGW. A target value of the resistance is less than **10 ohms**. The Contractor shall report the measured value in an approved form to the Engineer. The Engineer will instruct necessitate of installation of counterpoises to the Contractor who shall then provide the counterpoises as specified in **Clause 4.1.7.2.10.4** to the instructed towers and measure the resistances for reporting to the Engineer. In case the resistance is still high, the Engineer may order the Contractor to install additional counterpoises.

4.1.7.2.11.5 Stringing of Conductor and OPGW

a) The fullest possible use shall be made of the maximum conductor lengths in order to reduce the number of joints to the minimum. The number and location of conductor and overhead OPGW tension joints shall be approved. Tension joints shall not be less than 15m from the nearest clamp.

b) Unless the Engineer agrees to the contrary, midspan joints shall not be not used-
   (i) at locations which would allow less than 3 clear spans between mid-span joints on a given conductor and wire
   (ii) in spans crossing power lines, telecommunications lines, public roads or buildings, and
   (iii) in single span sections.

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

d) Conductor and OPGW stringing shall be carried out entirely by tension stringing methods and the Contractor shall submit for approval full details of the precise method of tension stringing and of the stringing equipment which he intends to use. Conductors shall be kept off the ground at all times when the conductor is in motion. The method of tension stringing required to install all conductors and OPGW shall be continuously controlled.

e) The conductor and OPGW tension during stringing operation shall be kept as low as possible, consistent with keeping the conductor and OPGW clear of the ground whilst in motion. At no time will the tensions be allowed to exceed 75% of the final tension.

f) All stringing equipment shall be properly anchored and shall be positioned in such a way that structures, insulators and fittings will not be overloaded.

g) Conductor and OPGW drums shall be securely anchored during the stringing operation and drum jacks shall be of the self-braking type to prevent conductor over run.

h) Conductor an OPGW pulling shall be such as will ensure a continuously steady pull. Every precaution is to be taken to prevent damage to the conductor and OPGW. Clamps and other devices used for handling conductor and OPGW during erection shall allow no slippage or relative movement of strands or layers and shall not pinch or deform the conductor and OPGW Grooves in sheaves and tensioners shall be lined with neoprene or rubber. Sheaves shall have an electrical conducting path between their suspension points and the conductor supported within them and shall run with minimum friction.

i) Conductor and OPGW shall be effectively earthed in an approved manner during running out and at all places where men are working on them.

j) At least three months before stringing commences, the Contractor shall give due to consideration to all the factors involved and submit to the Engineer for approval a fully detailed stringing schedule stating locations of conductor and OPGW drums, winch operation for stringing and the proposed positions of mid-span joints, together with temporary staying wires of towers and all other relevant information.

k) Conductor and OPGW drums shall be closely examined before conductor pulling commences and all nails and other things which could damage the conductors and OPGW shall be removed. During stringing, the conductor and OPGW drums are to be supervised at all times and the conductor and OPGW shall be inspected for defects while it is being pulled off the drums. Any damage caused to conductors or OPGW shall be reported to the Engineer whose decision to replace or repair will be final.

l) Conductors and OPGW shall be carefully regulated to the correct prestress and initial tensions by a measurement of sags. Ambient temperature shall be measured by a thermometer suspended on the tower at the sag measurement position. Making for and application of anchor clamps shall follow regulation to initial tension without delay. Immediately after regulation and clamping has been completed in a section, the sag of conductors and OPGW shall not depart from the correct value by more that $^{+}/_{-}$1.5%. Suspension insulator sets shall be installed so that clamps are within 20mm of their correct position on the conductor.

m) The insulators strings shall be cleaned and inspected before assembly. Any defective insulator be shall be removed from site forthwith. Insulators have the security clip, cotter pins and other locking devices fully in place and shall be erected in a manner avoiding damage to the sheds, fibre-glass rod or locking devices.

n) Where required by the Engineer, the Contractor shall check prior to the issue of the Taking-Over Certificate that the sags of conductors and OPGW in selected spans are within the specified tolerance and shall make any adjustment necessary to ensure compliance.

