

PART 2:

Section VII - Employers Requirements

B. Specifications

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1. OVERHEAD LINE CONDUCTOR

1.1. General

The line conductor shall consist of Aluminium Conductor Steel Reinforced (ACSR) having the characteristics stated in the Technical Schedules (TS).

Aluminium and galvanized steel material and coatings shall be formulated to resist corrosion (including general pitting and inter-granular, galvanic, crevice and stress corrosion) when exposed to the severe environment of the transmission line detailed in Section 1 of this specification and as generally described by pollution level IV of IEC 60815 and by pollution Class 4 to 5 of ISO 9223 (SO₂ Pollution Class P2 and Chloride Pollution Class S1).

All overhead conductors shall have a design service life of minimum 50 years. The conductor material and the grease are to be suitable for continuous operation at 80°C without deterioration.

The conductor shall comply in all respects with the requirements of IEC 61089 and ASTM B232 or other approved standard. The outer layer wires shall be pre-formed so that they remain inert when the conductor is cut. The stranding of each layer of the conductor shall be as close and even as possible. The lay of the outermost layer shall be right-hand.

Each layer of conductor except the outer layer shall be covered with an approved grease of applied mass per unit length determined in accordance with IEC 61089 and as stated in the Technical Schedules. The extent of grease to be applied shall be Case 2 as described in IEC 61089. After application of grease and before the outer layer of wires is stranded the penultimate layer of wires shall be thoroughly wiped so that all remaining visible grease on the conductor is between the wires of the penultimate layer. The grease shall conform to the requirements of BS EN 50326 and shall not corrode the wires. It shall be compatible with any wire drawing lubricant present on the conductor wires and shall not flow within, nor exude from, the conductor below the drop point stated in the Technical Schedules. It shall exhibit adequate resistance to oxidation and shall conform to the test requirements stated in BS EN 50326 and as given in the Technical Schedules. The grease drop point shall not be less than 120°C. Unless the Contractor can produce evidence in the form of service records, test certificates, etc. which demonstrate to the satisfaction of the Employer's representative that this requirement is met, the Contractor shall carry out such tests as the Employer's representative may require, at no additional cost to the Employer.

The aluminium shall be of the highest conductivity commercially obtainable. The Contractor shall submit certificates of analysis giving the exact conductivity value per unit length.

Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper or other materials that may adversely affect the aluminium.

The line conductor shall be packed and supplied on non-returnable steel- framed structure (steel cable drums) prepared for overseas shipment, which are constructed in accordance with an approved national standard so as to enable the conductor to be run out smoothly and in lengths as long as can be conveniently handled and erected. Drums shall be marked with type,

size and length of conductor and also with an arrow to show the correct direction of rotation for rolling. The inner end of the length of conductor must be passed through the flange and be secured external to the barrel.

The type, size and number of conductors to be installed for each phase of the transmission line shall be as stated in the Technical Schedules. Where the phase is to consist of a bundle of sub conductors the shape of the bundle and the spacing between the sub conductors shall also be as specified.

1.2. Joints

Joints for connecting line conductor shall be of approved types. Tension joints for ACSR shall be of the compression type. The design of the joint for ACSR conductors shall be such as to make it impossible to position the steel sleeve incorrectly. The electrical resistance of each joint shall not exceed 75 per cent of the measured resistance of the equivalent length of reference conductor. Tension joints shall not permit slipping of or cause damage to or failure of the complete line conductor or any part thereof at a load less than 95 per cent of the ultimate strength of the line conductor stated in the Technical Schedules.

All joints shall consist of as few parts as possible and there shall be no danger of relative movement between individual layers of the conductor during assembly. Non-tension joints shall not permit any slip or damage of the jumper connection at a load of less than 25 per cent of the ultimate strength of the conductor, and shall be designed so that no loosening of the jumper connections can occur in service. The design of the joints and any special tools to be used in their assembly shall be such as to reduce to a minimum the possibility of faulty assembly and erection. Erection tools and methods shall be to approval, and no alteration in methods of erection or tools shall be made, after approval, without the written sanction of the Employer's representative.

Where mating surfaces and jumper terminals are to be bolted together they are to be protected at the Manufacturer's Works by a strippable plastic coating or other approved means.

Where dropper connections to substation equipment require aluminium-to-copper connectors, the aluminium fittings shall be of the compression type and watertight insulating washers shall prevent exposed contact between copper and aluminium.

Where dropper connections to substation equipment require conductors of different configuration to that for downleads, a suitable connector shall be provided. The connector shall incorporate aluminium bridging pieces between the conductor compressed dead-end fittings and shall have a current carrying capacity not less than that of the complete phase conductors.

1.3. Vibration dampers

Where the phase consists of a single conductor, only Stockbridge type vibration dampers shall be supplied.

The Stockbridge type vibration dampers shall be designed to :

- introduce an additional damping effect to that of the conductor and to control Aeolian vibration to ensure that the strain level in the conductors at the clamps, both suspension and tension is below the fatigue limit of the conductor strands,
- guarantee that conductor bending strain at suspension and tension clamps shall not exceed the limit of 150 macrostrains.

In order to evaluate the efficiency of the damping system the supplier must have developed suitable computer programmes that have been verified against experimental investigations and behaviour of actual transmission lines, so that he is able to simulate the behaviour of the phase conductor when subjected to wind-excited Aeolian vibration. Based on the type of conductor and its tensile load the supplier shall submit a damping study, with calculations of vibration amplitude and strain on phase conductors with and without vibration dampers.

The approval of dampers shall be conditional on the provision of evidence of satisfactory service life and performance. Evidence must be provided in respect of fatigue resistance, clamp to conductor grip, damping of aeolian vibration and control of subspan oscillation with disposition along the span as recommended by the manufacturers. Evidence shall be provided of resistance to ozone and ultraviolet light as well as to aging in the case of hardware employing elastomers.

Elastomers or other non-metallic materials if used shall have good resistance to ageing and be capable of withstanding temperatures between +0°C and +110°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultraviolet radiation and air pollution over the entire temperature range and shall have a semi-conductive property.

Dampers shall satisfy the requirements specified in IEC 61284, 61854 and 61897 as relevant.

1.4. Armour rods

Approved pre-formed helical armour rods shall be fitted to the line conductor at all suspension towers.

The armour rods shall be of a material that is compatible with the material of the line conductor to which it is attached such as to eliminate any effects arising from dissimilar metals corrosion.

Armour rods shall have an end form appropriate to the application and operating voltage. The lay of the armour rods shall be right handed.

Identification marking shall be provided on a durable label attached to each set of armour rods. This label shall include details of the conductor material and diameter range. In addition each armour rod shall be provided with a discrete painted colour coding and a marking indicating the conductor size and starting point for application respectively.

Pre-formed helical armour rods may only be removed and reapplied after the original application for the purpose of adjustment during line construction procedures, in strict accordance with the manufacturer's recommendations.

2. OPGW

2.1. Scope

This specification details the requirements for the design, manufacture and testing of optical fibre cables, including Optical Power Ground Wires and accessories for application as Earthing & Telephone/data cable with EHV power cable circuits.

132kV overhead lines shall contain one OPGW as shield wire as specified in the Technical Schedules.

The OPGW for overhead line earthing shall be designed to withstand lightning strokes, short-circuit current, ambient and extreme temperatures and loadings specified in the Technical Schedules with no effect on the attenuation of the optical fibres and no permanent damage to the data transmission characteristics of the fibre optic cable.

At suspension towers the earth conductor suspension clamp shall be securely bonded to the tower steelwork by means of a multistrand aluminium flexible bond wire having a cross-sectional area adequate to carry the short circuit current as mentioned in the technical data sheet. The bond shall be terminated with compression lugs and shall not interfere with the suspension clamp movement.

At tension towers the earth conductor clamps shall each be securely bonded to the tower steelwork by means of suitable lengths of multistrand aluminium flexible bond wires having a cross-sectional area adequate to carry the short circuit current as mentioned in the technical data sheet. The bond shall be terminated with compression lugs.

Suspension towers shall be provided with the facility to accommodate suspension and tension clamps and bonds.

The equipment to be supplied shall conform in all respects to this specification. Unless another standard is specifically mentioned in this specification, all material and practices employed in the works must be in accordance with such other authorised standard appropriate to the country of manufacture, which in the opinion of this company shall ensure an equivalent or higher quality.

All Dielectric Self Supporting Fiber Cables shall be used for the link between the OPGW to the Optical Distribution Frames while Direct buried Fiber Optic Armoured Cables shall be used for purpose of underground electric transmission line sections.

All overhead conductors shall have a design service life of minimum 50 years including and as well as for OPGW, ADSS and Direct Buried Fiber Optic Armoured Cables. A warranty of at least 5 years, after operational acceptance, is also required.

All material used under this Contract shall be new, of the highest quality and of the class most suitable for working under the conditions specified, shall withstand the variations of temperature and atmospheric condition arising under working conditions without distortion or deterioration or setting up of undue stresses on, or impairing the effectiveness of any part.

2.1.1. FO Cable and Accessories

This section contains equipment requirements for pilot fibre optic cable and accessories. Design criteria shall be in accordance with IEC 60793-1, 2 60794-1, 2 and ITU-T (G.655) recommendations as well as Telecommunication system requirements. Type test certificate for the fibre optic cable is required.

2.1.1.1. Fibre Optic Cables

The Fiber Optic Pilot Cables shall comprise of the OPGW and ADSS for pilot and data applications.

2.1.1.1.1. OPGW Cables

The OPGW (Optical Power Ground Wire) shall have the following design standards:

- i. The cross section has minimum elements such as:
 - a. Aluminium-clad steel armour layer
 - b. Extruded Aluminium Core tube
 - c. Gel-Filled Buffer Tube covered
 - d. 48 optical fibers separated in groups of 12 with colour coded Group/Binder/Buffer separator following the EIA 598-C colour coding standard
- ii. Concentrically stranded metallic wires shall surround the protective optic unit. The properties of the metallic wires shall be in conformity with ASTM B415 and B416 or IEC 61232. The surface of the OPGW shall be free from all imperfections that are visible to the naked eye such as nicks, indentations, excess of lubricants etc. Adjacent wire layers shall be stranded with reverse lay directions. The direction of lay of the external layer shall be right hand. The wires in each layer shall be evenly and closely stranded around the underlying wires or around the central core. For aluminium-clad steel wires, the aluminium covering on each individual steel wire shall be continuous and uniform and shall provide sufficiently strong bonding strength at the boundary between aluminium layer and steel core.
- iii. All aluminium and aluminium alloy material and coatings shall be formulated to resist corrosion (including general pitting and inter-granular, galvanic, crevice and stress corrosion) when exposed to the severe environment of the transmission line detailed in the Technical Schedules and as generally described by pollution level IV of IEC 60815 and by pollution Class 4 to 5 of ISO 9223 (SO₂ Pollution Class P2 and Chloride Pollution Class S1).
- iv. The aluminium-clad steel wires shall be as according to IEC 61232 or ASTM B415 class 20SA and their use is restricted to the inner layer. Aluminium-clad steel wires are not permitted in the outer layer of the OPGW.

- v. Aluminium alloy wires shall be aluminium-magnesium-silicon grade in accordance with BS EN 50183. Close control of the ratio of Mg/Si alloying elements and the proportion of impurities shall be exercised in order to minimize the risk of corrosion degradation during the service life of the OPGW. The Contractor shall submit certificates of analysis giving the composition of the alloy and the percentage and nature of any impurities in the metal of which the wires are made. The type of alloy shall be proposed by the conductor manufacturer and is subject to the approval of the Employer's representative. Precautions shall be taken during manufacture, storage and erection of conductors to prevent the possibility of contamination by copper and iron or other materials that may adversely affect the aluminium.
- vi. The aluminium-clad steel wires shall be as according to IEC 61232 or ASTM B415 class 20SA and their use is restricted to the inner layer. Aluminium-clad steel wires are not permitted in the outer layer of the OPGW.
- vii. The optical fibers shall be made of high pure silica and germanium doped silica. UV curable acrylate material is applied over fiber cladding as optical fiber primary protective coating. They shall be suitable for operation at 1550 nm and 1625 nm wavelengths and shall comply with the requirements of IEC 60793 and IEC 60794 series. The Contractor shall indicate index of refraction of the fiber core and cladding at 1550 nm and 1625 nm and the effective group refractive index for use with the Optical Time Domain Reflectometer (OTDR).
- viii. Fibers shall be contained in one or more loose buffer tubes allowing the fibers to be free from strain even at high operating loads.
- ix. Specific colour code shall be as described below in the fiber colour code section.

2.1.1.1.2. ADSS Fiber Optic Cables

The ADSS (All Dielectric Self Supporting) Fiber optic cable shall have the following design standard:

- i. The cable shall be designed to provide self-support performance of up to 800meters and shall be designed to operate under full weather load, ensuring safe and reliable lifetime performance
- ii. For installation in and for high-voltage lines up to 275 kV, an optional track-resistant jacket prevents dry-band arcing damage
- iii. The optical fibers shall be made of high pure silica and germanium doped silica. UV curable acrylate material is applied over fiber cladding as optical fiber primary protective coating.
- iv. The cable shall be an all-dielectric, single and dual jacket and track resistant construction
- v. The cross section shall be comprised of:
 - a. HDPE (High-Density Polyethylene) outer jacket

- b. Aramid strength yarns between the outer and inner jackets with rip cord
- c. Inner Polyethylene Jacket
- d. Water blocking tube
- e. 4*Gel-filled buffer tube material containing 12 fibers each in a tube/buffer which shall follow the TIA-598-C colour coding standard
- f. Central strength member

Specific colour code shall be as described below in the fiber colour code.

The Contractor shall include design, manufacture, supply, installation including hardware and splicing, supply of spares, testing, commissioning, remedying of defects, and maintaining the works during the defect liability period and any incidental work necessary for the proper completion of the work in accordance with the Specification.

The fibre optic pilot cables shall have the following main general characteristics:

- Fibres contained in loose tube.
- The fibre shall be of single mode type according to ITU-T Recommendation G.655 suitable for transmission of information at the ITU-T recommended rates of either 2, 8, 34, 140, 155 or 622 Mb/s.
- The fibre shall have dual operative windows, at 1550 nm and 1625 nm.
- Minimum of 48 fibre cores.
- Maximum optical attenuation shall be 0.22 dB/km for 1550 nm, and 0.24 dB/km for 1625 nm.

Each individual fibre shall be colour coded for identification purposes, with the details of the colour coding scheme described below.

The Tenderer shall provide a drawing showing a cross-section of the cable indicating the dimensions of each element it contains. The drawing shall provide a clear illustration of the design and make-up of the cable. Technical descriptions detailing the fibre optic cable performance shall be provided.

All necessary civil works and installation materials required to complete the fibre optic cable system shall be included in the Contract.

All fibre optic cables shall have a design life of at least 25 years.

2.1.1.1.3. Direct Buried Fiber Optic Armoured Cables

The cable shall be a fully armoured all dielectric, Non-Zero Dispersion Shifted, 48 fibres, Optical Fibre Cable Specifically manufactured for underground Installation. The cable is to be laid inside a High-Density conduit, the same place there shall be high voltage transmission line

power cables. A written confirmation must be obtained from the cable manufacturer giving an assurance that the cable so offered is suitable for underground installation alongside the HV power cables and that it will give a reliable communication link suitable for Protection of the power cable, Speech and Data Transmission.

The Manufacturer shall also submit a list showing Locations where similar cables have been laid underground alongside similar HV power cables or of higher voltages and the duration over which the cables have been in Operation.

NOTE: It should have the pre-requisite Mechanical Protection to prevent damage during installation and due to other Human activities, such as excavation. The cable should also be Rodent resistant. The cable must be specifically manufactured for underground installation and must be all dielectric fully armoured, hence unaffected by Electromagnetic induction from the HV power cables. This must be specifically stated in the Tender Offer.

The cable shall be designed, manufactured and tested according to the following international standards:

IEC 60793-1	Optical fibre Part 1: Generic specifications
IEC 60793-2	Optical fibre Part 2: Product specifications
IEC 60794-3-10	Outdoor cables- family specification for duct and directly buried optical telecommunication cable
ITU-T G.650	Definition and test methods for the relevant parameters of single-mode fibres
ITU-T G.655	Characteristics of Non Zero Dispersion Single-Mode Optical Fibre and cable
EIA/TIA 598	Colour code of fibre optic cables

The optical fibers shall be made of high pure silica and germanium doped silica. UV curable acrylate material is applied over fiber cladding as optical fiber primary protective coating.

The cable shall be an all-dielectric, single and dual jacket and track resistant construction

The cross section shall be comprised of:

- HDPE (High-Density Polyethylene) outer jacket
- Aramid strength yarns between the outer and inner jackets with rip cord
- Inner Polyethylene Jacket
- Water blocking tube

- 4*Gel-filled buffer tube material containing 12 fibers each in a tube/buffer which shall follow the TIA-598-C colour coding standard

Central strength member Inner Sheath: The Fiber Optic Cable shall be covered with tough weather resistant Black High Density Polythene Compound (HDPE) of thickness not less than 1.2mm. It shall be circular, free from holes, joints, mended pieces and defects.

Armouring: Armouring shall be provided over inner sheath by Corrugated Stainless Steel Armouring Tape to make the cable rodent and Termite Proof. The steel tape should be both side coated with transparent polymer coating of minimum thickness of 0.05mm. The height of the corrugations shall be minimum 0.6 mm and the pitch of the corrugated tape shall be max. 2.5mm.

The expected life of the cable is at least 25 years. The supplier shall submit necessary statistical calculation to prove this requirement.

Mechanical/Environmental requirements:

- Proof test: Entire length of the fibre should be subject to a tensile proof stress of > 100 (0.7 Gpa)
- Strip ability force: $1.3 \leq F \leq 8.9\text{N}$
- Dynamic tensile strength: >3.8 Gpa (Nominal 5.26 Gpa) For both Unaged/Aged (30 days at 85 degrees Celsius and 85% RH)
- Dynamic fatigue: ≥ 20 (Nominal 22)
- Static Fatigue: ≥ 20 (Nominal 25)
- Fiber curl: $\geq 4\text{m}$ radius of curvature
- Fiber micro-bend:

Mandrel Dia mm	No of Turns	Wave length nm	Induced attenuation in dB
32	1	1550	<0.5
50/75	100	1550	<0.05
50	100	1550	<0.10
60/75	100	1550	<0.05

- The induced attenuation due to fiber wrapped around a mandrel of a specified diameter.

- Induced Attenuation at 1550nm: ≤ 0.05 Db/km
- Temp Humidity Cycling -10 degree Celsius to 85 degree Celsius: < 0.05 dB/km up to 98%RH where ref Temp is +23 degree Celsius
- Water Immersion 23 degree Celsius: ≤ 0.05 Db/km
- Heat Aging, 85 degrees Celsius, where Ref Temp is +23 degree Celsius: ≤ 0.05 Db/km

Mechanical Requirement of the cable:

- After each mechanical tests below, the change in attenuation shall be ≤ 0.05 dB/km for each individual fiber.
- Tensile strength: The cable shall withstand a load of value $\leq 9.81 \times 2.5 \times W$ is the weight of 11km of the cable @ strain $\leq 0.25\%$
- Crush load: The cable shall sustain a compressive load of 4 KN/100x10mm.
- Impact load: Shall withstand an impact caused by a mass of weight of 50N
- Torsion load: Shall withstand a load of 100N for 2m cable length.
- Water penetration: Shall meet or exceed the limit as per latest. TEC specification.
- Cable bend: Minimum-bending radius will be 20D, where 'D' is outer dia of the Cable.

2.1.1.2. Optical Fibers Characteristics

The optical fibers shall be Non-Zero Dispersion-Shifted Fiber (NZDSF) type, made of high pure silica and germanium doped silica. UV curable acrylate material shall be applied over fibre cladding as optical fibre primary protective coating. The chemical composition of the fibers shall be specifically designed to minimize the effect of hydrogen on the transmission properties. The detail data of optical fibre performance ITU-T G.655 standard and in particular as shown in the following table.

Category	Description	Specifications
Optical Specifications	Attenuation between 1525-1625nm at 1550 mm	≤ 0.22 dB/km
	Attenuation between 1565-1625nm at 1625 mm	≤ 0.24 dB/km

	Attenuation discontinuities @1550nm	≤ 0.05 dB
	Attenuation coefficient at water Peak (at 1385 ± 3 nm)	≤ 1.00 dB/km
	<p>Chromatic Dispersion coefficient in 1530-1565nm band:</p> <p>λ_{\min} and λ_{\max}</p> <p>Minimum value of Dmin</p> <p>Maximum value of Dmax</p> <p>Dmax – Dmin</p> <p>Sign</p> <p>Chromatic Dispersion coefficient in 1565-1625 band:</p> <p>λ_{\min} and λ_{\max}</p> <p>Minimum value of Dmin</p> <p>Maximum value of Dmax</p> <p>Sign</p>	<p>1530nm and 1565nm</p> <p>1.0 ps/nm.km</p> <p>10.0 ps/nm.km</p> <p>≤ 5.0 ps/nm.km</p> <p>Positive</p> <p>1565nm and 1625nm</p> <p>4.0 ps/nm.km</p> <p>14.0 ps/nm.km</p> <p>Positive</p>
	Dispersion Slope	< 0.07 ps/(nm ² .km)
	<p>Polarisation Mode Dispersion @1550nm</p> <p>Individual Fibre</p> <p>Cabled Fibre PMD for 90% of fibre in a cable</p> <p>PMD Link Design Value</p>	<p>≤ 0.2 ps/$\sqrt{\text{km}}$</p> <p>≤ 0.3 ps/$\sqrt{\text{km}}$</p> <p>≤ 0.1 ps/$\sqrt{\text{km}}$</p>
	Cut-off Wavelength (λ_{cc})	≤ 1550 nm
	Mode Field Diameter @1550nm	9.0 ± 0.7 μm

	Macro Bending Loss @1550nm (1 turn of fibre, $\Phi 32\text{mm}$) (100 turns of fibre, $\Phi 60\text{mm}$)	<0.5dB <0.05dB
Dimensional Specifications	Cladding Diameter	$125 \pm 1 \mu\text{m}$
	Core/Clad Concentricity Error	$\leq 0.8 \mu\text{m}$
	Cladding Non-Circularity	$\leq 1.0\%$
	Coating Diameter	235-225 μm
	Coating-Cladding Concentricity Error	10 μm
	Fibre Curl	$\geq 4\text{m}$ radius of curvature
Mechanical Specifications	Proof Stress	1%
	Stripability force to remove secondary coating of fibre	$1.3 \leq F \leq 8.9$
	Dynamic Tensile Strength Unaged Aged (Aged at 85°C, 95% RH for 30 days)	>550 Kpsi (3.8 GPa) >440 Kpsi (3.0 GPa)
	Dynamic Fatigue Parameter	≥ 20
	Static Fatigue Parameter	≥ 20
Environmental Characteristics	Temperature Dependence of Attenuation (Induced attenuation at -60°C to +85°C)	$\leq 0.05\text{dB/km}$ at 1550nm

	Temperature Humidity Cycle (Induced attenuation at -10°C to +85°C, 95% RH)	≤0.05dB/km at 1550nm
	Water Immersion (Induced attenuation at 23 ± 2°C)	≤0.05dB/km at 1550nm
	Heat Aging (Induced attenuation at +85 ± 2°C)	≤0.05dB/km at 1550nm

Dimension and Properties:

Physical	Fibre Count (G.655)	48 or 96 (as per Scope of Supply)
	No of loose tube/filter	4/2
	Fibre number per tube	12
	Glass Composition	
	Core	Germania (GeO ₂) doped Silica (SiO ₂)
	Cladding	Silica (SiO ₂)
	Primary Coating	2 layers of UC curable resin

2.1.1.3. Fiber Colour Coding

The colour code for the fiber optic strands shall follow the TIA-598-C standard for the 12 fiber cores. The fibers shall be grouped into buffer tubes of 12 fibers each. The buffer tubes housing the optical fibres shall be coded for ready identification at either end. Buffer tubes shall be filled with a compound to provide resistance to water penetration, vibration damping and for shock absorption.

For the 48 fibers (or more) the colour coding scheme shall be as described below:

TUBE/ GROUP	FIBER COLOURS												BINDER COLOUR
1	1	2	3	4	5	6	7	8	9	10	11	12	BLUE
	Blue	Orange	Green	Brown	Slate	White	Red	Black	Yellow	Violet	Rose	Aqua	
2	13	14	15	16	17	18	19	20	21	22	23	24	ORANGE
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
3	25	26	27	28	29	30	31	32	33	34	35	36	GREEN
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	
4	37	38	39	40	41	42	43	44	45	46	47	48	BROWN
	Blue	Orange	Green	Brown	Slate	White	Red	Clear	Yellow	Violet	Rose	Aqua	

Each optical fiber for identification shall be color-coded corresponding to sequential numbering. The colour shall be integrated in the fiber coating and shall be homogeneous. The colour shall not be erased when handled during splicing. The original colour shall be discernible through the design life of the OPGW. The colour should not bleed from one fiber to the other and not fade when wiping the fiber with acetone or alcohol. If the fibers are regrouped in bundles or in tubes the later shall be coloured according to a determined code.

2.1.1.4. Terminations

The interface between the fibre optical transmission system and the fibres of the optical cable shall be at the optical distribution frames using low loss de-mountable optical connectors of the plug-in type. The maximum insertion loss for a pair of mated connectors shall be 0.25 dB.

In order to cater for system failures, system expansions and re-routing etc., manual patching facilities shall be provided.

Mating connectors shall be provided as part of the Contract. Caps shall be provided for each coupler to prevent dust ingress to the couplers of unused fibres. The Tenderer shall state the manufacture and type of connectors proposed. All connectors shall be so positioned to facilitate easy cleaning and inspection.

All spare fibres shall be terminated with appropriate optical connectors.

2.1.1.5. Optical Distribution Frames

Optical Distribution Frames (ODFs) shall be used for termination of optical fibers in either the terminal stations or repeater stations. Where the ODF is under the scope of the contractor for termination of fibre cables and approach cables, they shall be of 42U free standing fiber cabinets type designed for termination of single mode optical fibers with FC-PC connectors inside equipment enclosure racks located within the Telecom Room. The patch panels shall include the following specifications and accessories for fiber optic cables:

- Minimum 19" width:800mm by depth:800mm cabin
- Glass door

- IP55
- 600kg minimum carrying capacity
- Light grey in colour
- Mounting bolts
- FC Type receptacle,
- Interconnect sleeve or bulkhead adapter
- Jumper cables
- 48 core fiber drawers
- Storage for fiber
- Cable clamps with strain relief
- Flip card for easier record keeping

Bottom case integrated with wide cable entry point provides maximum versatility. The rubber edged sliding mechanism on the cable entry point at bottom with $w=350\text{mm}$ \times $d=250\text{mm}$ allows large cabling infrastructure applications. On rubber edged sliding mechanism max cable entry opening is $w=350$ \times $d=150\text{mm}$. After inserting the cables, the rubber edged mechanism holds and fixes the cables in parallel preventing the cabinet from dust entry.

Front door is integrated with decorative 2,5mm thickness aluminium extruded frames, full length smoked, shatterproof, antistatic, 4,0mm thickness glass with single point locking handled lock. Front door Aluminium extruded frame allows, decorative PVC Stripes charming the attraction, Anthracite Grey for Light Grey Cabinets. Front door opening direction is set right to left, but reversible to left to right at site with removing the hinge system. Hinge System shall be spring loaded easy operating version, which allows you to remove the whole front door from cabinet.

Side Panels shall be lockable and removable with barrel style lock, multifolded bending technology with 8 fold bending to provide rigidity. Additional Vertical Cable Tray $w:100\text{mm}$ can be housed at back side where the main cable bundles run through. Extensibility feature of cable trays by using 2 pcs for 200mm wide, 3 pcs for 300mm wide cable tray system could be managed.

The panel shall contain railed shelves where the 48Core fiber drawers can be drawn for easy splicing and maintenance works. The shelves shall also be well spaced to avail comfortable fiber working environment.

Capacity min. 4 shelves for fibre optic cables, each with 48 fibres

Installations Free-standing Cabinet mounted type

Attenuation 0.5 – 1 dB/per connector

0.03 dB/per splice

Optical connectors F.C. - P.C. type

2.1.1.6. Fiber Optic Cable Joint Enclosures (Joint Boxes)

- 1- It is preferred that a universal joint enclosure is proposed for all types of cable. The enclosure shall provide adequate protection for splices, and shall provide storage for sufficient length of fibre for at least ten future splices. The size of the enclosure shall be of sufficient size to meet the minimum bending radius requirement of the fibre optic cable.
- 2- Joint boxes designed to protect all optical fibre joints from the environment shall be provided and located on appropriate joint towers immediately above the anti-climbing devices. Joint towers may be either tension or suspension towers, the latter being specifically modified to accept the optical termination fittings. Each joint box shall be capable of being hermetically sealed after jointing and hermetically resealed after reopening and reclosing.
- 3- The boxes, which shall be fitted with a bolted and lockable lid, shall be manufactured from stainless or galvanized steel and shall provide protection to Class IP 65 or better of IEC 60947-1. Access on the bottom edge of the box shall be by means of weather-tight glands sized for the incoming and exiting OPGW earth conductor. The box shall be made weatherproof by the use of corrosion-resistant sealing compound. an integral earth terminal shall be provided for joint box.
- 4- The joint boxes shall provide adequate protection for splices and shall provide storage for sufficient length of fibre for at least ten future splices. The size of the boxes shall be sufficient to meet the minimum bending requirements of the OPGW earth conductor.
- 5- The enclosure shall be made from metal and all surfaces shall be protected by galvanising. The enclosure shall be made weatherproof by the use of a corrosion-resistant sealing compound.
- 6- The joint boxes shall be of 2-way, 3-way and 4-way type for appropriate fusion purposes of fibers. They shall contain a fiber spicing capacity of 48 cores according to the Scope of Supply. They shall contain cassettes for securing of fiber jointing sleeves. The joint box shall be sealed with a gasket ring (preferably silicon rubber gasket ring) that can be locked and the sealing system air tight. It shall be rated to IP65 in accordance with IEC 60529.
- 7- The Contractor shall submit the design of the joint box for approval.

2.1.2. Earthing Conductor Joints

2.1.2.1. Optical Fibre Joints

The Contractor shall design, supply and install optical fibre cable joints. Each cable joint shall include termination box, mounting hardware, optical fibre splice kits, cable entry seals and all accessories required to produce a permanent optical joint. Details of the proposed optical fibre joints shall be submitted by the Contractor for the approval of Employer's representative.

Each termination box shall be capable of being hermetically sealed after jointing, and hermetically sealed after re-opening. The quality and type of termination boxes shall be determined by the Contractor and subject to approval by Employer's representative.

Optical fibre splices shall be of the fusion type and the optical attenuation of each splice shall be not more than 0.03 dB. The jointing shall be performed carefully to ensure similar cores are joined together throughout the line and to ensure 1:1 fiber continuity and core matching. Proper coordination between the fiber jointing teams shall be emphasized to ensure 1:1 fiber core matching and continuity.

It is preferred that a universal joint enclosure is proposed for all types of cable. The enclosure shall provide adequate protection for splices, and shall provide storage for sufficient length of fibre for at least ten future splices. The size of the enclosure shall be of sufficient size to meet the minimum bending radius requirement of the fibre optic cable.

The enclosure shall constructed from metal. Where metal is used, all surfaces shall be protected by galvanising. The enclosure shall be made weatherproof by the use of a corrosion-resistant sealing compound, an integral earth terminal shall be provided for enclosure.

2.1.3. Armour Rods

The provisions of the Specification in relation to armour rods shall also apply to armour rods for Optical Fiber Cables and ACS earth conductors. In addition, the number of layers making up the armour rod for Optical Fiber Cables shall be in accordance with the recommendations of the supplier of the suspension clamp for Optical Fiber Cables and shall be to the approval of the Employer's representative.

2.1.4. Installation of Overhead Earthing Cables

To permit the joint box to be moved to the ground for jointing purposes a suitable length of OPGW earth conductor, minimum 10 m span should be free on ground before the the joint box with cable is coiled and supported on the structure.

All required materials for fixing the OPGW earth conductor and for the installation of the joint boxes shall be supplied by the Contractor and the costs for these materials and joint boxes shall

be deemed to be included in the cost of the OPGW earth conductor, as shall the costs for carrying out all the necessary jointing and splicing.

Full details of the cable offered must be submitted with the bid, including :

- i. Cable construction and materials, including but not limited to the Mechanical Failure Load (MFL), Rated Tensile Strength (RTS) and Specified Maximum Working Tension (SMWT).
- ii. Installation methods and materials.
- iii. Jointing methods, materials and mounting arrangements.
- iv. Physical protection against the ingress and transmission of moisture.
- v. Identification marking and fibre coding.

3. INSULATORS AND FITTINGS

3.1. Insulator sets and earth conductor sets

Insulator units shall be the long rod polymeric (composite) type with metal fittings and shall comply in all aspects with the requirements of relevant IEC standards.

3.2. Types of insulator

Insulators shall be special aerodynamically shaped insulators designed to minimize the adherence of dust and other solids. The insulators shall be used to determine tower top geometry and dimensions.

The long rod polymeric (composite) insulators with shed material formed from RTV silicone elastomer, shall comply with the requirements of the Specification and shall be to the approval of the Employer's representative. The materials used for the polymeric insulators shall be of proven quality and formulation and shall meet all the technical and test requirements given in IEC Standard 61109, IEC Standard 61466-1, ANSI Standard C29-11 and ANSI/IEEE Standard 987. The Contractor shall provide documentary evidence to confirm that any composite insulators being proposed have proven service histories, when operating at voltages at least as high as that for which they are now being offered and in environments at least as aggressive. Confirmation shall be provided that both the material from which the insulators are made and the method of manufacture are identical for the insulators being proposed and for those whose service history is being presented. Copies of previous type test reports shall be provided.

Insulators on straight-line towers shall normally be of the suspension type. Suspension insulators shall have alternate large and small diameter sheds. Phase conductors shall be supported on suspension and tension sets of types specified in the Technical Schedules. Alternative "V" string configured insulators may also be considered.

Composite long rod insulators shall be preferably provided with ball and socket fittings in accordance with IEC 60120 and "W" type security clips for the insulator units themselves, in accordance with IEC 60372. Other types of end fittings shall be to the approval of the Employer's representative.

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

3.3. Grading rings & Corona devices

Grading rings and other corona shield equipment, formed from galvanized mild steel and of approved types, shall be attached in an approved manner to all suspension and tension insulator sets. The devices shall be attached to the insulator fittings, but not directly to conductor clamps or to the caps of insulator units. The design of the devices shall be such as to reduce, as far as reasonably possible, damage to the line conductors, clamps, insulator strings and devices themselves under all flashover conditions. The general shape and method of attachment of the live end device shall also not restrict the replacement of insulators under live line conditions.

The grading rings of the insulator sets must fulfil simultaneously the functions of arcing rings, corona shield and potential distribution devices. As arcing device, the guard rings shall be designed to protect insulators and conductors when flashover occurs. The arcing fittings shall be made of hot dip galvanized steel and must have the capability to withstand a short circuit current of 10 kA for 1 sec.

The arcing fittings must be designed such that in case of a flashover the arc will be led to the end burning spot. They may reach a final temperature not exceeding 600°C during the short-circuit. The function of arcing protection must not be greatly altered by the power arc.

As corona shield devices, the grading rings shall be designed to ensure a corona-free insulator and string set.

As potential distribution devices, the grading rings must be designed to ensure that for each insulator fin a potential value as required by the insulator manufacturer is ensured.

The design of the grading rings shall consider and optimize simultaneously all the functions required. The rings shall be strong enough to support a maximum point load of 90 kg.

Grading rings shall be supplied for all composite long rod insulators and the Contractor shall provide data and previous service histories to confirm that suitable protective devices have been offered.

All suspension and tension insulator sets for the general run of lines shall be provided with grading rings at both line and earth ends.

3.4. Electrical design

All insulators and insulator sets shall comply with the technical requirements of the Technical Schedules.

3.5. Mechanical design

The mechanical strength of the insulators shall be as stated in the Technical Schedules.

The design shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to the development of defects.

Insulating material shall not engage directly with hard metal. All fixing material shall be of approved quality and applied in an approved manner and shall not enter into chemical action with the metal parts or cause fracture by expansion in service.

3.6. Marking

Each insulator unit shall be legibly and indelibly marked with the name and trademark of the manufacturer, the year of manufacture and the SML (specified mechanical load) in accordance with IEC 61109.

3.7. Clamps and fittings

Suspension and tension anchor clamps for line and earth conductors shall be of approved types and shall be as light as possible. All clamps shall be designed to avoid any possibility of deforming the stranded conductor or of separating the individual strands.

All connecting fittings between the conductor and the tower steelwork such as a clevis to tongue, shackle to plate or link which are subject to a tensile load in service shall comply with IEC 61284 except that each fixing pin shall be secured by a threaded nut and a split pin. A backing washer is not required and the unthreaded shank of the fixing pin shall extend 3 mm through the clevis or shackle. The nut shall, during erection, be tightened to the end of the thread and be backed by a phosphor bronze or austenitic stainless steel split pin. A clevis or shackle opening shall not exceed the thickness of the corresponding tongue, plate or link by more than 3 mm. Adequate bearing area between fittings shall be provided and point contacts shall be avoided wherever this is possible without adversely affecting the flexibility of the fitting.

Fittings made of steel or malleable iron shall be galvanized in accordance with the Specification. All bolts and nuts shall comply with the requirements for tower bolts and nuts and shall, unless otherwise specified, be locked by locknuts. The mechanical strength of the fittings shall be as stated in the Technical Schedules and the minimum failure load of each fitting shall be stated on the drawings. All clamps and fittings (except grading rings) which could be the subject of direct or indirect lightning or short circuit current shall withstand short circuit current as mentioned in the technical data sheet without alteration of their electrical or mechanical performance values.

Fittings shall be provided in all insulator sets to allow live line replacement of insulator units to be carried out. Insulator sets shall be fitted with shouldered extension links, at each end of the insulator strings, suitable for standard strain carrier yokes of live line maintenance equipment and for bundled line conductor, an attachment plate behind the tension clamp to enable the load on the tension set to be relieved when making adjustment to the sag-adjusting links.

Suspension clamps for ACSR line conductor and ACS steel earth conductors shall be free to pivot in the vertical plane about a horizontal axis passing through and transverse to the centre line of the conductor. Suspension clamps shall permit the complete conductor to slip at approximately 15% of the UTS tension stated in the Technical Schedules, but the conductor shall be mechanically clamped in an approved manner. The supporting groove beyond the clamp shall be curved in the vertical plane to allow for the conductor leaving the clamp at the

maximum inclination to be obtained in service. The mouth of the supporting groove shall also be slightly flared in plan. The grooves in the clamping piece or pieces shall be bell-mouthed at each end. All conductor grooves and bell-mouths in ferrous clamps shall, after galvanizing, be smooth and free from waves, ridges or other irregularities. Suspension clamps for earth conductor shall be designed for attachment of the required flexible earthing bond that is to be bolted between each suspension clamp and the tower steelwork. Suspension clamps (except pilot/auxiliary suspension string clamp) for ACSR line conductor and ACS steel earth conductors shall be sized for the use of armour rods. Suspension clamps in pilot/auxiliary suspension strings for single line ACSR conductors shall have the facility for attaching 200kg of counterweights. Use of Armour Grip Suspension clamp or cushion clamp with integrated preformed rods may also be offered subject to approval of the Employer's representative.

Suspension clamps for optical fibre (OPGW) earth conductors shall be free to pivot in the vertical plane about a horizontal axis passing close to and transverse to the centre line of the conductor. The conductor shall be mechanically clamped in an approved manner. Suspension clamps shall permit controlled axial movement of the conductor through the clamp, without causing damage to the conductor, under unbalanced load conditions. The tension unbalance at which this slippage can occur shall be approximately 15% of UTS. Unless otherwise approved, the suspension clamp unit shall be designed such that there is progressive stiffening of the optical fibre conductor up to the suspension clamp, which is a point of maximum bending. Complete protection of the optical fibres from damaging radial crushing loads under the clamp shall be ensured by the use of a suitable armoured suspension clamp, of either the Armour Grip Suspension (AGS type with Armour Rods and an internal elastomeric clamp liner) or an armoured metallic suspension clamp which is specially designed for the specific size OPGW and incorporates armour rods and positive metallic 'stops' in the suspension clamp body. Suspension clamps for OPGW earth conductor shall be designed for attachment of the required flexible earthing bond that is to be bolted between each suspension clamp and the tower steelwork.

Elastomers or other non-metallic materials used in suspension clamps shall have good resistance to ageing and be capable of withstanding temperatures between +0°C and +110°C without change of essential properties. The materials shall have adequate resistance to the effects of ozone, ultraviolet radiation and air pollution over the entire temperature range.

Tension anchor clamps for ACSR line and ACS earth conductors shall be of the compression type and shall comply in all respects with the provision of the Specification for line conductor joints where applicable to either the tension or non-tension components. The mechanical efficiency of such tension clamps shall not be affected by methods of erection involving the use of auxiliary erection clamps before, during or after assembly and erection of the tension clamp itself.

Tension anchor clamps for OPGW earth conductor shall be of the pre-formed helical type. They shall comply with the provision of the Specification for line conductor joints, but shall also support the OPGW earth conductor such that up to the Specified Maximum Working Tension (SMWT), the maximum increase in attenuation in the optical system does not exceed 0.05 dB/km.

All fittings for OPGW earth conductor shall be in accordance with the recommendations provided by CIGRE in the series of Reports entitled "Guide to fittings for optical cables on transmission lines, Part 1 Selection and Use" Electra No 176 (1998) and "Part 2 Testing Procedures" Electra No 188 (2000).

Tension insulator sets and clamps shall be arranged to give a minimum clearance of 150 mm between the jumper conductor and the rim of the live end insulator units.

Suspension and tension string tower attachments shall be of 'hinge' type. U-bolt or shackle attachment type shall not be allowed. Use of turnbuckles shall not be allowed.

The single suspension insulator set shall be used as standard set on suspension towers.

The double suspension insulator set shall be used for significant crossings as well as on the suspension towers where the weight span is greater than 500m.

A single tension insulator shall generally be used for overhead lines with a single phase conductor.

A double tension insulator set shall be used for significant crossings of the overhead line with single phase conductors.

For the full length of the OHL route, all types of insulator sets shall be fitted with arcing devices on both ends, i.e. live end and line end of the respective insulator string.

The double suspension insulator set shall be orientated in the longitudinal plane of the overhead line.

Spacing between double strings shall be sufficient to prevent clashing of adjacent insulator units.

In order to enable the installation of double tension insulator sets, double point attachments for all tower cross arms shall be provided.

Double insulator strings shall be designed to ensure that following the breakage of one insulator string, the set shall remain intact and withstand the resulting static and dynamic loadings imposed.

The electrical and mechanical performances required for the insulator sets are shown in the Technical Schedules.

All insulator sets including their clamps and fittings shall, in fair weather, be free from corona discharges. This shall be proven by test. An extinction corona voltage at least 5% higher than the phase-to-earth value of the specified highest voltage for equipment shall be obtained.

All insulator sets must be equipped with all necessary shield devices in order to keep their radio and television noise as low as possible. The radio interference (RI) performance of the insulator sets shall be proven by test. A noise level less than 45 dB above 1 microvolt must be ensured.

4. STEEL TOWER DESIGN

4.1. General

Towers shall be of the self-supporting type in vertical configuration as specified in the Technical Schedules.

The towers shall be designed to carry the line conductors with the necessary insulator sets, earth conductors and all fittings under the conditions specified.

For double circuit towers the line conductors of each circuit shall be disposed in 'Vertical' configuration and symmetrically arranged with two overrunning earth conductors to provide the shielding angle specified in the Technical Schedules.