o) Joints, clamps, etc. shall be applied using the approved tools and in such a manner that no bird-caging, over-tensioning of individual wires or layers or other deformation or damage to the conductor and OPGW occurs. Cutting of layers of conductors shall be carried out with tools designed to prevent damage to underlying strands.

p) Compression fittings shall be applied only by linemen approved by the Engineer, using approved methods. The outer surfaces of conductors and OPGW and the interiors of compression sleeves shall be scratched-brushed immediately before assembly.

q) After conductors have been made off and landed, stringing sheaves shall be removed and suspension clamps and vibration dampers shall be fitted with minimum delay. Suspension clamps shall be fitted with due regard to offsets where appropriate, and the conductor and OPGW shall be cleaned before the clamp is assembled.

r) The Conductor shall keep a record of all sagging showing details of the section, the sagging and checking spans, ambient temperature, pre-stress, initial and final sags, the date of sagging and clipping-in offset, etc. This record shall form part of the final records for the line and shall be handed over to the Engineer prior to the issue of taking-Over Certificate. The records shall be available for inspection at any time.

4.1.7.2.11.6 Tests at site

4.1.7.2.11.6.1 General

Following investigations and tests shall be carried out by the Contractor, when ordered by the Engineer.

Those investigations and tests as mentioned in the Price schedule will be paid for at the rates entered. Other investigations and tests not scheduled in the Price Schedule shall be deemed to be included in the prices of the relative items of the works.

4.1.7.2.11.6.2 Ground Prove Tests

Tests by means of an approved type of penetrometer or other approved means shall be carried out during the check survey as provided for in **Clause 4.1.7.2.5.** Results of these tests shall be submitted to the Engineer on an approved form giving a preliminary indication of the ground bearing properties and water levels, etc. Bore penetration shall be at least 9m below ground level in poor ground.

4.1.7.2.11.6.3 Laboratory Soil Tests

Where ordered by the Engineer, the Contractor shall obtain soil samples and submit these for tests to an approved laboratory to determine the necessary properties of the soils for the purpose of foundation designs. Such information shall be detailed in an approved manner and conclusions given as to the recommended bearing pressures to be adopted. Tests shall be carried out generally in the manner described in BS-1377

4.1.7.2.11.6.4 Ground Bearing Test

Where ordered by the Engineer, the Contractor shall carry out ground bearing tests to determine the ground bearing capacity, by means of loading a 300 mm square plate in an approved manner. Tests shall be carried out generally in the manner described in BS-5930.

4.1.7.2.11.6.5 Pile Bearing and Uplift Tests

Where ordered by the Engineer, the contract shall carry out pile bearing and uplift tests for all types of pile generally in accordance with the method given in the BS CP-2004. Such tests shall be carried out to determine the ultimate uplift and bearing values.

4.1.7.2.11.6.6 Foundation Loading Tests

Where ordered by the Engineer, foundation loading tests shall be carried out in full scaled individual footings.

4.1.7.2.11.6.7 Records of Site Investigation Tests

All records of site investigation tests shall be detailed in an approved manner. Sample log sheets, charts, etc. shall be submitted to the Engineer for approval before any investigation commences. All site investigation data, charts, etc. shall be handed over to the Engineer in triplicate upon satisfactory conclusion of the tests, and before the issue of Taking-Over Certificate.

Where the Contractor carried out other tests at his own expense, not ordered by the Engineer, and to the contrary, where the Employer had independent tests made along the route of the line, such information shall be made available to the Contractor.

4.1.7.2.11.6.8 Concrete Tests

The Contractor shall carry out tests on sample of concrete from the foundation works, as required by the Engineer as specified in **Clause 4.1.7.2.5.** The test specimens shall be stored at the site at a place free from vibration under damp sacks for 24 hours. They shall be then removed from the moulds, marked and stored in water at a temperature between 10^0 C and 21^0 C until the testing date. Specimens which are to be sent to a laboratory for testing shall be packed for transit in a damp sand, or other suitable damp materials, and shall be brought in the laboratory at least 24 hours before test. On arrival at the laboratory, they shall be similarly stored in water until the time of the test.
The results shall be handed in triplicate to the Engineer, as soon as possible after testing, and not later than seven days.