Double circuit terminal towers shall be capable of terminating four earth conductors.

The methods of attachment of the conductor(s) to the towers shall be by means of suspension clamps at the suspension towers and by means of tension anchor clamps at tension towers. The attachment of the earth wire for suspension towers shall be capable of accommodating OPGW suspension and tension clamps.

Tower design to be considered that tower will be tested as per IEC 60652 with positive tolerance on 100% individual and total load as per IEC 60652 for each load case.

4.2. Types of tower

The towers shall normally be of the following standard types, and as stated in the Technical Schedules.

Maximum height of towers to be considered as 40 meters in the spotting however all the combinations of towers to be designed and tested as required in this technical specification.

Table 1: Tower Types– Vertical Configuration

Type	Position of use	Angle of deviation or entry	Type of insulator
Type S	Straight line	0° - 2°	Suspension
Type T10	Angle	0° - 10°	Tension
Type T30	Angle	10° - 30°	Tension
Type T60	Angle	30° - 60°	Tension
Type T90/ Trm	Angle	60° - 90°	Tension

	Terminal	0° - 45°	Tension
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The duties of two or more tower types may be combined into a single type if this should be economically advantageous to KETRACO and be approved by the Employer/Employer's Representative.

The standard height of towers shall be based on the sag of the conductor specified in the Technical Schedules at the maximum temperature specified in the Technical Schedules and at the specified basic span length plus the specified normal ground clearance.

The standard types of tower shall be designed so that, where required by the Employer's Representative, the towers may be extended by the heights stated in the Schedules. An extended tower shall be designated by the addition to its standard designation of the symbol + followed by the height of the extension in metres, and a reduced height tower by the symbol - followed by the reduction in metres. Variations in height from the standard height tower are to be achieved with the minimum change to the common portion of the tower. The range of body extensions shall be from -3m to +12m in steps of 3 meters.

Standard, extended and reduced towers shall be designed for and provided, where necessary, with independent single leg extensions from +1 metres to +4 metres in steps of 1 meter for use on sloping ground.

The tower outline and leg and body extension should be in accordance with the attached drawings and meet the requirements according to the drawing, this technical specification, datasheet and related standards. It should be noted that the drawings are only for tender purpose and contractor is responsible for checking them and reporting any problems/ modification/ optimization for Employer's Representative approval.

Extensions and reductions shall be designed so that the towers and their foundations shall comply with all the specified requirements for the standard towers and foundations.

If, during the finalizing of the line route (or during tower spotting, construction phase etc.), it is learned that special towers are required for any reason a modified tower from the range being supplied under the contract shall be used wherever possible. A specially designed tower may only be used where circumstances are such that a modified standard tower would be impracticable. **The Contractor shall inform the Employer's representative immediately the need for such a tower becomes apparent.** Special towers, special extensions and special parts for standard towers shall be provided where required and shall be of approved designs.

Modified or special towers might require type test or additional safety factors, this requires employer's representative approval.

The type of tower to be used at each position shall be approved by the Employer's representative.

4.3. Use of standard towers

The standard types of towers shall be designed for use as follows :

Where the transmission line route is a straight line, Type S towers with suspension insulator sets shall normally be used.

Where the transmission line route makes any deviation not exceeding 2° , Type S towers with suspension insulator sets shall normally be used.

Where the transmission line route makes a deviation exceeding 2° angle towers with tension insulators shall be used.

Where in a long straight run of transmission line route it is, in the opinion of the Employer's representative, desirable to arrange for sectioning and tensioning off of the line and earth conductors, Type S towers shall be provided at approved positions for this purpose. Section lengths shall not normally exceed **5.0 km**.

The towers shall be designed in such a manner that they will sustain the loads with one or two circuits erected.

The transmission lines shall be terminated on Type Trm towers with tension insulator sets. The maximum angle of entry of the line to the terminal tower is 45° . Type Trm towers shall be designed to withstand all specified loadings with and without downleads erected. The downleads shall be assumed to exit from the Type Trm towers at any angle up to but not exceeding $\pm 45^{\circ}$ from the tower line centre and at any vertical angle to the horizontal between 0° and 45° . The downlead conductors between the terminal tower and the transforming station gantry or anchor blocks shall be erected with substantially reduced tensions, and shall normally be supported at both ends on light duty tension insulator sets. Earth conductors shall be included in downlead spans. Gantry Load Calculation shall be provided for employer's representative approval.

Special transposition towers are to be provided when necessary in addition to any auxiliary steelwork and additional insulator strings if required.

4.4. Final sags and tensions

The line and earth conductors shall be erected so that the final tensions at the "everyday temperature" in still air shall be the figures stated in the Technical Schedules and shall be equal in all spans, excepting for sections with spans differing considerably from the basic span where compliance with the specified tensions under the assumed maximum loading conditions may necessitate a lower figure for the "everyday temperature" still air tension.

At "everyday temperature" in still air, in any span, the earth conductor sag shall be approximately 10 per cent less than the line conductor sag.

At an early stage of the contract, and prior to the commencement of tower design, the Contractor shall submit for approval the final sag and tension calculations which shall clearly

indicate the basis upon which the line conductor and earth conductor will be designed and the standard tower heights determined. The calculations shall consider the tension limitations specified in the Technical Schedules together with the mass of grease and spacers and spacer-dampers and the mass of Aircraft Warning Markers where appropriate. The requirements for differential sagging of the earth conductor as specified in this Clause shall be included.

The Contractor shall submit for approval curves showing the correct initial and final sags and tensions of the line and earth conductors at various temperatures and spans, the former making allowance for such permanent stretch as may take place in service i.e creep compensation.

4.5. Span lengths

The expression "span length" shall be taken to mean the horizontal distance between the centre lines of adjacent towers.

The design spans are specified in the Technical Schedules and their respective meanings are as follows :

Basic span shall mean the horizontal distance between the centres of adjacent supports on the ground level from which the height of standard supports is derived with the specified conductor clearances to ground in still air at the maximum specified conductor temperature.

Wind span shall mean half the sum of adjacent horizontal span lengths supported on any tower.

Weight span shall mean the equivalent span length of the conductor mass supported at any tower.

All standard towers, where used with corresponding specified maximum angles of deviation, and straight line towers where used at straight line positions, shall however be designed so that where the ground contours are favourable the sum of the two adjacent spans may not exceed the maximum sum of adjacent spans stated in the Technical Schedules. No single span shall normally exceed the maximum single span length stated in the Technical Schedules, except on special towers.

Where towers designed for straight-line positions are used at locations other than straight-line positions the sum of the two adjacent spans shall be reduced in an approved manner to compensate for the increased loading due to the conductor tensions.

Where the ground contours are favourable all standard towers, except straight-line towers, may, at the discretion of the Employer's representative, be used at straight-line positions or at relatively small angles of deviation, with the sum of spans exceeding 2.2 times the basic span length.

4.6. Conductor spacing and clearances

The spacing between individual conductors, phases and the clearance between the clamps, arcing horns, jumper loops or other live metal and the tower steelwork under all specified conditions shall be not less than the figures stated in the Technical Schedules.

The specified clearance between line conductors and support steelwork shall be obtained on the assumption that the conductor may leave the support point at the following angles to the horizontal measured in the plane containing the conductor (+ is below the horizontal):

Suspension towers 0° to 15°

Tension towers -10° to 20°

It shall be assumed for tower design purposes that, under wind loading, jumper loops will swing transversely. If required, each complete jumper shall be provided with not less than two jumper weights in order to limit the swing of the jumper to the angle stated in the Technical Schedules. Designs to determine the swing of the jumper loops and the required mass of any jumper weights, where necessary, shall be provided. The Contractor may provide alternative design proposals and calculations based on the use of unweighted or weighted pilot sets or post insulators to control the swing of jumper loops. Regardless of the solution chosen the costs of the method to provide the required electrical clearances between jumper loops (whether wind loaded or not) and tower metal shall be included in the cost for the tower structure.

The minimum clearance at 1000 meters above sea level between line conductors and ground or other objects shall be as specified in the following table. Clearances at higher altitudes shall be submitted by the contractor to the client for approval. These clearances shall be obtained under conditions corresponding to the final still air sag of the line conductors at their maximum operating temperature and with any angle of swing of the conductors from the vertical between zero and 45°, it being assumed (for simplicity) that the aforementioned sag is always applicable. The minimum clearances shall be as follows :

An additional clearance of 0.5 m required to allow survey and sagging errors and shall be considered in profile design.

Table 2: Minimum Clearances between Line Conductors and Ground or Other Objects

Item	Description	Minimum Clearance (m)		
				132 kV
1	Normal ground			6.7
2	Roads – road level -Highest vehicle 5m			6.7
3	Roads – road level (Highway) highest vehicle 6.1m			7.5
4	Power transmission & Telecommunications lines:			
	Lowest line conductor of upper line to highest conductor or earth wire of lower line			2.7
	Lowest line conductor of upper line to support of the lower line on which a person may stand			3.6
5	Railway:			
	Rail level			8.0

Item	Description	Minimum Clearance (m)		
				132 kV
	Electrified Railway crossings, building, gantries, or other structures on which a man can stay			3.6
6	Street lighting			2.3

Where obstructions of other types are met, the clearances shall be approved. It should be noted that, contractor is responsible for reporting crossing with any infrastructures (e.g. road, railway, telephone line, pipeline, power line and etc.), and maintain the vertical and horizontal distance from them and also assist the client in obtaining required approval for the crossing from related organisation. In addition, crossing angle should be 60-90 degree, in case that meeting 90 degree is not possible, the contractor shall report the situation to employer's representative and seek related organisation approval.

Attention shall be given to pipeline crossings. Measures shall be taken to avoid any damage to the pipeline due to a fault current flowing through the footing of the tower. Such measures shall be discussed and agreed with the Employer's representative and the owner of the pipeline. Towers to be located at least tower falling distance away from any pipeline.

4.7. Applied loads, normal loading conditions

The assumed maximum simultaneous loadings on the towers, based on the appropriate angles of deviations and span lengths and with the particulars given in the Technical Schedules shall be as follows :

4.7.1. Transverse loads

- i. **Wind perpendicular.** The normal transverse load shall be the wind pressure stated in the Technical Schedules acting at right angles to the line on the whole projected area of the line and earth conductors over the specified wind span stated in the Technical Schedules and the transverse horizontal resultant of the maximum line and earth conductor tensions, stated in the Technical Schedules, together with the wind pressure stated in the Technical Schedules on the projected area of the insulators and on the projected area of the members of one face of the towers. Suitable allowance shall be made for the projected area of crossarms, earthwire peaks, any fibre optic transmission system equipment mounted on the tower and Aircraft Warning Markers. The full wind span shall be taken regardless of the angle of line deviation. The transverse components of line and earth conductor tensions shall be computed for the full range of specified angles of deviation.
- ii. **Wind at 45°.** As i., but with wind acting at 45° to the line. For wind at 45° the length of conductor to be considered shall be taken as the projected length at right angles to the wind direction.
- iii. **Wind at 0°.** As i., but with wind acting at 0° to the line. This to be considered for minimum and maximum angles of deviation.

- iv. **Reversed wind.** As i., ii. and iii. but with wind acting in the opposite direction to the transverse and horizontal resultant of line and earth conductor tensions calculated on the minimum angle of line deviation and the conductor tension given in the Technical Schedules.

4.7.2. Vertical loads

- i. **Maximum (Normal).** For maximum (normal) load conditions the mass of the line and earth conductors, the mass of the insulators, insulator fittings, earth conductor fittings, spacers, dampers and ancillary apparatus where applicable. It shall be assumed that the maximum (normal) vertical loads shall include the actual mass contained in the weight spans specified in the Technical Schedules.
- ii. **Minimum.** For the minimum load condition, the mass of line and earth conductors shall be considered to be zero. The mass of the insulators shall be ignored.
- iii. **Uplift.** The uplift force acting on the towers shall be assumed to be equivalent to the mass of line and earth conductors contained in the uplift span specified in the Technical Schedules

4.7.3. Longitudinal loads

- i. **Normal (Maximum).** The longitudinal components of the line and earth conductor, 100% tensions at related weather cases (checked at all angles of entry) (terminal towers only).
- ii. **Section.** All tension towers shall be designed for the out-of-balance longitudinal components of loading. The magnitude of these loads shall be 30 per cent of the maximum actual line conductor and earth conductor tensions stated in the Technical Schedules.

All standard types of tower shall be designed for the loading conditions shown in the Appendices of this Technical Specification.

All towers shall be designed to accommodate Aircraft Warning Markers that may be located on the earth conductor in accordance with the requirements of Clause 4.14 of this Technical Specification. The Contractor shall give details of any reductions required to the lengths of spans where the Aircraft Warning Markers are used.

Care shall be taken in the design to allow for any additional loads to which the towers may be subjected during the erection of the towers themselves and of the conductors and insulators.

4.8. Applied loads, unbalanced loading conditions

All standard types of tower shall be designed for the unbalanced loading conditions shown in the Appendices of this Technical Specification and in the Technical Schedules. This applies to all loading cases referred to in Clause 4.7 of this Technical Specification. At the conductor

attachment points not affected by the unbalanced loads, all loads shall be the normal transverse, the maximum, minimum (or uplift) values for vertical loads and the longitudinal loads specified in Clause 4.7 of this Technical Specification. For terminal towers the longitudinal loads shall be the tensions specified in the Technical Schedules. The longitudinal unbalanced loads shall be assumed to act at right angles to the cross arm and the same direction when more than one attachment point is assumed to carry unbalanced loads.

4.9. Applied loads – construction and maintenance loading conditions

In addition to the loadings specified for normal and unbalanced conditions in Clause 4.7 and Clause 4.8 respectively of this Technical Specification, towers shall be designed to withstand all the construction and maintenance loading conditions recommended in EN 50341.

Still air conditions shall be assumed. Conductor tensions shall be calculated assuming the temperatures stated respectively in the Technical Schedules for initial construction conditions and for everyday maintenance conditions.

All tension towers shall be designed to withstand temporary terminal conditions under initial stringing and sagging conditions.

All applied loads shall be multiplied with the factors of safety stated in Technical Schedules.

As minimum, towers shall be designed to withstand the construction and maintenance loading conditions given in the Appendices of this Technical Specification and in the Technical Schedules.

The Contractor shall ensure all towers can safely withstand any other loading condition that may exist during construction operations with the minimum factor of safety as recommended by EN 50341.

4.10. Tower design

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

Each tower type shall also be so designed that no failure or permanent distortion shall occur in any part of the tower when tested with applied forces equivalent to construction and maintenance loads with the relevant factors of safety.

ASCE10-1997 "Design of Latticed Steel Transmission Structures" must be used as the design code substantiated by the data mentioned in those specifications.

Double circuit towers shall be designed for two circuits ; however, double circuit towers must be designed in a way that they could withstand stringing of one circuit at one side for long-term in all weather cases (to be used as one circuit tower).

For unbalanced loading conditions all members shall be designed for either span broken.

Unstressed members when employed to reduce the slenderness ratio of leg or bracing members shall be designed in an approved manner to provide the necessary support.

Tower members on which a man may stand (defined as being at an angle of less than 45° to the horizontal) shall be capable of withstanding an ultimate point load of 1.5 kN at any point on the member.

The arrangement and methods of carrying out the tests stated in the Technical Schedules on towers shall be approved.

The Contractor shall submit to the Employer's representative such drawings, stress analyses and calculations as he may require for the checking of the designs of all standard or special towers. These shall specifically include the design of all members, whether main or redundant, and the design of all plates, with particular attention to earth wire and conductor take-off arrangements.

Computations shall be presented in a clearly arranged format and worked out in detail to demonstrate clear evidence of each stage of the work. The use of PLS-Tower Software is desirable, using other softwares is subjected to the employer's representative approval. Computer input data shall be provided. Stability calculations shall be computed in accordance with the 1st order theory. Graphical calculation of forces will not be admissible. The applied formulae for computation of tower member stability shall be clearly stated to enable subsequent checking.

The software used shall be freely accessible to the Employer's representative and KETRACO for checking tower designs. A copy of the software shall be handed over to KETRACO on completion of the project.

Stubs shall be considered as part of the foundations. Therefore, the Safety Factors of foundation shall apply to stubs.

Finite element analysis to be considered in tower design and shall be checked in Tower model by the PLS-Tower.

Rupture check shall be considered and checked in the tower model.

4.11. Foundation reactions

Upon completion of the tower design the Contractor shall submit the foundation reactions applicable to that tower. The foundation reactions shall consider all the loads applied to the tower for the complete range of its utilization and include the effects of tower self-weight and the component of wind force applied at the top of concrete. The horizontal and vertical reactions shall be presented for each leg under each loading case considered for the tower design (including differential leg extension shear factors). A schedule shall be presented

summarizing the loading cases that are critical for each of the foundation classes, as appropriate.

For the calculation of foundation reactions, the factors of safety specified for foundations in the Technical Schedules shall be applied except that the maximum vertical uplift loads shall include the dead weight of the tower with a factor of one.

4.12. Anti-climbing devices, step bolts, anti-theft bolts, bird guards and bird diverters

Each tower shall be fitted with an anti-climbing device of an approved design fixed at a height of between 3.0 and 5.0 metres above ground. The anti-climbing device should be the best available construction to prevent unaided access up the tower, lockable gates shall be provided. No barbed wire is to be used on towers within national park boundaries. The position of the anti-climbing device on the tower should preferably be such that a standard device is used regardless of the tower body or leg extensions that may be employed. The suitability of such devices shall be checked by assembly on towers erected for test or assembled as part of the check erection process.

On each double circuit tower, two diagonally opposite legs, shall be provided with step bolts of approved type fixed at equal centres of between 300mm and 380 mm throughout the height of the tower starting immediately above the anti-climbing device and continuing to the earth conductor peak. Where, for structural reasons, it is not possible to maintain the equal centres it shall be acceptable to change the centres by not more than 30 mm. Below the anti-climbing devices, holes shall be provided for removable step bolts at the centres stated above. Sets of step bolts to fit these holes shall be provided where required by the Employer's representative, at the price stated in price schedule.

Step bolts shall be not less than 16 mm diameter and must be grade 5.6. Step bolts shall not be permitted in stressed connections. Maximum distance between the step bolts shall be 350 mm.

Anti-theft bolts shall be provided from ground level to 2m above the anti-climbing device.

Towers shall be equipped with approved devices immediately above each suspension insulator attachment point to prevent birds perching above the insulators. The devices shall be easily removed and replaced to facilitate maintenance work.

A bird warning system shall be provided to prevent bird collisions and electrocution. The system is bird diverters and/or bird flappers. Bird flight diverters shall be capable of being firmly clamped to Conductor/Earthwire/OPGW. The contractor is responsible for localizing the areas where bird flight diverters are needed.

Bird flight diverter (BFD) should have the following specifications, however the contractor shall ensure the efficiency of the proposed bird flight diverters and shall consider its effect on the line design:

- BFD must be dynamic type and shall consist of warning disc and associated clamps & connectors.

- BFD shall be suitable for efficient working and shall retain good physical characteristics under all weather conditions.
- BFD shall be designed for expected service life of at least 15 years.
- BFD shall be suitable for installation on live line.
- For visibility of BFD, warning disc shall be provided, which shall:
 - have glow in dark feature. Glow in dark shall remain activated for at least 12 hours after exposure to sun light. If Glow in dark stickers are used, the same shall be laminated and suitable for all weather conditions.
 - have contrasting coloured (combination of any two colours from Red, Yellow, Orange, White) retro-reflective surface with Sun and Moon light reflectors on both faces. Since, warning disc is to be designed to rotate, the colour change, while revolving, shall provide significant forewarning.
 - swing, sway and rotate easily.
 - be resistant to all weather conditions
 - be aerodynamically stable so that diverter faces minimum amount of drag force which provide swing and rotation effect under medium/strong wind speed.
 - be made of UV stabilized plastic. Bearing shall be made of stainless steel and should allow free spinning in minimum wind speed of 2 km/hour.
- The BFD size and weight shall be finalized as per manufacturer guideline and project specifications.
- The interval between diverters is 5–20 m, it shall be finalized based on the BFD size and manufacturer guideline.
- The warning disc shall be suitable for hanging on conductor/earth wire/OPGW, by means of clamp & hardware, with the following specifications:
 - The clamp for holding conductor/ earth wire / OPGW shall be made of UV stabilized engineered composite plastic (polymer) or metal and shall be suitable for live line installation by hot stick or drone.
 - All metal hardware used in Bird Flight Diverter including bearing must be made of corrosion free material.
 - All plastic (polymer) parts must be UV stabilized.
 - Clamp must be suitable for gripping the conductor/OPGW/ earth wire strongly, otherwise due to aeolian vibrations/high wind speed diverters may shift and move from its original position and get collected at mid span (lowest sagging point).
 - Parts of the clamp touching conductor must be able to withstand temperature range from -5 °C to +85 °C.

4.13. Notice plates

Conspicuous danger and tower number plates, circuit number and phase sequence plates of approved types, vitreous enamelled and resistant to fading under the climatic conditions at Site, shall be provided and fixed in approved positions on all towers.

Plate and lettering sizes should be finalized with the client. The back of the plates shall be coloured black.

The danger and tower number plate shall be fixed above the anti-climbing device.

The line code identification plate shall be attached centrally immediately below the danger plate.

Phase sequence plates of approved types coloured red, yellow and blue respectively to indicate the line conductor phases shall be provided for each circuit and fixed in approved positions on all towers.

Circuit number plates shall be coloured in accordance with KETRACO's standard requirements. The first plate is to be fixed just below the anti-climbing device, the second halfway up and the third just below the lowest cross arm.

Aerial tower number plates shall be provided and fixed in an approved position on the earth conductor peak of every tenth tower. The plates shall have yellow numbers on a black background.

Enamelled plates shall be provided with fibre washers, front and back, at the securing screws or bolts.

All inscriptions shall be in the Swahili and English language.

Flags are utilised during maintenance works to identify specific circuits. Flag fixing brackets are therefore to be fitted to each step bolt leg of the tower, one immediately above the anti-climbing device and one on the climbing leg adjacent to each cross arm.

25 wristlets shall be provided. A wristlet shall consist of a curved stainless steel disc 34 mm diameter and 2 mm thick fitted to a good quality 12 mm wide nylon strap, with buckle, suitable for all sizes of wrist diameter. The steel disc shall be colour coded for line identification finished in vitreous enamel.

4.14. Aircraft warning markers, obstruction lights and tower painting

In restricted areas and pipeline crossings Aircraft Warning Markers (AWM) shall be fitted to the earth conductors and Air Traffic Obstruction Lights (ATOL) on the towers in order to satisfy requirements of Authorities. Where required by KETRACO, ATOL shall also be installed on the highest phase line conductor(s) and the towers shall be painted as specified.

- a. **Aircraft Warning Markers.** Where required AWM shall be spherical of 600 mm diameter and manufactured in fibreglass. The spheres shall be coloured International Orange which shall not fade when subjected to the direct rays of the sun. They shall be manufactured in two halves and designed such that assembly and attachment to the earth conductor is simple.

Provision for drainage shall be provided. Suitable clamping devices shall be provided which will not damage the conductor but will prevent the sphere from twisting or slipping on the conductor. All metal parts used for holding the spheres in position shall be of mild steel and galvanized.

The warning spheres shall be fixed on the earth conductor in any required span and shall be erected, as required by Chapter 6 of Annex 14 to the ICAO Regulations, at intervals of not more than 30 metres on the overall earth conductor system. A proposal shall be made by the contractor where markers are to be applied

The first and last spheres in any span shall be approximately 10 metres from the towers defining the span.

With twin earth conductors, provided the spacing of the spheres on either earth conductor is suitably staggered to provide the above requirements, the placing of the spheres can be alternated between the two earth conductors at uniform spacing.

- b. **Air Traffic Obstruction Lights on Towers.** Where required ATOLs shall be installed on the towers defining the span, of International Standard red in colour, and having the following general features :
- i. conforming to Chapter 6 of Annex 14 to the ICAO Regulations
 - ii. two lamps per tower of which only one may be lit at a time (by utilizing a switch-over relay)
 - iii. having minimum luminous flux of approximately 10 candela, steady aviation red light
 - iv. having minimum lamp life time of approximately 20 000 hours
 - v. all components shall be corrosion-proof for use in marine and damp tropical climate conditions.

The system offered shall be comprehensive and complete in every respect. If a system fed by cables is proposed, it shall be designed to withstand the induced high voltage that can occur during earth fault conditions. It shall consist of a constant current regulator, high voltage cable, dimmer switch, protection equipment, insulating transformers, lightning arresters, etc. The connection and cabling to the nearest available safe mains supply shall be deemed to be included.

Should a solar powered system be proposed, the battery supplied shall be able to maintain the minimum luminous flux of 10 candela under the condition of dusty solar cells. A battery maintenance interval of 5 years minimum shall be guaranteed. Photovoltaic panel output shall be de-rated, over and above age de-rating, by 40%, on account of dust accumulation on the panel surface. The upper edges of the solar panels shall be fitted with stainless steel needle strips, effectively preventing birds from sitting in these locations.

It shall be noted that the supply of equipment shall include the necessary spare parts as per the manufacturer's recommendations, for a service period of five years, the cost of which is to be included in the price quoted.

The tower obstruction light system shall be to the approval of the Employer's representative.

- c. **Tower Painting.** Where required and to comply with requirements of Authorities certain towers need to be painted with three coats of approved epoxy resin type paint with red and white strips of widths complying with ICAO Regulations. The life span of the paint system shall be not less than 30 years and the colours shall not fade within this time under strong sun radiation.
- d. **Maximum height of towers in the tower spotting to be 40 metres only.**

4.15. Emergency Restoration System (ERS)

4.15.1. Scope of Specification

This specification describes the technical requirements for the design and supply of emergency restoration system (ERS). Each emergency restoration system will consist of all necessary parts, services, software, and all other equipment necessary to restore a damaged or destroyed permanent transmission tower in the event of an emergency.

Specifically, this work will document the requirements necessary for the column sections, the foundations, the articulating gimbal joint, the guy plates, the anchors, the guy wire, the guy wire accessories, the insulators, the conductor hardware, construction tools, spare parts, computer software, and field training.

4.15.2. Qualifying Requirements

The ERS manufacturer must have provided at least 3 sets of ERS anywhere in the world in strict conformance of IEEE 1070-2006, "IEEE Guide for the Design and Testing of Transmission Modular Restoration Structure Components", including earlier or later versions. Strict conformance of IEEE 1070-2006 includes testing requirements, material requirements, fabrication requirements, and all other geometric and dimensional requirements listed in the IEEE 1070 standard. The manufacturer shall submit with his proposal, a certified copy of the Design Test Report as required in Section 4 of IEEE Standard 1070-2006.

If the manufacturer has never produced, or is incapable of producing, their ERS structures in accordance with the IEEE 1070 standard, then they should explain their deficiency to the purchaser and explain why they are unwilling or unable to conform to common international requirements. The purchaser may decide, on a case by case basis, to accept a technical proposal from manufacturers who are unable to comply with this standard.

International standards that are not relevant to Emergency Restoration Systems are not suitable for substitution. For example, the IEC 60652 standard is pertinent to loading tests on overhead

line structures and while it may be specified in addition to IEEE 1070-2006, as it makes no mention of emergency restoration structures it will not be considered a standard for emergency restoration structures.

4.15.3. ERS Towers

The following restoration scenario should be utilized:

1. Single Circuit, three vertical phase, Tangent (0° - 15° Line Angle) Suspension Structures.
2. Single Circuit, three vertical phase, Angle (60° -line Angle / Dead End) Tension Structures

Towers to be used at 132 kV should also be suitable for use at lower voltages. The towers should have modular components which can be reconfigured into economical designs at different voltages.

All towers must withstand the loading conditions specified in Section 4.15.7 of this document.

All towers must maintain clearances and support spans in accordance with Section 4.15.7 of this document.

The towers should use a configuration which is suitable for a vertical disposition of conductors.

4.15.4. Structure Components – General

Each ERS will consist of modular components which can be used to construct a temporary transmission tower in a variety of different configurations. These components must be light-weight to allow for manual transportation if needed. Each major component of the ERS structure shall conform to all the dimensional and geometric requirements of IEEE Standard 1070-2006.

In order to simplify construction, the ERS structures shall minimize the number of guy wires used to support the structure. Guy wires will only be attached at the same level as the insulator attachment points and only one additional intermediate guy location between the lowest insulator attachment point and the foundation shall be allowed.

The primary material used in the construction of the ERS and the fabrication and welding of that material shall be in complete compliance with Section 3 of IEEE Standard 1070.

The ERS structural components shall meet the testing requirements of IEEE Standard 1070-2006. All ERS Components shall be identified and marked as required in Section 6.1 of IEEE Standard 1070-2006.

The ERS shall be suitable for a variety of internationally recognized standard fall arrest equipment. The tower shall be capable of attaching a lifeline fall arrest system. In addition, the tower shall accommodate the use of standard locking rebar snap hooks with shock absorbing lanyards and individual harness.

Only one size and diameter of threaded fastener as specified in IEEE Standard 1070, shall be used to assemble the ERS structural elements. Different sizes of fasteners may be used for associated items such as construction tools, conductor hardware, or connections between insulators.

Any ferrous materials used must be galvanized as per the latest revision of BS EN ISO 1461 or BS EN 10244-2 as applicable. Any threaded parts can be galvanized as per ASTM A-123 which is the applicable standard. All materials must be protected from corrosion and capable of outdoor or warehouse storage for a period of 20 years with no required maintenance.

4.15.4.1. Column Sections (Mast Components)

All components shall have the following characteristics:

- All Column sections shall be made in accordance with Figures 1A and 1B in IEEE Standard 1070.
- Each column section shall be routinely tested in accordance with Section 5.1 and 5.2 of IEEE Standard 1070.
- A minimum of 20% extra connecting bolts, nuts and lock washers shall be supplied with each column section.

4.15.4.2. Foundation Plates

The foundation plates shall be made in accordance with Figure 4 in IEEE Standard 1070.

4.15.4.3. Gimbal Joint

The gimbal shall be made in accordance with Figure 3 in IEEE Standard 1070.

4.15.4.4. Guy Plates

The Guy plates shall be made in accordance with Figure 2 in IEEE Standard 1070.

4.15.4.5. Box Sections

The Box Sections shall be made in accordance with Figure 5 in IEEE Standard 1070.

4.15.4.6. Insulators

Suspension insulators shall generally conform to all applicable electrical and mechanical tests as required by ANSI C29.11 and IEC 61109. Suspension insulators shall be capable of being linked together to form a two-part insulator or multi-part insulator. This allows modular construction for different voltages.

The individual post insulators shall have a minimum diameter of fiberglass reinforced resin rod of 3.5 inch (88 mm). Post insulators shall be capable of being linked together to form a two-part insulator or multi-part insulator. This allows modular construction for different voltages.

All suspension and post insulators shall be designed to be suitable for ACSR conductor and shall meet the requirements of section 3 Insulator and Fitting.

Five percent (5%) additional spare suspension insulators, and five percent (5%) additional post insulators and five percent (5%) additional of each size of grading shield shall be supplied.

Anchors

Each anchor shall terminate with a triple eye nut suitable for attachment of preformed type guy wire grips.

Each anchor shall have a minimum strength of 150 kN. The actual holding strength of the anchor may be less than this depending on the soil. The anchor itself should be able to withstand 150 kN of load.

Each anchor shall be hot dip galvanized as per the latest revision of BS EN ISO 1461 or BS EN 10244-2 as applicable.

Installation tools for anchors must also be provided as described in section 4.15.5.1.

A quantity of Manta-Ray anchors or similar anchors are to be provided. These anchors should be capable of being installed with a hydraulic jack hammer as specified in section 4.15.5.1. The anchors should be self-locking when set in place with a hydraulic pulling device, (i.e. a load locker). The minimum bearing area of these anchors shall be 450 cm². These anchors should be supplied with a 1 m extension rod and a 2 m extension rod. Extension rods with lengths of 3.5 ft and 7.0 ft are acceptable.

A quantity of cross-plate anchors shall be provided. These anchors should have a minimum bearing area of 2500 in². The cross-plate anchors should come included with a 3 m extension rod that ends in a triple eye attachment. Extension rods with a length of 10 ft are acceptable.

Triple Helix anchors should be provided. The triple helix anchor should have a 38 mm square shaft with a minimum helix thickness of 10 mm. An anchor with a 1.5 inch square shaft with a helix thickness of at least 3/8 inch is acceptable. The three helices should have minimum diameters of at least 343 mm (13.5 in), 292 mm (11.5 in), and 241 mm (9.5 in). The triple helix anchor will include a 1.5 m extension rod and a 3 m extension rod. Extension rods with lengths of 5 ft and 10 ft are acceptable.

Rock anchors shall be provided. The rock anchors must be suitable for installation in solid rock. These anchors should be supplied with a 1 m extension rod. Extension rods with a length of 3.5 ft are acceptable.

Anchors with an extremely large bearing area are not required. These types of anchors are not practical especially for swampy areas as this type of soil has no shear strength. Large concrete anchors are a better solution for this type of soil. Concrete anchors with weights of 10 to 20 ton may be used with the guyed structures as an effective anchor. Large concrete anchors are not included in this specification and will be provided by local suppliers if deemed necessary.

4.15.4.7. Guy Wire and Grips

The guy wire shall be 9/16"-19 strand EHS guy wire as specified by ASTM A475. All guy wire shall conform exactly to ASTM A475. The guy wire shall have a minimum breaking strength of 149kN. The guy wire shall have a 9/16" diameter. Guy wire shall have 19 strands for flexibility. Guy wire with 7 strands is not acceptable. All guy wire shall be supplied in spools of 2000 m or of 1000 m.

Preformed helical grips suitable for attachment with the above guy wire shall be provided. The strength of the preformed grip should be equal to the strength of the guy wire.

Guy wire thimbles shall be provided for effective attachment of guy wires to anchors or guy plates. The guy wire thimbles should be appropriately sized for attachment with the guy wire specified in this document.

Anchor attachments ending in a thimble eye do not require an additional guy wire thimble.

Thirty percent (30%) additional spare guy wire and fifty percent (50%) additional compatible helical preformed grips and guy wire thimbles shall be supplied beyond the minimum required to build any of the ERS Structures specified in Section 4.15.1.

4.15.4.8. Conductor Hardware

Ultimate strength of each hardware component shall be suitable for triple ACSR conductor and shall meet the requirements of section 3. Insulator and Fitting.

All ferrous materials shall be galvanized in accordance with the latest revision of BS EN ISO 1461 or BS EN 10244-2 as applicable. All materials shall be free from burr, sharp edges, lumps and dross and shall be smooth so that any connecting parts may be assembled or disassembled easily. All threaded parts shall be galvanized after threading and excessive zinc shall be removed from threads. Drilling shall be made before galvanizing. All nuts and lock nuts shall be re-tapped after galvanizing and shall be capable of being turned on the bolt threads easily without using a wrench. All cotter pins shall be made of stainless steel in order to avoid oxidation.

A minimum number of different types of hardware shall be provided in order to minimize confusion during emergencies. All insulator/hardware assemblies shall be designed to attach to the structure in 1.45 m increments to correspond to the column section lengths supplied in order to minimize confusion during emergencies.

Only one size of shackle shall be supplied. These shackles shall be capable of fitting all hardware and guy wire anchoring assemblies and be supplied with a bolt, nut and cotter.

Bolted tension clamp shall be supplied to fit the range of conductors specified.

The conductor and overhead shield wire suspension and tension clamps shall be capable of allowing a minimum 150 line angle at the suspension clamp.

A quantity of suitable turnbuckles corresponding to at least one half the quantity of suspension insulators, shall be provided for take up of hardware assemblies. Minimum take up shall be 0.3 m.

Routine mechanical pull tests shall be applied to all hardware items in accordance with IEEE Standard C135.61-1997. All galvanized wire rope with swaged fittings shall be proof tested to one half (50%) their ultimate strength

Test reports shall be prepared in detail containing all the data, number of tested samples and other necessary information as required by IEEE Standard C135.61-1997.

A minimum of ten percent (10%) additional spare hardware shall be supplied beyond the minimum required to build any of the ERS Structures specified in Section 4.15.1.

4.15.4.9. Guy Strain Insulators

An additional quantity of fiberglass guy strain insulators, having a minimum length of 2.5 m, shall be provided to provide electrical clearance for guy wires. These guy strain insulators shall have a minimum strength of 149 kN. These guy strain insulators shall be provided with sufficient hardware for connecting them together when a greater length is required.

The quantity of guy strain insulators should be sufficient to build the structures specified.

Suspension insulators may be used instead of guy strain insulators.

4.15.5. Tools

A quantity of all necessary construction hydraulic tools and hand tools shall be provided for assembly and erection of a complete emergency restoration structure.

4.15.5.1. Anchor Installation Tools

Anchor installation kits shall be supplied. Each anchor installation kit shall have:

- An 18 HP gasoline hydraulic power unit, capable of delivering 5-8 gpm (20-35 lpm) at a maximum pressure of 2000 PSI (13790 kPa).
- A compatible hydraulic driving hammer (i.e. 90 pound class and above for 8 inch. 200 mm, concrete applications) for installing the anchors in soil,
- A compatible hydraulic rotary hammer for drilling holes in rocks for installing rock anchors
- A compatible hydraulic proof testing unit for locking and proof testing soil anchors and proof testing rock anchors,
- All necessary and compatible hydraulic hoses, rock drill bits (5 per rotary hammer), and torque installation tools for the rock anchors. Hydraulic hoses shall have quick disconnect type couplers.

4.15.5.2. Construction Tools

Each set of construction tools shall consist of the following:

- One (1) gin poles made from aluminum alloy will be provided. The gin pole shall be supported on one corner of a column section and allow lifting of up to 200 kg to the top of the structure. The gin pole shall be suitable for simultaneous lifting a column section and a post insulator support section. All necessary snatch blocks and rigging ropes will be supplied with the gin pole. All ropes shall be polyester with a minimum diameter of 15 mm. The gin pole shall have a davit arm to keep loads clear of the structure while being raised by a capstan hydraulic power unit, and low friction bushings for rotation of the load. A slider shall clamp to the corner members of the emergency restoration structure and allow the gin pole to be raised on the structure using manpower or a pulley and the capstan winch.
- A ½ ton hydraulic capstan winch with foot pedals shall be provided with each gin pole for controlling the speed of the capstan. This capstan shall be capable of being powered by the same hydraulic power unit used to install the soil anchors (section 4.15.5.1). The capstan shall be mounted to a plate that can be anchored to the ground.
- A quantity of eight (8), high-quality 2-ton Tractel Tirfor-style grip hoists will be provided with 45 m of 7/16" (11.5 mm) wire rope. Forged safety hooks shall be provided on both ends for the grip hoist body and for the 7/16" wire rope.
- A quantity of twelve (12), reversible ratchet for hand installation of ERS bolts. The reversible ratchet shall be made of forged material and provided with a ½" square drive and socket to fit the ERS bolts used to join the tower sections. A quantity of twelve (12) forged closed box wrenches will also be provided as an assembly tool.
- A quantity of six (6), three (3) ton reversible chain hoists will be provided for tensioning of guy wires and conductor. Forged safety hooks shall be provided on the reversible chain hoist. The hook throat openings shall be a minimum of 35 mm and sufficient chain shall be provided to have a standard lift of 3m.
- A quantity of nine (9), pulling eyes that attach to the anchor rods and allow placement of safety hooks for either the 3 ton chain hoist or the 2 ton grip hoist shall be provided.
- A quantity of nine (9), automatic wire grips suitable for gripping the 9/16 x 19 strand guy wires shall be provided. They shall have a minimum safe working load of 65 kN. The grips shall be made of forged steel and have a bail suitable for attachment of the 3 ton chain hoist safety hook.
- A quantity of one (1) 3 m, 16 mm diameter double loop 6x37 steel wire rope slings shall be provided. These slings shall have a loop eye swaged at both ends and have an ultimate strength of 100 kN. A quantity of one (1) 3 m, 75 mm wide, two ply nylon slings shall be provide for lifting purposes. The slings shall have a twisted eye at both ends and have a rated capacity of 40 kN when loaded vertically. A quantity of eight (8) 1.8 m long, round endless slings, with a rated capacity of 24 kN when loaded vertically, shall be provided for temporary guying of this structure.
- One (1) self-contained 6 ton hydraulic wire cutter shall be provided. This self-contained hydraulic cutter shall be capable of not only cutting the 9/16 x 19 strand guy wire but also the ACSR conductor and the overhead static wire.
- For each foundation, four (4) foundation stakes of 25 mm diameter and 1.2 meters in length shall be provided for staking the foundations to the ground. The stakes shall have a pulling eye at the top for retracting the stakes after use.
- A quantity of six (6), aluminum conductor lifting hooks shall be provided. These lifting hooks shall be made from high strength aluminum alloy and shall a minimum ultimate strength of 45 kN.
- A quantity of 20 foot ocean cargo storage containers shall be provided. These containers shall be outfitted for holding all of the hardware, insulators, guy plates, guy and anchor accessories, tools (including the gin pole) and nuts and bolts. The insulators shall be

held in individual racks or PVC tubes in order to protect them. All hardware and nuts and bolts shall be stored in ferrous containers. There shall be easy access to the containers and easy access to the parts in the containers. The 20 foot ocean cargo storage container shall be lockable to prevent loss. All ERS components shall be stored in these 20 foot containers.

Field Training

The Supplier shall be required to impart training to utility field and engineering personnel at a mutually agreed upon site for a minimum period of five (5) working days. The training shall include actual field training imparting firsthand knowledge about the assembly of modular structures, fixing of foundation plates, erecting of structures on the foundation, guying the tower with anchoring arrangement and stringing of conductor. Specific instructions shall be given for installation of ERS using cranes, gin pole and hydraulic hoisting equipment. The training shall also include classroom lectures, including training in computer analysis programs described in section 4.15.6 in order to assist the purchaser's personnel in determining the capabilities of the structures. The class room training may also include explanation/demonstration of actual scenario. Special stress shall be given so as to ensure that the trained personnel acquire proficiency in restoring of failed structures so that they can take up this work independently.

Any additional construction equipment not supplied in the ERS proposal (e.g. cranes, helicopters, etc.) or material (e.g. conductor) and all construction personnel (except for the field trainer) shall be supplied by the purchaser.

4.15.6. Computer Software

Computer software capable of being run on personal computers using Microsoft Windows shall be provided.

The computer program shall be able to be copied as many times as deemed necessary by the purchaser for multiple users employed by the purchaser without incurring additional or recurring licensing fees or requiring a special hardware (e.g., USB) key.

The program calculations shall show if loads are acceptable with the various structure components used, and they shall also show the foundation and anchoring forces. Applicable computer calculations shall take into account the flexibility of structures and possible displacement of anchoring or foundations.

The same computer programs shall also calculate and show construction loads. The program shall calculate the total weight of the structure and provide lifting loads for the tilt up gin pole method of erection, crane erection, and helicopter erection.

The computer program should be specially developed in order to analyze emergency restoration structures. The computer program should not require any additional software in order to run or analyze emergency restoration structures. The supplier shall guarantee that the computer software will provide accurate and true predictions of the structure capability and component (i.e. insulator and anchor) loading.

The computer programs and calculations shall use the following typical input data:

- Emergency restoration structure geometry.

- Conductor specifications.
- Overhead shield wire specifications.
- Wind loading on conductor and structure.
- Overload safety factors.
- Guy slopes.
- Wind and weight spans.

The computer program and calculations shall have the following typical output data:

- Allowable conductor height and span.
- Insulator loads.
- Guy and anchor loads.
- Right-of-Way requirements.
- Graphic representations of the structures to be built.