4.1.7.2.11.6.9 Support Footing Resistance

The resistance to earth of the complete foundation of individual structures shall be measured in an approved manner before the stringing operation of overhead earthwire, as specific in **Clause 4.1.7.2.11.6.2.** The placing of tests electrodes shall normally be along the center line of the route in such direction as to ensure that the lowest resistance to earth is recorded, and a note shall be made of the direction in the time of the test.

4.1.7.2.11.6.10 Additional Footing Resistance Test

If in the opinion of the Engineer, it is necessary to reduce the tower footing resistance by means of counterpoises, the Contractor shall make further measurement after the additional counterpoises have been carried out before the stringing operation of the overhead earth wire. Any further measurement shall be carried out as necessary without extra charge.

4.1.7.2.11.6.11 Measurement of Galvanising Thickness

The Contractor shall have on site an instrument suitable for accurate checking of galvanizing thickness for the Engineer's use. The gauge shall be available from time of arrival of the first consignment of steel work until the issue of Taking-Over Certificate. The cost of the gauge and other operating expenses shall be deemed to be included in the contract price and the gauge shall remain the property of the Employer.

4.1.7.2.11.6.12 Testing of Rock Anchors

Where rock anchor foundations are used in hard rock, as provided for by the Engineer's order, the Contractor shall test individual anchors by tensile test loading to failure for obtaining design data of the foundations. The test shall be considered satisfactory if the steel bar fails by yielding at or above its ultimate strength.

Anchor for the testing shall be installed away from permanent foundation anchors but in the same rock. The frequency of the test shall depend upon the different types of hard rock encountered and the number of tests performed shall be such as to give confidence in the employment of rock anchor foundations and experience of the type of rock suitable for their use. The frequency of test shall, in the case of dispute, be reasonably determined by the

Engineer. Tests shall be carried out generally in the manner described in BS-8081 on ground anchorages.

The cost rock test shall be included in the relevant schedule rates.

4.1.7.2.11.6.13 Test on Completion

The line shall be energized at full working voltage before handing over, and the arrangement for this and such other test as the Employer/ Engineer shall desire to make on the completed line shall be assisted by the Contractor who shall provide such labour, transport and other assistance as required without extra charge.

4.1.7.2.11.6.14 Surplus Material

Surplus material paid for by the Employer shall remain property of the Employer and shall be stored at the project terminal substation. Waste material will not be taken over or paid for by the Employer.

4.1.7.2.11.7 Costing of towers and Transmission work

4.1.7.2.11.7.1 Bill of Quantities

The quantities set out in the Volume I of bidding document -Price schedules are, unless otherwise defined, estimated quantities of the materials, design and works. They are not to be assumed as the actual and correct quantities to be executed by the Contractor in fulfilment of his obligations under the Contract. The Contactor is presumed to have satisfied himself as to the relevance of the estimated quantities in the preparation of his Tender.

4.1.7.2.11.7.2 Cost of Drawings, Reference Standards and Records

The provision of all drawings, design calculations, records and the supply of the relevant reference Standards etc. as stated or specified in the Contract shall be included in the Contract Price.

4.1.7.2.11.7.3 Cost of Survey work

The cost of full precision or check ground survey undertaken by the Contractor on the Employer's instruction shall be entered in appropriate Schedules in Volume I of the tender document, and distances shall be measured to the nearest meter along the centre-line of the route. The unit price shall include for the establishment or re-establishment of the line route from terminal points and other such fixed points the Employer may define, full ground survey, profiling, support plotting, preparation of Simms document tree marking and tree schedule and pegging of support locations.

4.1.7.2.11.7.4 Cost of Route clearance and access roads

Route clearance undertaken by the Contractor on the Employer's instruction shall be entered in the appropriate schedules in Volume I of bidding document and distances covered shall be measured to the nearest metre along the centre line of the route.
Cost of

4.1.7.2.11.7.5 Cost of tower foundations

4.1.7.2.11.7.5.1 General pricing requirements

The cost of foundations shall be entered in Schedule 4 under installation and other services. Where additional work is required over and above that provided for in the Specifications, this will be paid on a measured basis at unit prices submitted.