The computer software shall allow easy analysis of ERS. The programs shall be accompanied by a detailed instruction manual that explains the theory used and gives examples for each type of structure. The programs shall come ready to analyzing the following types of structures:

- Angle or Suspension Chainette
- Angle or Suspension Four Pole
- Single or Double Circuit Herringbone
- Angle or Suspension Horizontal Vee
- Delta Horizontal Vee
- Running Angle
- Single phase Tension
- Three phase Tension

The computer program should be easy to learn. A qualified engineer should be capable of learning to use this software within one day. Any software program that requires a week or more of training is strictly disallowed as this creates an additional burden at a time of emergency. Software programs must be user friendly.

The program must give clear and failsafe outputs. If a tower is not sufficient to meet the necessary loading conditions, then the program should immediately display a failure message or it should neglect to provide a printout. A computer program that analyzes a failing tower design and still outputs a printout of the tower is strictly disallowed. For emergency use there is no time to analyze outputs and therefore all outputs should be limited to only passing results.

4.15.7. Loading Conditions

The following loading and assumptions shall be incorporated into the design and analysis of the ERS structures specified in Section 4.15.1. Computer printouts showing the results of each analysis shall be supplied, clearly showing the results. The quantity of anchors and guy wire shall be determined from the maximum required from this analysis and the required spare quantity requirements specified throughout this document.

4.15.7.1. CONDUCTOR AND OVERHEAD SHIELD WIRE DATA

The phase conductors to be applied are ACSR, and its data are specified in section 1 and technical datesheets.

The shield wire to be applied on ERS is OPGW (48 cores). OPGW data could be find in section 2 and technical datesheets.

4.15.7.2. HIGH WIND LOADING DATA

The following values shall be used in the design of the ERS:

Vertical overload safety factor (conductor):	2
Wind overload safety factor (structure and conductor):	2
Tension overload safety factor (conductor):	2

Wind speed is specified in technical datesheets.

NOTE: The horizontal forces caused by wind on the emergency restoration structure shall be calculated by the following equation:

$$F = C\rho A$$

in which:

F: horizontal force caused by wind

ρ : wind pressure

A: projected area of one face of the structure or conductor

C: drag coefficient = 1.0 for conductor only

C: drag coefficient based on structure solidity ratio and selected from the table below:

Solidity Ratio	Drag Coefficient
0.1	3.4
0.2	2.9
0.3	2.5
0.4	2.2
0.5	2.0

Source: IEC 60826

4.15.7.3. OTHER LOADING DATA

All loading calculations shall be carried out by the Supplier and shall meet the requirements of section 4.7.

Broken wire condition is not required for emergency towers.

Construction and maintenance loading conditions as well as all needed additional loadings such as minimum temperature, etc. shall be considered by the Supplier.

Calculation shall be done for minimum and maximum angle of deviation.

4.15.7.4. REQUIRED SPANS FOR ERS

The design of ERS towers must be suitable for the spans specified in technical datesheets.

4.15.7.5. REQUIRED ELECTRICAL CLEARANCES.

The ERS towers must be designed to meet the required clearances stated in section 4.6 as well as tower outline (Section VII. Part D. Drawings), and any other clearances deemed necessary according to the supplier design.

5. FOUNDATION DESIGN

5.1. General

All standard and special foundations shall be designed to resist the reactions resulting from any height of tower and its extensions. The stresses in the various parts of all foundation structures shall not exceed the figure stated in the Technical Schedules.

Concrete shall be reinforced and shall be designed, detailed and constructed, using design mixes to BS 5328 (BS EN 206-1 AND BS 8500), in accordance with BS 8110 or other equivalent approved standard.

The connection between tower and foundation shall, for self-supporting towers, be by means of stub angles with bolted-on cleats designed to transfer the leg loads, as required in the Technical Schedules, into the main concrete block comprising the foundation. The stub for each tower type shall be standard for all heights of tower and, where practical, foundation class. The stub shall be fully encased inside the pad or extend to the bottom of the foundation.

The stub is considered as part of the foundation, therefore the safety factor of the foundation shall apply to the stub and cleats calculation

All steelwork below ground except reinforcement bars, whether part of the tower or part of the foundation shall be galvanized and be completely covered with encasing concrete not less than 75 mm thick from a point 300 mm above ground down to the main foundation block, or, for rock foundations, down to the rock. Where necessary, the encasing concrete shall be keyed to the steelwork or to the main foundation in an approved manner. Cover over the reinforcement bars shall not be less than 50 mm, and in contact of soil & concrete shall be at least 75 mm.

Where the Contractor wishes to use rock or ground anchor array foundations, he shall provide evidence of his previous successful use of anchors in rock and in ground (if such anchors are proposed) for overhead line foundations and of their satisfactory service life. He shall provide a Method Statement defining procedures to be used for design and installation of the anchors, including specific details about quality controls and the actual equipment which will be used for drilling and grouting. The Contractor will be expected to carry out sufficient testing of his proposals, in the presence of the Employer's representative, to confirm that his methods for design and installation will produce anchor foundations that are fit for purpose, prior to approval by the Employer's representative of the system.

Design and/or proof testing to IEC 61773 shall be carried out for all anchor foundations ; a suitable proposal and work programme shall be submitted by the Contractor for the Employer's representative's approval together with the initial submission to use anchor foundations.

The type of foundation to be used at each tower position shall be to approval of the Employer's representative and shall normally be decided on the most economical solution.

Special foundations and their extensions shall be provided where required and shall be of approved designs.

Single footings of each standard class of tower foundation designed in accordance with the particulars given in the Technical Schedules (Appendix E) and any special foundations when instructed by the Employer's representative shall be tested in accordance with the requirements of the Tests section of this Technical Specification.

5.2. Foundation types

The foundations for the towers shall be of the following types and shall be designed in accordance with the particulars given in the Technical Schedules.

Self-supporting suspension and tension towers :

- Concrete pyramid (or pad) and chimney foundation
- Rock anchor array foundation
- Special foundation. (Pile array foundation, rock foundation, extended pad or pyramid foundation, ground anchor foundation, raft foundation).

Foundations shall conform to the following general requirements :

- a. **Concrete pyramid (or pad) and chimney foundation.** The concrete shall be reinforced. All steelwork below ground level (except concrete reinforcement) shall be completely galvanized and firmly keyed and grouted and designed to withstand the load due to the specified conditions in accordance with the particulars given in the Technical Schedules. The stubs shall be directly buried in concrete and loads in the stubs shall be transferred to the main concrete block by means of bolted-on cleats, which shall comply with the requirements of the Technical Schedules.

In no case shall the allowable bearing capacity of the ground be exceeded and any eccentricities created by biaxial loading shall fall within the middle third of the base on both axes. In no case shall the area of the base in uplift due to the effect of the eccentricities be greater than 25 per cent of the total area of the base.

It should be noted that all concrete block foundations which are founded in rock strata shall be constructed such that the bottom pad of the foundation shall be cast directly against either a vertical wall of rock for a minimum height of 250 mm or against an undercut into the rock of at least 15° to the vertical and extending for a height of at least 250 mm. Formed concrete pyramid foundations shall not be used in rock.

In areas where black cotton soils are encountered, pad and chimney foundations shall be installed where soil parameters permit. Imported fill to the approval of the Employer's representative shall be used for backfilling.

- b. **Rock anchor array foundation.** These shall be offered in solid rock and in fractured rock which is encountered between the ground surface and the setting depth of the normal pad and chimney foundation. Anchors may be either passive or stressed ; special care must be taken to ensure protection of the tendons against corrosion. The anchor array shall be terminated in a reinforced concrete cap set a minimum depth of 300mm into the rock. The cap shall provide the resistance to compression and shear loads, with the anchors being used to resist uplift. A concrete chimney shall be provided around the stub from the top of

the cap to the required height above ground level. The anchorage hole shall be minimum 100mm diameter to ensure required reinforcement cover can be achieved and maintained. The contractor shall provide all necessary rock parameters (RQD and UCS) to prove the rock strata encountered.

- c. **Special foundation.** In addition to the standard foundations, where the investigation of subsoils according to the Specification has indicated ground of very low bearing capacity and/or high water table in granular soils or other special circumstances, special foundations are to be provided. A special foundation will normally be one that has been specifically designed for a site, and shall be tailored to fit the geotechnical conditions for the site. These foundations shall be designed in accordance with established principles of soil mechanics and shall be of one of the following types – either concrete pad and chimney with enlarged pad, concrete raft or deep reinforced concrete piles (bored or driven) with reinforced concrete cap.

In addition, special foundations may include the use of ground anchor array foundations, which in certain circumstances could be designed to cover a specific and agreed range of ground conditions, as well as extended pad or pyramid and chimney foundations, which may be used for a predefined range of ground conditions.

- i. Extended pad foundations can be used to extend the range of soil parameters for which the original standard foundation was designed. The extended reinforced concrete pad shall be cast under and tied into the standard foundation. This foundation type is used frequently for ground conditions where water is encountered in reasonably compact frictional soils.
- ii. Raft foundations are infrequently used, they are an expensive alternative, but they are sometimes employed in areas which have been subject to mineral working and which perhaps have been backfilled. The large pad, encircling all four legs, shall be designed to maintain the relative position of the legs.
- iii. Pile foundations shall comprise multiple reinforced concrete piles bored or driven to a depth determined by the Site soil investigation.
- iv. Bearing for pile foundations shall be composed of pile end bearing or shear resistance of the soils developed over the effective surface area of the piles depending on whether the pile is end-bearing or designed in friction. The under-surface of the pile cap shall be considered as not contributing to the bearing surface of the foundation.
- v. Ground anchor array foundations may also be offered as an alternative in compact dry frictional ground conditions. The general design requirements shall be as for the rock anchor array foundations, but design parameters shall be proposed by the Contractor based on his investigations and experiments.

All types of foundations shall be designed to withstand uplift, settlement, overturning and sliding when subjected to the specified conditions of tower loading. Allowance shall be made in foundation design for hydrostatic pressure where this may occur and the effects of seasonal rains, drying out, cyclic loading and wind induced vibration of tower members. All foundations shall make adequate provisions to resist horizontal shear forces in the region of the ground line, making due allowance for the effects of hillside leg extensions.

All standard foundations shall accommodate a range of chimney extensions which shall be designed to cater for ground level differences between the available heights of tower hillside leg extensions, when these are employed in sloping terrain. The cost of these concrete chimney extensions are deemed to be included in the cost of the standard foundation.

For all tower types the design of the footings for the compression legs shall not differ from those for the tension legs.

As far as practicable, for any one standard tower type, the foundation stub joint and also the dimensions of each standard foundation shall be identical for standard towers, for extended towers and for leg extensions and shall comply with the requirements of the Specification on construction.

The soil investigation and foundation class selection carried out by the Contractor during survey shall be expected to provide sufficient data to permit the Contractor to design and install each foundation satisfactorily. In the rare case where further confirmatory investigations may be required to enable the type and size of a special foundation to be determined, the Employer's representative may require a 'specialist' soil investigation to be undertaken and a report and recommendation submitted. The report shall, as a minimum, include the results of in situ penetrometer or vane tests as well as providing values for soil cohesion and/or friction values obtained by means of quick, undrained triaxial compression tests to BS 1377 from undisturbed bore hole samples, together with other complementary laboratory test results.

Subject to the approval of the Employer's representative, where other towers adjacent to the bore hole are deemed to require special foundations, additional in situ tests shall be undertaken to extend and correlate the soils test data. These tests shall include, but not necessarily be confined to, use of the standard penetrometer, the shear vane, the pen vane or the Dutch Cone (static penetration test) and bearing plate tests.

As an addition to the main quotation which shall be completed in full and shall be based on the foundation types specified, alternative types of foundation differing from those specified may be considered subject to the approval by the Employer's representative of design principles, parameters, and all relevant factors affecting the performance of the proposed foundations over the service life of the transmission line.

The designs for foundations for special towers shall consider the actual maximum loadings to which the particular tower under consideration will be subject in service due to its position on the transmission line profile. The specified unbalanced loadings and the assumptions of temperature and wind pressure shall otherwise apply together with the specified factor of safety.

Foundation designs for special towers shall conform to the conditions stated for foundations for standard towers and shall be developed following a comprehensive evaluation of the soil conditions prevailing at the tower site(s) under consideration.

The Contractor shall submit to the Employer's representative such drawings, stress diagrams and calculations as he may require for checking the design of any foundation.

A protective coating shall be applied to the surface interfaces of the foundation and tower legs to provide protection from the adverse effects of aggressive salt, soil and air. The coating shall be of silicone or epoxy formulation, shall not be less than 200 microns thick, and shall be

applied on whole surface of foundation concrete, from base level of foundation up to stub connection level. The type of coating shall be to approval of the Employer's representative.

6. STEELWORK DETAILING AND MANUFACTURE

6.1. Detailing and fabrication

The lattice transmission towers are 4-legged self-supporting tower with hot rolled galvanized steel angle and gusset plate members that assembled together with bolt, nut, plain and spring washers.

The material used for main leg angles and stubs shall not be less than 6 mm thick and the material used for all other tower steelwork shall have a minimum thickness of 4 mm.

Welding shall not be used in the fabrication of any component used to form the tower structure.

Stub steelwork used to connect the tower to the foundation shall be at least the same section and steel thickness used for the lower tower leg which is attached to the stub.

The stub is considered as part of the foundation, therefore the safety factor of the foundation shall apply to the stub and cleats calculation

Horizontal members shall be detailed wherever possible, in such a way, as to place the horizontal flange on top.

No bolt hole shall, before galvanizing, be more than 1.5 mm larger than the corresponding bolt diameter. As far as possible, bolt heads, rather than nuts, shall be on the outer or upper faces of tower joints.

The distance between the centre line of any hole and the member end shall be in excess of 1.5 times the hole diameter. The distance between the centre line of any hole and the edge of the member shall be in excess of 1.25 times the hole diameter. Hole to hole distance shall not be less than 2.5 times the bolt diameter.

The design shall be such as to keep the number of different parts as small as possible and to facilitate transport, erection and inspection. Pockets and depressions likely to hold water, if not avoidable, shall be properly drained.

The holes necessary for accommodating the specified earthing counterpoise connections shall be provided on each leg of every tower and extension and the earth wire peak.

Suspension insulator sets and earth conductor suspension assemblies shall be attached to the tower such that the point of transverse rotation is on a full bearing surface.

All attachments shall be of 'hinge' type. U Bolt/shackle attachment type shall not be allowed

Provision shall be made on all tower types for the attachment of stringing and maintenance equipment to the cross-arms.

Approved means shall be provided on all towers and extensions to avoid risk of livestock being caught and injured in the angles between tower members.

Towers shall be equipped with approved devices immediately above each suspension insulator attachment point to prevent birds perching above the insulators.

6.2. Material

All hot rolled steel sections, plates and bolt and nut bars used shall consist of steel manufactured by an approved process and shall be to the requirements of BS EN 10025 for grades S275JR and S355J0 steel or equivalent from other approved standards. The steel shall be free from blisters, scales, laminations or other defects. Steel sections shall preferably be ISO Standard sections chosen with a view to avoiding delays in obtaining material.

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

6.3. Bolts and nuts

All metal parts shall be secured by means of bolts and nuts, plain and spring washers. The minimum diameter shall be 16 mm.

All bolts and nuts shall comply with BS 4190, BS EN 20898, ISO 898 1 and 2 or other approved standard and screw threads shall be to metric standards. Bolts and nuts shall be of steel, with hexagonal heads. Screw threads shall not form part of the shearing plane between members ; any thread in the bearing plane shall be to the approval of the Employer's representative. Bolts of any given diameter shall be of one grade of steel and marked for identification.

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

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

When in position all bolts or screwed rods shall project through the corresponding nuts, for a minimum of two full turns but such projection shall not exceed 10 mm. Suitable bolt grip tables shall be provided to demonstrate compliance with the above requirements.

All bolts shall be supplied with nuts, plain and spring washers.

6.4. Workmanship

All members shall be cut to jig and all holes shall be drilled or punched to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite to each other before being bolted up. Drifting of holes will not be allowed.

The drilling, punching, cutting 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 the towers on the Site.

All bends in high tensile steel shall be formed hot.

Built members shall, when finished, be true and free from all kinks, twists and open joints, and the material shall not be defective or strained in any way.

In order to check the workmanship, not less than 1 per cent of the members corresponding to each type of tower shall be selected at random and assembled to form complete towers in the presence of the Employer's representative at the Manufacturer's Works.

If the towers are fabricated or galvanized by Sub-contractors, the Contractor shall, if required by the Employer's representative, provide a resident inspector at the works of each Sub-Contractor during the time that the steelwork is being fabricated or galvanized.

6.5. Erection marks

Before leaving the Manufacturer's Works all tower members shall be hard stamped with distinguishing numbers and/or letters corresponding to distinguishing numbers and/or letters on approved drawings or material lists to be submitted by the Contractor. The erection marks shall be located on the member so that, after assembly and erection, all members can be individually identified.

The erection marks shall be stamped before galvanizing and shall be clearly legible after galvanizing. Care shall be taken to distinguish between various grades of steel.

The erection marks shall incorporate the standard tower nomenclature as given in this Technical Specification.

7. GALVANIZING

7.1. General

Except where specified to the contrary, all iron and steel used in the construction of the Contract Works shall be galvanized after all sawing, shearing, drilling, punching, filing, bending and machining are completed.

Galvanizing of all material, except core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with BS EN ISO 1461 and BS 7371 Part 6 and shall be applied by the hot dip process to provide thickness of zinc coating of not less than 610 gm of zinc per square metre of surface on steel bars, plates, sections and fittings. Threaded work shall have a coating weight of 305 gm of zinc per square metre.

Galvanizing of steel core wires of line conductor, earth conductor and counterpoise cable shall be in accordance with IEC 61089 and BS EN 10244-2 or other approved standard and shall be applied by either the hot dip or electrolytic process. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

All steel tower materials shall be treated with a sodium dichromate solution immediately after galvanizing.

The preparation for galvanizing and the galvanizing itself shall not adversely affect the mechanical properties of the coated material. Tests shall be carried out in accordance with requirements of this Technical Specification.

Sherardizing or other similar process shall not be used.

The Contractor shall keep available on site an instrument suitable to determine the thickness of galvanized coatings on steel members.

8. SURVEY AND SETTING OUT

8.1. General

The Contractor shall execute the works in accordance with the tower and material schedule and soil investigation results, provided that the works shall be subject to the modifications and variations due to the results of the survey.

8.2. Obtaining right of way

Subject to the requirements of landowners and their tenants, wayleaves corridor will be provided by KETRACO to enable the Contractor to carry out the erection of the lines. It is the Contractor's responsibility to provide access to the wayleave corridor. The contractor shall use the existing access tracks as referred to in Clause 8.4.

For the purpose of preparing his construction programme the Contractor may assume that by the date for access to Site for each section of the Contract Works KETRACO will provide the following facilities for access to Site :

- a. Over the whole length of the route, sufficient right of access as the Employer's representative agrees is essential for the Contractor's staff to carry out survey work and investigation of the general foundation conditions.
- b. Unless otherwise agreed, over not less than one-eighth of the route as specified above, in not more than seven continuous lengths there shall be :
 - i. such right of access for the Contractor's staff along the route as is necessary for the Contract Works;
 - ii. the right to transport material on to the route at intervals approved by the Employer's representative ;
 - iii. the right to make a reasonable width of track for a direct visual survey and for the transport of stores and material and the carrying out of erection operations along the route except where the route crosses buildings, orchards, gardens or any other ground over which the Employer's representative decides that such a track is not reasonably practicable.

The facilities in sub clause b. above shall be extended to the complete line as soon as available.

8.3. Access

Where the facilities obtained under Clause 11.2 of this Technical Specification have been provided, no other access shall be used without the consent of the Employer's representative.

All manhandling of materials to the site which is rendered necessary by restricted access rights must be agreed with the Employer's representative and paid for at the time and material rates

stated in the Appendices. The restricted access rights referred to in this Clause may arise as a result of specific wayleave restrictions, but not as a result of difficult ground conditions. The costs arising because of difficult ground and terrain conditions making normal vehicular access difficult or impossible will be borne by the Contractor.

The Contractor shall make all necessary arrangements (other than questions of wayleaves and access) with the occupant of the site, but if any difficulty shall arise the Contractor shall inform the Employer's representative thereof. The Employer's representative will thereupon take such steps as may be necessary.

If KETRACO is unable to provide the above mentioned facilities for access to the Site until after the date stated in the contract, the construction programme shall be modified by agreement with the Employer's representative.

The arrangements for the removal where necessary, and the actual removal of obstructions such as cultivated trees, pipes, field drains, village houses or huts, telephone, telegraph and power lines, preventing the erection of the permanent works will be made by KETRACO or, if the Employer's representative so requires, by the Contractor at the expense of KETRACO at the time and material rates stated in Section VII, except where such work shall be covered by the rates given in Section VII covering unit rates.

When the Contractor is about to commence work on any property he shall be responsible for ascertaining from the Employer's representative that the wayleaves are in order.

At least seven days before the commencement of construction works, the contractor shall provide KETRACO with lists of the towers which have been pegged and which tower sites are excavated and ready for inspection.

If the Contractor wishes to make a camp on any property he shall first obtain written permission to do so from the owner and occupier of such property. At all camps authorized persons shall be available to control the movements of labour, prevent trespass and to protect the interests of the owners and occupiers of the property.

In the event of any dispute or question of damage or of the adequacy of provisions made for permanent or temporary replacement or repair, the Contractor shall at once inform the Employer's representative.

When the Contractor is about to carry out erection of the conductors along or across public roads, telegraph or telephone lines, navigable water, or across power lines, he shall be responsible for giving adequate notice to the appropriate authorities of the date and time at which he proposed to perform the work. Where Local Authorities or other public undertakings affected deem it necessary for the protection of the public and the assistance of traffic to provide flagmen or watchmen or appropriate signalling apparatus, etc the cost of such provision shall be borne by the Contractor.

The Contractor shall, at his own expense, make good to the reasonable satisfaction of the Employer's representative, authorities, owners and tenants concerned, all land, property, roads, tracks, bridges, drains, fences, walls, hedges, gates and the like which are damaged or disturbed during the execution of the Works and shall remove all surplus construction material after erection. Temporary provisions shall be made by the Contractor to prevent straying of, or damage to, livestock during the execution of the Works and until the permanent reinstatement

of fences, walls, hedges, gates and the like is completed. The Contractor shall be held responsible for any damage to livestock due to failure to comply with the above requirements.

Individual trees, groups of trees, and other vegetation shall be thoroughly protected from damage incidental to construction operations by the erection of barriers or by such other approved means as the circumstances may require.

8.4. Access tracks

The Contractor shall provide at his own cost, all necessary local transport routes and access tracks and all labour, plant and materials necessary for unloading and erection, and shall be entirely responsible for their efficient and correct operation. KETRACO will, however, permit the Contractor to use any of its existing access tracks subject to these being restored to the satisfaction of the Employer's representative in respect of any damage which may be caused during the period of the Contract and the subsequent maintenance period. For this purpose the Contractor shall agree with the Employer's representative suitable records indicating the initial condition of each access track prior to its use.

Where the crossing of pipelines by vehicles and equipment is necessary, whether the pipes are above or below ground, the Contractor shall obtain permission to cross from the appropriate company or authority. The measures to be taken to protect the pipelines shall be agreed upon with them. Existing tracks shall be jointly inspected prior to their use and their condition recorded and agreed.

Provision shall be made to establish a vehicle access track along the length of the cleared strip to each tower site for purposes of construction.

All tracks constructed for access to the overhead line tower locations shall be clear 4.0m wide. The minimum work for the construction of access roads includes making, cleaning, obviating the obstacles of the way such as making access roads with width of 4 m and providing necessary facilities for transporting materials, equipment and machinery thorough fare as well as cutting trees and bundling them at the side of the way in any type of ground.

Access road shall be constructed in such a way as to be adequately drained to prevent washouts. Due attention is to be paid to potential erosion after construction of access roads. During the construction of access roads, the Contractor shall grade and slope the roads to prevent any unnecessary water flow across the road and to minimize soil erosion. Surface protection and erosion mitigation measures (drainage, stone pitching, gabions, etc.) have to be foreseen.

Safe percentage gradient of $\leq 20\%$ (Equivalent to 11 degrees of slope) shall be maintained for all possible locations for the safe movement of vehicles and machineries in hilly terrain.

If in some locations it is not possible to maintain the safe gradient of $\leq 20\%$, the 70% of the equipment manufacturer recommendation to drive on a slope shall be considered as the safe gradient of the access road. For example, If the manufacturer recommendation to drive on a slope is 25 degree, then the safe gradient will be 70% of the 25 degree i.e. 17.5 degree.

Junctions between new tracks and existing roads shall not impede or damage the latter or any associated drainage channels, etc. The junction must be cleaned and a proper danger sign board erected on the road side to warn the public.

Note:

- The client only acquires ROW for the line, so any cost / requirement for constructing access road outside the ROW is contractor's responsibility. The abovementioned specifications should be met to ensure safe transfer of material and equipment to site.
- The cost of access track(which is not included in the item 1.4 of the schedule 4 of the BOQ) is deemed to be included in overall project cost and no separate cost will be paid for this item.

8.5. Survey

The Contractor shall carry out his own final line survey based on the proposed line route under consideration of route modifications as requested by the Employer and on the Contractor's own route optimization proposals.

Final detail drawings of the defined line route shall be submitted to the Employer for approval. The drawings form the basis for obtaining the building permit by the Employer. The Contract Price shall include provision for additional detail drawings as may be required by the Building Authority.

For the new OHL sections within final precision survey and profile measurements, angle points may be shifted from the present preliminary route due to site constraints.

The line survey shall be performed by qualified and experienced surveyors. Not less than 15 days prior to the commencement of the work, the Contractor shall submit qualification records of the proposed personnel, the work program and a list of survey equipment for approval by the Employer / Employer's Representative.

The Contractor's line surveying personnel, through KETRACO's wayleave officer, shall in all cases, announce themselves to the occupier/ land-owner before entering any private property for the purpose of survey.

During the survey, the Contractor shall also check the eventual presence of existing water or gas pipe lines, electrical signal lines within the vicinity of the line or telecommunication antennas and to ensure that there will be no hazardous, induced voltages or any other interference. In the event of complications within the proposed line route corridor, the Contractor shall prepare a technical solution and submit it for approval by the Employer /Employer's Representative. Such services are deemed to be included in the Contract Price.

Profiles shall be produced as a result of a precision ground survey. The measuring techniques and instruments applied shall be state of the art and employ digital recording technique. The vertical tolerance between levels forming the profile and actual ground level shall not exceed 300 mm ; the horizontal distances shall have an accuracy of 1 in 2000 angular measurements of 1 minute.

KETRACO will provide LIDAR data (if available) to the Contractor to assist with route surveys and profiling.

Angle points are to be agreed with KETRACO and tied to Kenya National Local Grid (coordinates and elevations of points). The contractor will be required to assist KETRACO in the establishment of these angle points.

The LIDAR data shall be used by the contractor who shall undertake a check survey to confirm the accuracy and efficacy of the data provided. The check survey shall include the identification and labelling of all features including, but not limited to those listed below.

Should it be determined that the LIDAR data cannot be used for justifiable reasons then the contractor will be required to undertake the survey works by traditional methods. The survey shall include all necessary clearing of trees and vegetation and the setting out of the bearing for each section of line, the measuring and levelling and production of all necessary plans, profiles, route maps and tower schedules; the location of positions on the profiles in accordance with the Specification and all necessary setting out support for construction, all to the approval of the Employer's representative, at no extra cost. All surveying measurements, both linear and vertical, made on the line route shall be closed on standard reference points, or, where such points are not available the measurements shall be closed by alternative reciprocal measurements, the degree of closing error to be approved by the Employer's representative.

The levels along the surveyed centre lines shall be taken as follows :

- On flat ground, at intervals not longer than 20 m.
- At each depression, ditch or rise when the ditch is deeper than 400 mm or the rise is 200 mm high or higher.
- On sloping ground, at points where changes of slope occur and at intervening points not more than 30 m apart.
- On steeply sloping ground, at intervals of 20 m, if practicable.
- At each canal crossing to the water level at each side and determined maximum water level.
- At the centre point of each tower.

The Contractor shall survey all roads, railway lines, major canals, pipelines, power lines and telecommunication lines wherever they cross the route of the proposed line and shall indicate the following :

a. Roads and Railway Lines :

- Surface and class, eg first, second, paved, standard/metre gauge
- Names of adjacent towns,
- Angle of crossing,
- Chainage of centre and both sides of the road,
- Elevation of pavement and shoulders and ditches,

- If the road is curving additional data to define the curve of the road,
- The location of any mile post or sign board with their description, if located within 100 m of the crossing point.

b. Pipelines :

- Crossing chainage,
- Crossing angle,
- Number and size of pipes, if exposed,
- Trench width, if buried,
- Location of any identifiable mark on the pipeline route.

c. Power and telecommunication lines :

- Type of line,
- Voltage,
- Crossing angle,
- Crossing chainage,
- Distance to the nearest support on either side of crossing, and if one is within 50m of crossing, the support beyond it,
- The ground level and the level of the conductors at each of the support position above and the crossing point,
- A pole or a structure number and the line name.

If a road, a pipeline or a power line lies within 100 m of the survey centre line, chainage data and offset measurements shall be made to establish the proximity of the feature.

If a route is located along a street, full details of the street cross section at intervals of not more than 200 m and/or at places of varying street width shall be taken. Such details shall be agreed with KETRACO.

Where KETRACO or the consultant has commissioned a preliminary survey of the line route, either by aerial photography or by land based methods, the resulting data shall be made available to the Contractor. Tower sites determined by this survey shall be incorporated in the Contractor's survey and line profiles. It shall remain the responsibility of the Contractor to satisfy himself as to the accuracy and suitability of any preliminary profile so provided.

Where the line route has been established by KETRACO, the Contractor may expect that at the time of Award of Contract KETRACO will be in a position to indicate to the Contractor sufficient firm details of the location of terminal and angle positions for the Contractor to commence his survey with reasonable continuity of operation in the major sections of the lines.

After approval of the line route, the contractor shall clearly mark the points of angle points by concrete beacons with the round steel bar in the centre. The concrete mixture shall be 1:1:4, beacon minimum sizes 200 x 200 x 600 mm and the steel bar 10 mm diameter and 500 mm long.

Intermediate beacons, of the same design, shall be embedded at the intervals of approximately 1 km between angle points.

The Contractor shall be responsible for marking in an approved manner any special trees which, in his opinion, require to be felled or lopped in order to carry out a survey.

Where the route of the line is parallel to an existing line adequate falling clearance is to be provided between adjacent supports and conductors to the approval of the Employer's representative. The nominal spacing between the centres of the adjacent parallel transmission lines shall be as given on the bid drawings, in addition this requires employer's representative approval

8.6. Profiles Plans

The contractor shall use the LIDAR data for developing the line profiles and shall re-confirm the accuracy of the LIDAR data during the tower spotting process.

The Contractor shall prepare profile plans with tower locations plotted thereon. All drawings are subject for approval by the Employer/Employer's Representative. Tower spotting shall be based on the ground profile drawings prepared by him and design data specified.

The following principles and conditions have to be taken into consideration :

- where ground slope across the line route exceeds 1 in 25, the level of ground left and right of the center line shall be recorded up to a distances of ± 5 m at tower locations and ± 15 m in mid-span. These levels shall be indicated on the profile as broken and/ or chain lines and the distances stated. All features such as hedges, fences, graves, ditches, roads, railways, rivers, buildings, canals, telecommunication and all power lines shall be shown. Road numbers or name of roads shall be stated or, if unclassified, destination. For railways the destination are to be given, number of tracks, whether or not electrified and the level at the top of rail stated. The voltage level for power lines shall be indicated
- All buildings or high obstructions within 50 m from the center line shall be shown dotted at their measured height with the distance left or right of line indicated
- 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 50 m each side of the route center line
- Tower spotting shall be performed with PLS-CADD software. The related backup files have to be delivered to the Employer/Employer's representative.

- Checking shall be performed by conventional methods using sag templates or with the computer program, both to be provided by the Contractor; computer plotted profiles on plain plastic template sheets will be accepted
- Sag templates used shall be suitable for the respective climatic zone and for the ruling span of the section where the plotting is performed.
- Tower numbers, tower types, elevations, level differences, UTM (Universal Transverse Marcator) coordinates. Horizontal and vertical coordinates of all features affecting the line construction shall be indicated on the profile plan
- For all tower positions the specified maximum wind spans and the specified maximum and minimum weight spans shall be observed ; tower lists showing all parameters for each tower has to be provided by adequate tower spotting the lengths of successive spans in one section shall be as close as possible
- The tower spotting shall take into account the utilization chart of the various tower types, and shall use all tower extensions with satandard leg. The available legs shall be used for adaption of the base to sloped terrain only. In clearance check at max temperature, 50 cm margin shall be taken.
- at each suspension tower location the swinging angle of insulator set shall be verified in the specified condition of temperature and wind pressure, to guarantee the specified swinging angle are not exceeded. Counterweight are allowed, subject to approval of Employer/Employer's representative.
- tower spotting shall take into consideration the specified minimum ground clearances as well as the minimum distances of the conductors to obstacles to be crossed such as power transmission lines, main roads, houses, etc. as specified in the Data Sheets. The profile plans shall display the bottom conductor catenaries, at 80⁰C, together with the ground or special clearance curves, as well as the minimum temperature catenary; the Contractor has to provide a clearance calculation for all crossings of all classifications of roads, railways, rivers and all power and telecommunication lines in order to evidence that the required clearance is met under the worst conditions. Road crossings shall not be at an angle to the normal greater than 30°.
- fruit trees and crops shall not be removed at all during spotting and line clearance shall take consideration of their height during tower distribution
- special attention shall be observed near populated areas or close to the roads where the OHL is to be parallel with existing OHLs. The towers shall be placed as aligned as possible to the existing ones and their positions shall be subject to the Employer's / Employer's Representative's approval; in this respect, the location of the existing OHL towers shall be clearly marked on the drawings
- as a rule, number of suspension towers in a straight line section (between two successive tension towers) shall be limited by the section length which should not exceed 5km. However, sections longer than 5 km may be used based on the Employer/Employer's Representative approval.

Unless specified to the contrary the scale of the profile shall be:

1:2000 horizontally and

1:500 vertically.

The profile shall be plotted in such a way that the direction of the line on the profile sheets corresponds to the line route on the route maps. In general, individual profile sheets shall commence and finish at tension supports.

Each section shall normally be started on a new sheet. Where this is not practicable and continuation sheets are found to be necessary in long sections, the ground line is to be drawn so that there is an overlap of at least 300 mm between adjacent sheets.

The last tower of the preceding sheet shall be shown as the first tower on the following sheet. The date of survey of each section shall be added.

Note : Plan and profile and tower spotting shall be prepared by PLS-CADD software.

8.7. Line schedule

The Contractor has to submit the profile plans, route maps and tower lists to the Employer/Employer's Representative for approval including calculations to evidence that for all crossings the requirements are met. The detailed tower spotting shall indicate the tower locations exactly in order to identify the concerned landowners easily.

Additionally, a map showing all access roads necessary for the construction works (existing ones and ones to be constructed) has to be submitted together with the profile plans to the Employer/Employer's Representative for approval.

The negotiations with the landowners and authorities on the tower locations, the right of way and the compensation for land acquisition, for crops, temporary damages etc. are the responsibility of Employer.

The negotiations with the landowners and authorities on the access to the line for the construction works, the compensation for damaged crops and temporary damages on the access road are the responsibility of the Contractor.

During finalizing tower locations, cross/diagonal profile for each tower shall be prepared and leg extension must be determined and all shall be submitted for approval.

As soon as the final tower locations are agreed and approved by Employer's representative of KETRACO, the Contractor shall submit a line schedule. The line schedule shall indicate tower numbers, tower types, body and leg extensions, angles of deviation, insulator types, insulators string types, spans, equivalent spans, section lengths, accumulated spans, sags, foundation details, accumulated chainage and a "remarks" column in which details of crossings, etc. can be entered. At the completion of foundation works, the foundation types for each tower shall be added to the line schedule.

8.8. Sag templates

The Contractor shall provide three complete sets of sag templates on Perspex or similar material based on a maximum for each construction of three equivalent spans that encompass the range of spans encountered. The spans selected shall be to approval.

The templates shall show the line conductor sag in still air at the maximum temperature of line conductor specified in the Technical Schedules and the ground clearance line. An additional curve shall be marked on the template showing the conductor sag at minimum temperature in still air condition. Each template shall be clearly endorsed with the design loading conditions, type of conductor, basis of calculations, equivalent span and the scale appropriate to the scale of the relevant profile. The templates shall include a vertical scale showing the heights of the conductor attachment on the standard and extended towers.

The scales of the sag templates shall be 1:200 vertically and 1:2000 horizontally or other approved scales to match those used for the profile.

8.9. Route map

During the progress of the work, the Contractor shall record on profiles and on a set of map transparencies to 1:50 000 or other approved scale, such particulars as will allow an accurate reference to be made during construction and afterwards in case of any fault or projected modification to the line. The plans shall show the exact positions of every tower with approved reference marks so that, in conjunction with line schedules, the types of tower, foundations, insulators, counterpoise and the location of mid-span joints, repair sleeves, etc can be ascertained quickly. The data included on the plans and schedules shall be to the approval of the Employer's representative, to whom facilities shall be given for examining the plans during the progress of the work. The plans and not less than four copies of the schedules shall be the property of KETRACO but will be in the charge of the Contractor until the completion of the particular section of the work to which they refer.

Important note : Any pertaining information regarding airports or landing strips subject to Kenyan Civil Aviation requirements shall be shown on these maps.

8.10. Environmental Protection

An Environmental Impact Assessment Study (EIA) related to the project shall be prepared by contractor; unless it has been provided by KETRACO and specified in the contract. In any instance, the Contractor must prepare a Contractor's Environmental and Social Management Plan (C-ESMP) and its Management Strategies and Implementation Plans as necessary to manage the ES risks and impacts. These Management Strategies and Implementation Plans collectively comprise the Contractor's Environmental and Social Management Plan (C-ESMP). The Contractor is urged to observe the EIA study requirements but in addition, the Contractor will respect the general requirements stated in this chapter. Moreover, the Contractor shall inform the Employer/ Employer's Representative about all other environmental impacts caused by the construction works but not mentioned here or in the EIA Study, in order to decide about adequate protection measures.

The Contractor shall take all precautions to avoid damage to public property, crops, etc. and shall ensure that the work is adequately supervised so that damage is avoided.

Where the Contractor considers that damage cannot be avoided, if the work is to proceed normally, he shall notify the Employer/ Employer's Representative accordingly. If the Employer/ Employer's Representative confirms that such unavoidable damage will occur, the Employer will be responsible for compensation in respect of the damage and the Contractor shall proceed with the works within the limits indicated by the Employer. This does not apply to the access roads to the line route.

All surplus material shall be removed after erection and the site shall be left in a clean and tidy condition.

The following rules and procedures shall be adhered to by the Contractor with regard to protection of the environment:

- The contractor shall fully restore all temporary sites (e.g., borrow pits, worker camps, access roads) after use as per the ESMP.
- The Contractor pledged himself to treat the waste in accordance with the Kenyan Laws.
- The Contractor pledged himself to the treatment of all hazardous waste, generated by his activities on site in accordance with the current law of environmental regulations of the local Authorities.
- The Contractor pledged himself to deposit all dismantled equipment containing hazardous substances to the Employer's places, which are leak proof.
- In case, the hazardous substances leak into the surface water or ground water due to the Contractor's activities, he is responsible and undertakes improvement action. He will ensure on his own costs liquidation of the incurred damages.

8.10.1. Protection of vegetation

The Contractor shall limit the movement of his crews and equipment to the right-of-way and on approved access routes, so as to minimize damage to crops, orchards or property. No movement of machine and vehicles allowed outside approved access roads and construction platforms.

Fruit trees and crops shall not be removed at all. Route clearing shall be executed in accordance with the requirements specified in clause 11 below. No tree may be felled without the express prior permission of the Employer. Roots and other plants shall not be removed to prevent excessive surface erosion. Wood has to be transported to location as indicated by Employer. Burning on site is strictly prohibited.

Access roads shall be limited to as in clause 8.4. The finger roads are preferable instead of continuous access roads along the line. Access roads shall always run below the platforms for tower locations in order to reduce erosion impact.

Due to the calcareous formation in many parts of the line surface protection and erosion mitigation measures (drainage, small platforms, stone pitching, gabions etc.) are specified in clause 9.2: Site preparation and erosion protection.

Ruts and scars shall be obliterated ; damage to ditches, terraces, roads and other features of the land shall be corrected, and the land shall be restored to its original condition.

The Contractor shall be responsible to the occupants of the land which are crossed by the transmission line for any damage to personal property resulting from his fault or negligence, including damage caused by straying livestock, and he shall make prompt settlement of damages to personal property resulting from his negligence. The Contractor shall be responsible for notifying the Employer in writing of all instances of damage to crops plantation, livestock, etc.

Where the Contractor causes damage beyond the indicated limits within the wayleave or to a degree, which the Employer/ Employer's Representative considers excessive, the Contractor shall be responsible for reinstatement and/or compensation.

If, in such circumstances, the Contractor fails to pay compensation to the extent that in the Employer's/ Employer's Representative's opinion, the progress of the works is likely to suffer, the Employer shall negotiate and settle the matter and the cost shall be deducted from monies due to the Contractor.

The Contractor shall use all means necessary to control dust on roads, construction areas and borrow pits. Surfaces shall be regularly watered to prevent dust becoming a nuisance for the public and interfering with the proper execution of the works.

8.10.2. Protection of livestock

Adequate provision shall be made by the Contractor to prevent straying and injury to livestock during the execution of the works and until the permanent reinstatement of fences, walls, hedges, gates and similar is completed.

The Contractor shall not bring any dog on or near the site or suffer or permit any of his employees, representatives or agents or any Subcontractor to bring any dog on or near the site and shall cause the immediate removal of any dog which may be on or near the Site in breach of this provision.

The Contractor shall be liable for any injury to or loss of livestock due in the opinion of the Employer/ Employer's Representative to failure to comply with the above requirements. Means shall be provided on all lattice steel towers and tower extensions to avoid the risk of livestock being caught between tower members and being injured.

9. CIVIL WORKS

9.1. Soil investigation and foundation class selection

The Contractor shall be responsible at his own cost for ascertaining that the foundations to be employed are suitable for the sub-surface conditions encountered at each tower site. For this purpose he will be responsible for classifying these conditions at each tower site at an early stage of the Contract. Results of any geotechnical investigations already carried out for KETRACO will be provided as reference.

Once the overhead line route has been agreed and angle tower positions established the contractor shall undertake geotechnical investigations in sufficient detail to permit the Contractor to design and install each foundation satisfactorily at every tower location.

Geotechnical investigations shall be in accordance with BS 5930 and generally incorporate field assessments, ground investigations, sampling, and laboratory testing. Sufficient ground investigation data shall be made available to confirm foundation suitability and constructability.

The Contractor shall obtain information on ground properties of the various underground strata in which to provide sufficient soil, rock, and groundwater data for use in the uplift and compression design and checking of each foundation. In this respect all tower locations shall be investigated by borehole in soil (other methods for special soils such as rotary drilling and coring in rock, may be accepted if the Contractor proposes and the Client consents the method), to confirm or adjust the parameters for standard foundations given for bid purposes in the Schedules. The number and frequency of boreholes taken may vary along the route, will be determined by the variability or suitability of the soils encountered and will be subject to approval by the Employer's representative.

Firstly, all sites and every tower location shall be investigated by Dynamic Cone Penetration Testing (DCPT) or of the following methods (if the Contractor proposes and the Client consents) instead of DCPT:

- Static or Dutch Cone Penetration Testing (CPT)
- In-situ Plate Bearing Testing (PBT)

DCPT shall be carried out in accordance with ISO 22476. Soil and/or rock engineering descriptions shall be provided on a log at each probe site. Rock Quality Designation (RQD) shall also be provided where rock cores are taken.