The unit prices for foundations shall include all necessary geotechnical investigation and geotechnical studies as defined in the Specification, or as required by relevant authorities.

The unit prices for all foundations shall include for site clearing, excavating in any material by any means, manual or mechanical, and for ensuring stability and natural drainage inside the working area, concrete, bitumastic painting for all backfilling, compacting and disposal of surplus material, routine testing, site restoration and for all necessary supports to sides of excavations.

Removal of 'man-made' materials such as industrial waste, etc., which the Employer agrees is hazardous and which cannot be removed by normal means shall be paid for at unit prices to be agreed.

The complete cost of foundations for a support shall be entered at the appropriate Schedule 4-unit prices. The unit price shall include for all excavations, conventional pumping (including well-point dewatering), excavation supports, concrete work, formwork, reinforcing, template steelworks, routine testing, bitumastic painting, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification.

The unit prices shall also include supply of blinding concrete or the importation of any backfill material necessary due to the excavated material being unsuitable as backfill.
The unit prices for foundations shall include the use of whichever type of cement is to be used and density of concrete necessary to meet the requirements of the specification.

The unit prices for foundations shall include all base plate steelwork installation and setting out including the use of templates if necessary, setting to any level and any excavation necessary for setting out. The protective treatment to defined concrete faces or support steelwork and provision of site protection barriers shall be included in the rates for the foundations.

The unit prices for foundations shall include the cost for all earthing requirements labour.
Where site stabilizations outside the defined 'working area' is required this shall be undertaken at unit prices to be agreed.

The cost of design tests on foundations to prove the foundation design shall be entered in the appropriate section of Schedule 4. The unit prices shall include for the removal of concrete and steel down to 1m below ground level where this deemed necessary by the Employer.

4.1.7.2.11.7.5.2 Costing of Pile Foundations.

The cost of complete foundations for each monopole shall be entered at the appropriate Schedule 4-unit prices. The unit prices shall include for mobilization and de-mobilisation of piling rigs, setting out, cleaning, cutting to length, reinforcement and pile cap connection, jointing or piles as necessary, irrespective of number of piles, all excavations (including rock), conventional pumping (including well-point dewatering), exaction supports (including use of bentonite slurries), concrete work for piles, pile cap and tie beams, formwork, reinforcing, Base plate steelwork, anchor bolt setting, routine testing, backfilling, clearing up and all other work required to complete the foundation in accordance with the Specification.
The unit prices for piled foundations shall be based on:

- The unit price for a complete monopole foundation including pile cap and tie beams.
- A unit price for piles for the complete monopole based on the nominal length defined in Schedule 4.
- An additional unit price per foundation for the "average" length of pile greater than or less than the defined length below existing ground level. This unit price shall be applied once per complete support foundation irrespective of the number of piles in the foundation and shall be applied per metre length of increased or decreased "average" pile.

4.1.7.2.11.7.5.3 Costing of Flood Protection Walls

Where the Contractor considers that a gabion wall is necessary to protect a support, the cost shall be entered in the appropriate Schedule 4-unit prices.

4.1.7.2.11.7.6 Cost of towers

The cost of steel Lattice and braces, monopoles and sections for extensions shall be entered in Volume I, Schedule 1-unit prices. The unit prices shall include for standard cross arms, and shall include base plate steelwork.

The unit prices for steel towers shall include for access facilities, anti-climbing devices, attachment plates, Climbing Bolts, ancillary steelwork etc. used as standard on the support.

The unit prices shall include for all support mounted notice plates.

The cost of type tests on individual supports to prove the support design shall be entered at the unit prices quoted in the Schedule 4 for successful tests only. No payment for failed monopole tests. All other quality control requirements shall be included within the appropriate unit price.

The cost of tower paint including all necessary preparation, sample and routine tests shall be entered at Schedule 1-unit prices.