In the following, all tower location shall be investigated by Standard Penetration Testing (SPT). The contractor shall carry out soil investigation by boreholes in all tower location; In-situ testing in boreholes shall be done by Standard Penetration Testing (SPT) - or Shear Vane Testing (SVT) if the Contractor proposes and the Client consents. SPT shall be carried out in accordance with ISO 22476.

Laboratory testing shall be carried out on retrieved soil samples in accordance with BS 1377 and shall include one or more of the following methods of testing :

- Triaxial shear strength testing (cohesive soils)
- Direct shear strength testing (granular soils)
- Soil density
- Particle Size Distribution (sieve analysis)
- Moisture content
- Atterberg limits (plasticity, liquidity, and expansion indices)
- Chemical analysis
- Chemical analysis of sub soil water

Laboratory testing shall be carried out on retrieved rock samples in accordance with ISRM procedures and shall include one or more of the following methods of testing :

- Unconfined Compressive Strength (UCS)
- Point Load Test (PLT)
- Rock density

Where foundation excavations are to be of the open-cut type, the properties of compacted backfill are also to be examined and tested and related to undisturbed soil properties in accordance with the schedule on foundation tests.

Ground investigation, in-situ testing, and sampling at each tower site will be by use of an approved type of penetrometer or borer. The Contractor shall be responsible for any subsidence or failure due, in the opinion of the Employer's representative, to insufficient care having been taken in his examination of ground conditions or in installation of the foundations.

The ground investigation carried out by the Contractor during survey shall be expected to provide sufficient data to permit the Contractor to design and install each foundation satisfactorily. Where towers are deemed to require special foundations but do not fall on a scheduled main investigation site, additional ground investigation should be undertaken, subject to the approval of the Employer's representative, to extend and correlate data.

In the rare case where additional investigations may be required to enable the type and size of a special foundation to be determined, the Employer's representative may instruct a 'specialist' ground investigation to be carried out with a report and recommendation submitted. Proposals shall initially be submitted for approval. The report shall, as minimum, include details of the field work undertaken, field logs, the results of in situ and laboratory testing, interpretation of the results, and recommendations for design and construction. Such 'specialist' ground investigations shall also be captured in the price schedules.

Additional probe tests, as well as any other tests the Contractor deems necessary, should be carried out in areas of variable ground condition where the Contractor may wish to propose selective movement of some foundation locations. Where soil probing indicates the possibility

of rock due to 'refusal' of the probe test, the Contractor shall confirm by carrying out further probe tests at an adjacent location or by drilling that rock, to confirm that an isolated boulder has not been encountered. Further tests subject to the approval of the Employer's representative may be required to determine the rock quality. Sites with additional tests approved by the Employer's representative will be paid at the rates stated in the Appendices

Subject to the approval of the Employer's representative, the parameters obtained from the bore holes and sub-surface probe tests shall be classified into typical groups and employed in the designs of all foundations. The results of all soil and rock tests shall be submitted to the Employer's representative, together with any proposals that the Contractor may consider necessary, to ascertain the parameters and dimensions for the standard foundations given in the Schedules or the need for special designs.

Prior to construction the Contractor shall submit for approval his proposals for correlating the results of the detailed ground investigations and the soil and rock tests undertaken at each site with the parameters employed for the foundation design. These proposals shall also consider visual and manual checks and tests to be made after excavation and will be to the Employer's representative's approval.

The Contractor shall prepare and update the Line Schedule for construction purposes that clearly indicates the class of foundation to be installed at each site and records the soil investigation data on which the choice has been made. The schedule will be subject to approval of the Employer's representative prior to commencement of foundation construction.

When required by the Employer's representative, the Contractor will be required to make arrangements for a special comprehensive ground investigation to be carried out at any specified tower site, including deep borings and laboratory analysis of undisturbed soil samples, and for a report and recommendation to be submitted. The Employer's representative may require that this work shall be carried out by an approved subcontractor at rates to be agreed.

On completion of all field work, the Contractor shall submit a comprehensive geotechnical/soil investigation report to the Client/ Client's Representative that is containing the equipment's technical data and method applied during the investigation for each location, related drawings, borehole specifications, field test results, photos, laboratory observations and test results both in tabular and graphical form, practical and theoretical considerations for the interpretation of the test results, supporting calculations for the conclusions draw, and all required engineering data (to use for tower foundation design and etc.).

The following information shall be considered in the comprehensive geotechnical report (but not limited to them):

1. General geological Information of the region, nearest county/city/neighborhood;
2. Name and the coordination of transmission line APs and other tower location;
3. Name and coordination of each location (tower) and coordination of related SPT/DCPT/.../boreholes (and trail pits) Which belongs to the same tower;
4. Equipment's technical data and method applied during the investigation for each location;

5. Boreholes (and trail pits) specification and logs information of locations, such as Depth of the boreholes (and trial pits) and other boreholes data, visual finding, date of investigation, weather condition, the ground water conditions and specially the ground water level and etc.;
6. Reporting all test results including but not limited to: Permeability and Consistency tests, SPT (standard penetration test), DCPT (dynamic cone penetration testing), Hydrometer test, Particle size analysis, Determination of Atterberg limits, Direct Shear Test, Earth resistivity test report, Thermal resistivity test report, Corrosion study report;
7. All required data including but not limited to: Important characteristics of the soil layers like Cohesion coefficient (C) , Angle of internal friction (ϕ) , Modulus of subgrade reactions (Ks) , Allowable bearing capacity (q_{all}) , Coefficient of lateral earth pressure , Allowable slope of excavation , Depth of the poor soil , and etc.;
8. Chemical analysis of soil samples for determining soil properties and recommendations for the concrete criteria considering the Sulphate and chloride content of the samples and prevailing exposure conditions;
9. Earthquake acceleration coefficient and Seismicity of the construction site;
10. Recommendations for the foundation type, Cement type and water-cement ratio, Soil Collapse potential, Soil Collapse potential and etc.;
11. Conclusions and Guidelines.

9.2. Site preparation and erosion protection

Prevention and control of soil erosion at sites is of prime importance for the stability of the tower location.

Leveling of tower locations shall be minimized in sloped terrain therefore. Leg and concrete extensions adapted to the terrain profile shall have priority instead of extended soil movement and excavation works.

In case of cutting a slope, the upper surface material of the ground shall be protected from sliding. This has to ensured by

- stone pitching
- gabions
- stone walls (erected without or with mortar)
- concrete walls,
- whatever seems to be applicable and required by the Employer/ Employer's Representative.

The bottom edge of the tower site in sloped terrain shall be also reinforced by stone or concrete wall in order to avoid uncontrolled water draining. Drainage ditches shall be provided where necessary and required by the Employer/ Employer's Representative.

The tower sites themselves shall also be sloped as necessary to protect against erosion due to water flow. If there is a natural flow of water across the site, the water flow shall be diverted around the site or the site shall be suitably protected against erosion by grading and/or placing of rip-rap or other erosion barriers, or construction of drainage.

Prior taking over of the transmission line, all tower location susceptible to erosion shall be inspected in presence of the Employer/ Employer's Representative to check the effectiveness of the applied erosion protection.

Indications of erosion have to be rectified by the Contractor and improvements of erosion protection provided as approved with the Employer/ Employer's Representative.

All measures against erosion protection executed in the beginning of works and/ or prior taking over are deemed to be included in the Contract price.

9.3. Route clearance

The Contractor shall clear a strip of land through those sections of the route that pass through vegetation. Clearance shall consist of felling or trimming trees and other vegetation to obtain a clearance of not less than 8 m from the nearest conductors. All limbs and branches required to be trimmed shall be neatly cut close to the trunk of the trees or to main branches, and cuts more than 40 mm in diameter shall be painted with an approved paint. In determining the clearance and in estimating the mean height of the vegetation due allowance shall be made for seasonal growth.

Trees, scrub and undergrowth shall be cleared by felling not more than 150 mm above ground. Tree stumps are to be burned to prevent regrowth. All timber and brush shall be removed to the outer limits of the cleared strip and care shall be taken to avoid unnecessary removal of topsoil when clearing the strip. Before any burning of timber or tree stumps the permission of the police authorities shall be obtained. The Contractor shall be responsible for compliance with all military and local laws and regulations relative to open fires.

The extent of the land clearance during the construction period shall be determined by the requirements for safe construction and the strip of land to be cleared shall be in a cleared condition at the agreed handing over date for the whole transmission line.

Clearing operations shall be undertaken in such a way as to prevent damage to existing structures and installations, and to those under construction, as well as to provide for the safety of employees and the public.

Disposal of timber, bush, etc other than as stated above, or any land drainage or bridging or prevention of soil erosion or other special work arising out of the route clearance shall be done by the Contractor at his own cost.

9.4. Installation of foundations

- a. **General.** Foundation construction shall always be carried out with all due regard to the mitigation of any damage to the environment and in accordance with the findings of any Environmental Impact Assessments and Management or Monitoring Plans.
- b. **Site levelling.** From consideration of the impact on the environment it is normally preferable not to level sites, but to build the structures into the land form basically as it exists, using suitable steel leg extensions on the towers or concrete extensions on the foundations. However in exceptional cases, where tower leg foundations are located on the side of a hill or on a slope and it is decided that terracing, or cut and fill, is an option, full proposals for earthworks shall be submitted to the Employer's representative for approval before any excavation or filling takes place. Proposals shall show :
- how rainwater run-off from the hillside is to be allowed for and diverted around the foundation;
 - how the exposed surfaces are to be protected against weathering and the possibility of erosion;
 - the full depth and details of the foundation, with particular note of the presence of fill material;
 - that the Contractor is aware of the possibility of slippage taking place and has taken precautions to avoid it.

Preference will be given to proposals that minimize the amount of disturbance to the terrain environment. Material that is excavated in terracing shall be spread in an appropriate manner in an area near the tower but in such a manner that no instability is caused to the terrain and the spreading causes no environmental distress.

- c. **Foundations.** A record shall be kept of each foundation installed including details of the strata of the ground throughout the depth of excavation, the presence or not of water during construction and liability to seasonal flooding, together with results of tests carried out and all other relevant information.

Where ground conditions necessitate, the foundation dimensions shall be increased and concrete added and/or reinforced as may be approved by the Employer's representative.

Where ground conditions are unsuitable for the installation of any standard or modified standard class of foundation the Contractor will be required to make arrangements to provide a piled or other special foundation as may be approved. The Employer's representative may require that such specialist foundation work shall be carried out by an approved subcontractor.

In ground which may be flooded at any time of the year and where the soil is such that enlarged pad or raft foundations may be employed economically the excavated subsoil remaining after backfilling shall be formed into a flat topped mound approximately 0.75 m high extending approximately 1 m beyond all sides of the tower base. The sides of the mound shall be battered to minimize the effects of erosion. The mass of the mound shall

not be considered in the uplift capacity of the foundations. The foundation stubs shall be extended to allow for the change in ground level such that the encasing concrete extends to 300 mm above the level of the top of the mound. The cost of forming the mounds will be included in the total cost of the foundations.

In areas where black cotton is encountered the contractor shall make provision for importing backfill material.

- d. **Excavation.** During excavation, the Contractor shall take adequate precautions to prevent earth disturbances that might affect the safety of personnel, property and the Site Works.

Before excavations are commenced the Contractor shall submit his proposals with regard thereto for the Employer's representative's approval. Excavations shall be close timbered or sheeted, planked and strutted as and when necessary and kept free of water by pumping or other means during the course of the work and shall ensure the safety of personnel working within them. The sides of excavations shall normally be vertical unless otherwise specifically agreed with the Employer's representative.

Should dewatering be necessary during excavation and concreting works due consideration shall be taken to ensure there will be no adverse influence on adjacent structures as a result of the lowered ground water table.

Written approval shall be obtained from the Employer's representative before explosives are used for excavating foundations in rock. The Contractor shall be responsible for complying with local regulations concerning the use of explosives and for the safekeeping and handling of explosives. Proper warning shall be given of all blasting operations. During operations involving the handling or use of explosives, the Contractor shall be responsible for the safety of personnel, Site Works and people or properties in the vicinity of the Site. The Contractor shall make good at his own expense any damage caused by the use or mishandling of explosives. No blasting is permitted near permanent work or dwellings.

Blinding concrete shall be provided under all concrete foundations at the base of the excavation for a thickness of at least 75 mm and shall be deemed to be included in the price of the foundations. In cohesive material the final 150 mm of ground above formation level shall only be removed immediately prior to placing the blinding concrete.

- e. **Stub setting.** Stubs for tower foundations shall be carefully adjusted to an approved template and shall be held in the correct position while the concrete for the foundation structure is placed. The templates shall not be struck until at least 24 hours after foundations have been completed nor before the completion of backfilling activities. The spacing and levels of the stubs after the templates have been struck shall be such as to ensure correct alignment of the towers without forcing of members during erection and shall comply with the construction tolerances stated under sub clause j.
- f. **Formworks.** Formers shall normally be employed to produce the correct foundation shape and ensure no loss of aggregate or cement. All formers shall be sufficiently strong to withstand the pressure arising from the concrete during compaction and shall be capable of removal without undue disturbance to the concrete.

Formers may consist either of steel, timber or plywood elements.

The faces of the formers that are in contact with the concrete shall be cleaned and oiled or coated to prevent any concrete adherence to them and to facilitate their removal.

Formers shall not be removed before sufficient hardening of the cast-in concrete has taken place and in no case less than 24 hours after the concrete has been placed. Any concrete that has been damaged during formwork removal or is honeycombed must be removed by chipping to sound concrete and then repaired at the Contractor's expense and to the Employer's representative's approval.

- g. **Reinforcement.** All steel rod reinforcement shall be clean and free from loose mill scale, loose rust, oil and grease or other harmful matter and except at bends shall be truly straight before being surrounded with concrete. Evidence of steel quality, which shall be to an approved Standard such as BS 4449, shall be provided. The numbers, lengths, diameters, forms and positions of all reinforcing bars shall be in accordance with approved drawings.

The steel reinforcement shall be so connected as to form a rigid cage or mat. To prevent displacement before or during concreting, the bars shall be secured one to the other with 18-gauge soft iron wire. Sufficient precast rings or distance blocks shall be used between the reinforcement and the bottom and sides of the excavations to ensure the correct cover of concrete around the bars. The distance blocks shall be made of concrete of not less strength than that of the concrete in which they occur. The foundation reinforcement shall be bonded to the tower stub with 7/4 mm galvanized steel wire strand before concreting.

Steel rod reinforcement shall be bent cold in a manner that will not injure the material. Bending hot at a cherry red heat (ie not exceeding 840°C) may be allowed except for bars that depend for their strength on cold working. Bars bent hot shall not be cooled by quenching.

Bends, cranks or other operations on reinforcing bars shall be in accordance with approved drawings. Where splices or overlapping in reinforcement are required the bars shall unless otherwise approved have an overlap as specified in BS 8110.

- h. **Concrete.** Unless otherwise approved, concrete for foundations and for encasing concrete shall be to Design Mix Grade C35 to BS 5328 (BS EN 206-1 AND BS 8500) with minimum cement content of 300 kg/m³ concrete, maximum water cement ratio of 0.6 and maximum slump of 75 mm. The concrete mix is to be designed by the Contractor and submitted to the Employer's representative for approval in sufficient time to permit the necessary tests on compressive strength to be carried out prior to construction commencing.

Ordinary Portland cement (CEM I) is to be used or other approved composition in case of a normal soil. Blended cements which offer resistance to chemical attack will be required if the soil contains active chemicals that affect Portland cement. Any other different type of cement used is subject to approval of the client and must meet requirements of KS EAS 18-1:2001, (BS EN 197-1) BS 12 or any other approved cement standard

Cement shall be stored in an approved manner.

All aggregates shall be obtained from sources approved by the Employer's representative and shall be clean and free of clay, earth, organic matter, salt or other impurities. The aggregate shall comply generally with the requirements of BS 882.

Coarse aggregate shall be gravel or broken stone of angular or rounded shape, of approved grading and shall pass a mesh not more than 40 mm square for foundation concrete or 20 mm square for encasing concrete.

Fine aggregate shall, unless otherwise approved by the Employer's representative, be sand, well graded from 4 mm gauge downwards. No seashore sand shall be used, and unwashed pit or river sand shall not be used unless approved by the Employer's representative.

Water shall be obtained only from sources approved by the Employer's representative. It shall be clean, free from deleterious materials and chemically neutral.

Cement shall be measured by weight, either by use of one or more complete bags or by weighing on site. Other ingredients shall be measured by weight or by volume, and concrete shall be mixed in batches using one or more complete bags of cement. Only in exceptional circumstances shall a bag of cement be divided. When mixing by volume is adopted, suitable batch boxes of approved dimensions shall be made and used for the measurement of coarse and fine aggregates. A calibrated container for the measurement of water shall also be used.

All concrete shall be thoroughly mixed by machine, with only sufficient water to ensure a workable mix. Consistency tests shall be made when required by the Employer's representative by checking the maximum slump in a truncated cone 300mm high and of standard dimensions. No concrete shall be mixed or placed when the temperature of the air or the ingredients is less than 2°C nor shall concrete be placed when its temperature is greater than 32°C. In hot conditions the initial temperature of the mix should be kept as low as possible, by shading the materials against the sun. Retarding admixtures may be used subject to the Employer's representative's approval. Freshly placed concrete shall be properly protected against the weather.

Test cubes of 150 mm face in accordance with BS 1881 shall be made during the progress of the works, comprising a minimum of one set of four cubes per tower or per day, or one set of four cubes for each 6 m³ of concrete placed if greater.

Cubes shall be tested in accordance with BS 1881 and this Technical Specification.

Contractors shall submit plans showing where the concrete will be mixed for each tower site and how they propose to transport the concrete to the foundation location. If the concrete is being made "off-site" and transported in "ready-mix" trucks, then the journey time must be noted and approved by the Employer's representative. Transportation shall be such as to avoid segregation of the concrete constituents.

The concrete shall be vibrated or thoroughly rammed during placing to ensure that it is homogeneous and free from voids. Excessive vibration shall be avoided.

The upper surface of the concrete for all types of foundations shall be made by a continuous pour of foundation concrete and shall be sloped in an approved manner to prevent accumulation of water.

Unless otherwise approved, there shall be no joints in the concrete foundation. Where the construction of the foundation is such that joints are unavoidable adequate bond between the old and new concrete shall be ensured by chipping the old concrete to a rough, clean

surface free from loose particles. Immediately before placing the new concrete, this cleaned surface shall be primed with a layer approximately 15 mm thick of a wet mix of cement and fine sand in equal proportions.

Particular attention shall be paid to the need to ensure complete curing of all concrete and the Contractor shall supply information in his method statement relating to his proposed methods for curing and for protecting the concrete. Curing and protection shall start immediately after the compaction of the concrete and shall ensure adequate protection from:

- premature drying out, particularly by solar radiation and wind
 - leaching out by rain and flowing water
 - rapid cooling during the first few days after placing
 - high internal thermal gradients
 - low temperature or frost
 - vibration and impact which could disrupt the concrete and interfere with its bond to the reinforcement.
- i. **Backfill.** Proper precautions shall be taken to ensure that all backfilling and compaction of earth is done thoroughly and evenly round all parts of each separate foundation block or structure. The backfill shall be placed in layers not exceeding 200 mm in thickness and shall be compacted to achieve the bulk density assumed in the design using a method of compaction included in the Contractor's method statement and approved by the Employer's representative. Backfilling only from one side or corner of an excavation hole shall not be allowed. In wet or flooded situations adequate provision shall be made to ensure the excavation is kept free from water whilst work is carried out. Stub setting templates shall not be removed before completion of backfilling.

Organic matter and silt shall not be used as backfill material. All temporary timbering, shuttering, etc and all decomposable or perishable material shall be removed from the excavations prior to backfilling.

Black cotton soil or peat soil shall not be used for backfilling and it is categorised as unsuitable material. Contractor shall import suitable soil for backfilling.

- j. **Construction tolerances.** Foundation setting tolerances shall be in accordance with the requirements stated below.

Unless otherwise noted, stub angles shall be placed in the tower footings as shown on the contract drawings, and shall be supported in the proper position by means of rigid frame or equivalent suitable device to insure placement of the stubs within the tolerances specified below. The stub angles shall be held rigidly in a manner to prevent displacement during the placing of concrete.

Stub angles shall be set to the following tolerances :

- i. Horizontal distance between adjacent angles shall not be less than the specified distance nor more than 1/8 inch greater than this distance, measured at the top of concrete and back of angles.
- ii. Horizontal distance between diagonally opposite angles shall be within 3/8 inch of the specified distance, measured at the top of concrete and back of angles.
- iii. The elevation of the top of each angle shall not be less than specified, and the difference in elevation between the tops of the four angles at a tower shall not exceed 1/8 inch or 1/1000 of the horizontal distance between stubs, whichever is less, with proper allowance for unequal-length leg extensions.
- iv. Each stub angle shall not deviate more than 1 inch from its specified position in the concrete footing, and the center of the four stub angles for each tower shall not deviate more than 1 inch from the staked centerlines of the tower.
- v. The faces of the angles shall be parallel to the corresponding sides of the tower within a tolerance of 1/16 inch in the width of the angle, with no more than a 2-degree twist from its true position (rotation about the heel of the angle).
- vi. The batter on each face of the angle shall not deviate from the specified batter more than 1/64 inch per foot length of exposed stub angle.

Tolerances for the position of the tower and excavations in relation to the tower position given on the profile shall be:

Table 3: Tolerances for the position of the tower and excavations

	Out of alignment	From centre line of route	From transverse centre line of tower
Suspension tower	0.25°	±25 mm	±250 mm
Tension tower	0.25°	±25 mm	±25 mm

- k. **Site clearance.** As soon as practicable at each tower site, backfilling shall be completed, surplus soil removed and the site cleared. Final site clearance will normally be carried out at the same time as fitting of anti-climbing devices and tower plates, and shall be undertaken without delay.
- l. **Protection of tower footings.** At locations where water due to flood or tidal water may affect the foundations or cause erosion of the ground near the tower foundations, protection to the foundations and to the ground surrounding them shall be provided by the Contractor. Methods include stone revetment, concrete placement, gabion structures or reinforcement of ground surfaces as well as drainage schemes as necessary. Other methods, where more

suitable, are not precluded and the Contractor shall furnish recommendations for the provision of protection at such locations.

10. ERECTION

10.1. Storage and erection of steelwork

10.1.1. General.

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

10.1.2. Assembly and erection.

The Contractor shall erect the towers for the transmission line in accordance with the erection diagrams, construction lists and other drawings and instructions.

Unless otherwise approved, towers with concrete foundations shall not be erected until the concrete has had 14 days in which to cure, or such longer or shorter time as may be approved, depending on the type of cement used and on local conditions.

The method of assembling and erecting a tower shall be such that during erection no member shall be subjected to any stress in excess of that for which it was designed.

Misalignment or misfit of adjacent sections or members attributable to the adopted method of erection shall be corrected by changing erection methods as necessary to eliminate the trouble.

All members shall have their joints cleaned when bolted up. As far as possible bolt heads, rather than nuts, shall be on the outer or upper faces of tower joints.

All towers assembled on the ground shall be kept off the ground with wood so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure.

If erected by assembling in sections, the initial tightening of bolts shall be adequate for dead load, live load and direction stresses, but shall not be so strong as to prevent aligning and fitting adjacent sections or members. The assembled sections shall be adequately supported during erection.

Spanners used during erection shall be well shaped and shall fit closely onto the hexagon to avoid damage to nut and bolt heads. The use of any wrench that may deform the nut or cut or flake the galvanizing will not be allowed. During assembly, punching, reaming or drilling for correction of mismatched holes shall not be permitted without the authorization of the Employer's representative in writing.

Proper precautions shall be taken to ensure that towers are not strained or damaged in any way during erection. Suitable ladders shall be used, whenever necessary, during erection of towers. All ladders and removable step bolts shall be removed when erection work is not in progress.

If any shop errors in the steel are discovered, the Contractor shall notify the Employer's representative who will decide whether the error shall be corrected on site or the members shall be replaced.

All exposed steel surfaces around the holes or on cuts on which such corrective work is permitted shall be given sufficient coats of a zinc rich paint to provide sufficient protection to the steel and shall be to the approval of the Employer's representative.

All towers shall be vertical under the stresses set up by the overhead line after conductor erection. A tolerance of 25 mm for every 10 m height may be allowed.

After erection each tower shall be thoroughly inspected by a special crew to check the condition of the section surfaces and the correct tightness of the nuts on the bolts. The final tightening of the nuts shall be carried out using torque wrenches and the nuts shall be torqued to the values proposed by the Contractor and approved by the Employer's representative.

On each tower the Contractor shall install the relevant danger and identification plates as indicated in the erection drawing.

In order to prevent pilfering, all bolts and nuts from ground to two metres above of the anti-climbing device shall be secured by means of specifically designed anti-theft type bolts and nuts to the approval of the Employer's representative on each tower.

All foreign matter and surplus materials shall be removed from the towers and from the site upon completion of erection.

10.1.3. Earthing and resistance measurements.

The Contractor shall install and test the structure grounding in accordance with this Technical Specification.

10.1.3.1. Earthing

The transmission line earthing system shall be designed and installed in accordance with the requirements of EN 50341-1.

The Contractor shall undertake preliminary soil resistivity measurements along each line route as soon as possible after Award of the Contract. The number and location of test points as well as method of testing shall be agreed with the Employer's representative.

The earth electrodes at the base of each tower shall be designed and implemented with respect to local soil conditions. All towers shall be designed to have a resistance to far earth lower than 10 ohms.

In the presence of the Employer's representative, the Contractor shall measure the electrical footing resistance to earth of each tower before the earth conductors are erected. These measurements shall be recorded by the Contractor in the form of a tower footing earth resistance profile of an approved type.

The following materials or their equivalents shall be used:

- Earthing rods shall be made of galvanised steel, with a minimum diameter of 20mm and minimum length of 3m. There shall be provision for coupling rods to extend their length if necessary. A bronze or brass bolted clamp shall be provided for connection of earthing cables to the earthing rods;
- Earthing cables (counterpoise) shall be of galvanised steel wire with 11.5mm diameter.
- Connection of the counterpoise to the tower steelwork shall be by means of a compressed lug and two galvanized bolts and nuts, washers and spring washer on the tower stub at least 500 mm above the foundation surface. The minimum diameter of the bolts shall be 12 mm. The holes in the leg/stub steelwork shall be factory drilled prior to galvanizing.
- The earthing counterpoise shall pass through the concrete chimney via an encased, flexible PVC pipe and exit from the chimney at the required depth. On completion of the earthing installation the PVC pipe shall be filled with a cement mortar mix.

The depths of the upper ends of earthing rods and the depth of burial of earthing cables shall not be less than the following values:

- Cultivated (soft) soil 800 mm
- Normal soil 500 mm
- Rocky ground 150 mm
- Where required drilling or augering methods shall be used for installing the earth rods. The holes shall be filled with bentonite and the earthing rod pushed into the prepared holes.

Type A: Every tower shall be fitted with compulsory earthing on two diagonally opposed legs. The earthing rods, one per leg, shall be driven vertically into the ground to a depth of 3m at a distance of 5m from the footing and shall be connected to the tower legs by earthing counterpoise cable.

Where the measured tower footing resistance is greater than 10 ohms the earthing shall be enhanced using one of the systems detailed below.

Type B: Installation of earthing rods as described in type A above but with one 3m rod and earthing counterpoise cable connected to each tower leg.

This type of earthing system shall be used in cultivated (soft) soil where type A earthing does not provide adequate earthing.

Type C: Installation of earthing rods as described in type B but with each rod being extended to 6m long and earthing counterpoise cable connected to each tower leg.

This earthing system shall generally be used where the ground conditions are not favourable, but not rocky.

Alternatively, an additional 3m earthing rod shall be connected to each previously installed rod via an additional 5m of counterpoise cable.

Type D: Any special measures and methods (deep grounding, counterpoise connection to the adjacent tower, earth conductivity improving chemicals etc.), subject to approval of the Employer's representative, which shall be used in specific soils where type C earthing cannot provide sufficient reduction in resistance.

For all types of earthing system, each section of earthing cable shall be separately bolted to the tower in order that it can, if required, be disconnected for the purpose of earth resistance measurements.

At each tower connected to an earthing system the Contractor shall measure the electrical footing resistance to earth with the system connected. The measurements shall also be recorded by the Contractor on the tower footing earth resistance profile to be provided as a final record.

The terminal towers shall be connected to the substation earthing grid.

Type and thickness of galvanizing shall provide sufficient protection of steel for 20 years service and shall not be less than 610g/mm².

Metal roofs of existing buildings constructed within 30 m of the centre of the transmission line shall be securely earthed. A minimum of two earth connections shall be made to opposite sides of the roofs by means of earthing (counterpoise) cable, which shall be led down the sides of the building to earth. The earthing cable shall be securely fixed in cleats to the sides of the buildings and not less than 2 m of the cable shall be buried in the ground at a depth of at least 800 mm.

All metallic fences both new and existing, which cross under, or which are located near and parallel to the transmission line shall be earthed as follows:

- One earthing rod shall be used to ground each 100 m of fence that is parallel to and within 50 m of the centre line of the transmission line. One earthing rod shall be used on each side of the right of way to earth fences crossing under the line.
- Earthing rods, to which the fence wires shall be bonded, shall be driven to a depth of not less than 1.5 m. All metallic fence gates within the right of way shall be electrically bonded to the fences.

10.2. Erection of insulators

Insulators and insulator fittings shall be assembled and installed by the Contractor as shown on the drawings, and in accordance with the recommendations of the manufacturers.

All insulators shall be handled carefully during transportation, assembly and installation on the tower to avoid damage and shall be cleaned when installed using techniques which cause no damage to the surface of the insulator.

Proper precautions shall be taken to ensure that insulators and fittings are not strained or damaged during erection of the insulator sets, and during the pulling out and erection of conductors.

The Contractor shall take adequate precautions to ensure that dust and dirt is excluded from insulator ball and socket joints.

10.3. Crossing of public services

At crossings of roads, railway lines, buildings, waterways, telegraph and telephone lines, over or under other power lines, the provisions of any Regulations to which KETRACO is subject shall be complied with. No additional payment will be made for any temporary guarding or scaffolding required for erection of the conductors at crossings.

When the Contractor is about to carry out erection of the conductors along or across power lines or telecommunication circuits, public roads, waterways, he shall be responsible for giving advance notice to the appropriate authorities of the date and time at which he proposes to carry out the work. Where authorities, or public undertakings deem it necessary for the protection of their employees or property, or of the public, or for the regulation of traffic, to provide flagmen or watchmen, the cost of such provision shall be borne by the Contractor.

Contractor shall pay Kenya Power for the relocation of lines and/or undergrounding of existing 66,33,11 and 0.415 kV lines that the new line will cross. These costs shall be deemed to be included in the contract price.

10.4. Erection sags and tensions

The line and earth conductors shall be erected so that the tensions at "everyday temperature" in still air shall be the figures stated in the Technical Schedules and shall be equal in all spans, except for sections with spans differing considerably from the basic span where compliance with the specified tensions under the assumed maximum loading conditions may necessitate a lower figure for the "everyday temperature" still air tension.

At "everyday temperature" in still air, in any span, the earth conductor sag shall be approximately 10 per cent less than the line conductor sag.

In calculating the initial sags and tensions, allowance shall be made for the elasticity and coefficient of expansion of the conductor materials.

The "equivalent span" method shall be used, in which the tension in any section length is that which would apply to a single span equal to the square root of the figure arrived at by dividing the sum of the cubes of the individual span lengths, in the section considered, by their sum. Unless otherwise approved, the sag of any one conductor should not differ from the correct sag by more than 3 per cent and, in any one span, the maximum permissible difference in sag between conductors of different phases shall not exceed 150 mm.

The sag of the subconductors of any one phase shall not differ by more than 50 mm.

Employing the approved design sags and tensions as the basis the Contractor shall submit, for approval, calculations for the initial sags and tensions to be employed during stringing activities. These calculations shall take into consideration the effects of creep for each of the phase and earth conductors and also that, for instance, Aircraft Warning Markers will not be installed at the time of sagging. For sections where Aircraft Warning Markers are to be installed additional initial sag and tension data shall be provided.

10.5. Erection of line and Aluminium Steel Clad earth conductors

At least 3 months prior to the commencement of stringing activities the Contractor shall submit his stringing schedule identifying the stringing sections, locations of tensioner and puller, the proposed position of mid-span joints, drum identification numbers, sagging spans and, where appropriate, check sagging spans. The sagging span shall normally be the longest span within the section but consideration shall be given to establishing a line-of-sight to the puller station. In addition, details of temporary staying of towers, joints of control and other relevant information shall be submitted.

The fullest use possible shall be made of the maximum lengths of line and earth conductor in order to reduce to a minimum the number of joints. The number and span location of tension joints shall be approved. Unless otherwise approved there shall be no tension joints in adjacent spans or in sections, between tension towers, of less than three spans; there shall be no joints in spans crossing roads, navigable waterways or buildings or in the spans immediately adjacent thereto. All joints shall be at least 30 m away from structures.

The conductors, joints and clamps shall be assembled using the approved tools and shall be erected in such a manner that no bird-caging, over-tensioning of individual wires or layers, or other deformation or damage to the conductors shall occur. Running out blocks shall be of an appropriate diameter to avoid the formation of permanent "sets" in the conductor and shall be to approval. The use of midspan compression joints for the purpose of pulling out conductors during erection and the use of insulators and line materials in general for erection purposes will not be allowed. Auxiliary erection clamps, or hauling devices shall be of approved design, and shall under erection conditions, allow no relative movement of strands or layers of the conductors. If required by the Employer's representative, this property shall be demonstrated by actual test. Cutting of layers of ACSR or ACS conductors shall be carried out with tools designed not to damage underlying strands. Cropping or shearing of complete conductors shall not be permitted. The cut ends of the conductors and the joints, clamps and fittings attached to the conductor themselves shall be treated in an approved manner to prevent ingress of moisture.

The Contractor shall measure, by means of approved micro-ohm meter equipment in accordance with the Tests section of this Technical Specification, the electrical resistance of all joints after completion and before erection. The resistance of the joint shall be in accordance with the requirements of the Specification and shall in no case be greater than 75 per cent of the resistance of the equivalent length of conductor. The values of resistance measured shall be recorded on a schedule that shall be submitted to the Employer's representative as part of the final records. Any faulty joint shall be cut out and replaced at the Contractor's expense.

All current carrying surfaces of bolted connections shall be coated, prior to erection, with an approved conducting compound in an approved manner.

In case of local damage to isolated strands of a conductor during erection the use of repair sleeves of approved type may, in exceptional circumstances, be permitted upon application to and at the discretion of the Employer's representative who will regard repair sleeves as joints in respect of permitted locations. Any use of repair sleeves shall not incur additional cost to KETRACO.

The Contractor shall at his own expense make suitable arrangements for temporary guying of towers, where necessary. Suitable plates (detachable or otherwise) shall be provided on the

towers for the attachment of any temporary guys. The additional loads imposed on specific towers during erection by the use of temporary guys shall be calculated and approved. Attachment of the guys to the tower shall be accomplished so as not to cause damage to steelwork or the galvanized coating.

The line and earth conductors shall be erected employing tension stringing methods and equipment and shall not at any time during erection come into contact with the ground or any obstacle, such as walls, fences or buildings, except when the conductors are at rest. Approved means shall be provided to prevent any damage to conductors where these are run over temporary supports.

Conductor running-out blocks shall be free running and of approved materials and dimensions.

Conductors shall be clamped in, vibration dampers and spacers shall be erected, as soon as practicable but in any case within 72 hours after having been tensioned to the correct sag.

The Contractor shall make any necessary special arrangements for running out and sagging the conductors where the route crosses buildings, orchards, plantations, gardens, or other ground over which erection cannot be carried out in the normal manner. No extra charge for man-handling of material or for any special precautions or methods necessary at such positions shall be allowed.

The Contractor shall also make such special arrangements as the Employer's representative may approve where power lines are to be crossed. Where the conductors have to be erected whilst the power line to be crossed is energized, no additional payment to the prices stated in Volume 1 shall be made for any special scaffolding or equipment required.

Where required by the Employer's representative, prior to the issue of the Operational Acceptance Certificate, the Contractor shall be responsible for checking that the relative sags of the conductors are within the specified tolerance. Such checks shall be carried out at selected points along the route as required by the Employer's representative.

At the end of the maintenance period stated in the Conditions of Contract, the line conductor sag adjusting devices for bundled subconductors shall be finally not more than 50 mm plus or minus, from their median position, unless otherwise approved.

The Contractor shall provide suitable dynamometers, thermometers, sighting rods and other approved apparatus necessary for the proper checking of the work. Dynamometers, if used, shall read in kilograms or Newtons and, where required by the Employer's representative, shall be tested and, if necessary, recalibrated.

The Contractor shall keep a record of the particulars of the sagging of conductors in each section of the route showing the mean actual sag of the line conductors and date of stringing as well as the ambient and conductor temperature. The data shall be handed to the Employer's representative at the conclusion of erection work.

Clearances between phase conductors and ground and between jumpers and structures shall be checked during erection and before handing over the line.

The Contractor shall submit his proposals for a test regime to the Employer's representative for approval prior to fieldwork commencing.

10.6. Erection of Optical Fibre Ground Wire (OPGW)

The fullest use shall be made of the maximum lengths of conductor to reduce the number of joints to a minimum. The locations for joints shall be approved by the Employer's representative.

The conductors and clamps shall be assembled using approved tools and shall be erected in such a manner that no bird-caging, over-tensioning of individual wires or layers, over-tensioning or stressing of optical fibre elements, or any other deformation or damage to the conductors shall occur.

The conductors shall not at any time during erection come into contact with the ground or with any obstacle, including walls, fences and buildings.

The relevant clauses related to erection of line conductors shall apply also for OPGW earth conductors.

The erection of OPGW is to be effected in such a manner that neither torsion nor bending stresses on the conductor during erection, sagging, jointing or landing shall cause any damage or deterioration to the optical fibre system. Suitable precautions shall be taken, using for example torsionally stable pulling ropes, suitable running-boards, counterweights and running blocks. Special attention shall be paid to ensure that the conductor at no time is subjected to bending in excess of that permitted by the minimum bending radius specified by the manufacturer. Running-out blocks shall be sized to conform to the minimum bending radius specified by the OPGW manufacturer.

The Contractor shall carry out tests to confirm the satisfactory condition of optical fibres prior to erection.

Once installation of OPGW earth conductor is complete a series of tests to be agreed with the Employer's representative shall be carried out to ensure the satisfactory operation of the cable. The tests shall be carried out in both directions.

The tests shall include but not be limited to:

- Optical attenuation on OPGW earth conductor terminated with connectors carried out in both directions at 1550 nm and 1625nm.
- Loss distribution to measure the uniformity of loss in the optical fibres and joint losses in the OPGW earth conductor using an optical time domain reflectometer (OTDR).

On completion of the tests three hard copies as well as one soft copy of the test report shall be supplied to the Employer's representative.

Optical attenuation of the OPGW earth conductor terminated with connectors shall be measured and recorded at the end of the guarantee period and it shall not be more than 102 per cent of the reading at commissioning.

The contractor shall submit his proposals for erection and test regimes to the Employer's representative for approval prior to fieldwork commencing.

10.7. Work at ends of the line

The location and orientation of towers at the ends of the line are to be studied with extreme care and Method statements and drawings with sufficient detail are to be provided prior to outages being granted. Outage dates and outage durations are to be requested 6 weeks in advance to allow KETRACO sufficient time to arrange these outages.

10.8. Final inspection

Upon the notification by the Contractor that the work is finished on a completed section of line, the Employer's representative, prior to issuing the Operational Acceptance Certificate, will inspect the completed Works, in order to ascertain that they have all been carried out in accordance with the Specification and to the Employer's representative's satisfaction.

In particular, it will be ascertained that at least:

At tower positions,

- backfilling of the excavations, ramming, levelling around foundations, draining of higher footings on sloping ground, dispersal of excess earth etc, is complete.
- Concrete protruding above ground is correctly shaped, finished and sealed. Counterpoise earthing is installed where required.
- Silicone, epoxy or other approved painting has been correctly applied. Steel sections are straight and not damaged. Bolts and nuts are correctly fitted with washers and are properly tightened and locked.
- The line and earth conductor fittings are erected in accordance with the drawings and are complete. The line and earth conductors are correctly clamped. Electrical clearances from jumpers to tower steelwork are adequate.
- All tower steelwork, bolts, nuts, lock nuts, cotter pins, washers and split pins on all fittings are properly fitted. The tower steelwork is free of all foreign matter.
- Anti-climbing devices, danger and identification plates are complete and correctly fitted.

Along the transmission line.

- The conductors and earthwire are clean, without strand damage and free of mud, foliage, loose wires, etc. The sags of all conductors and earthwire are in accordance with sagging documents and clearances are correct.
- All packing and surplus materials have been removed from the site. The cutting and removal of trees and all route clearing is in accordance with the Specification.
- All access and inspection tracks are completed and in good condition.

11. REMEASURED WORK

11.1. Measurements of work

All measurements of length for the purpose of payments shall be to the nearest metre, and shall be made, after erection, along the centre line of the transmission line without allowance for sag or slope.

All measurements of mass for the purpose of payments shall be to the nearest kilogramme, and shall be calculated from the approved working drawings, steel being assumed to have a density of 7850 kg/m³.

All measurement of the cleared strip shall be based on the prices stated in Volume 1 which shall be deemed to be the average for the total line route irrespective of the varying density of the vegetation or the nature of the terrain.

All measurements for the purpose of payments shall be made jointly by representatives of the Contractor and the Employer's representative.

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11.2. Towers and foundations

The rates given in Appendices for the standard types of towers, standard foundations, and earthing and for excavation, concrete, steelwork and reinforcement for foundations of special towers shall include all work which the Contractor may have to do when installing the standard towers, foundations, special foundations and earthing, regardless of the nature of the ground, the presence of water, the slope or irregularity of the ground surface or other local conditions, except that where sloping ground necessitates the use of individual tower leg extensions, these extensions will be paid for at the appropriate rates given in the Appendices. The foundation rates are deemed to include for any additional work that may be required to secure foundations against the effects of soil erosion.

If a combined-use tower is proposed and different prices have been entered in Volume 1 for the individual tower types, it shall be noted that payment shall only be made for the tower type that was necessary at the location; for instance an M/H tower at a location with say 25° deviation will only be paid at the scheduled rate for an M tower.

The rates for modified standard foundations shall be made up from the rates in Volume 1 or shall be otherwise approved.

Single leg extensions for standard and extended towers shall be paid for at the rate stated in the Volume 1.

Steelwork additional to an otherwise standard tower, such as additional brackets, etc shall be paid for at the special steelwork rate stated in Volume 1. Where a standard tower is erected on special foundations or on a special extension the standard tower shall be paid for at the rate

stated in Volume 1 and the special extension and the foundations shall be paid for at the appropriate rates stated in Volume 1. Special towers, or standard towers with radical modifications to the main structure, and the special foundations shall be paid for at the appropriate rates stated in Volume 1.

11.3. Tests

The Employers has the right to inspect materials and equipment, and witness factory tests of any plant and equipment included in this Contract. The cost of a satisfactory and approved type test shall be paid for at the rates stated in Volume 1. Prices for tests shall include manufacture, supply, erection and dismantling of all materials and provision of all test facilities. The Contractor shall also include in the price for the attendance by up to six (6) Employer's representatives (3 KETRACO's representatives and 3 Consultant's representatives) to witness the tests, that is, six (6) Employer's representatives for each trip.

The price shall include food, accommodation, daily allowance, visa expenses, round trip air fare between Nairobi and/or Employer's representative's home office and any other countries where equipment are to tested and any internal transportation within the country of the test.

Each consignment of material shall be inspected and tested in the presence of Employer's representatives.

For each inspection, the following are to be provided for each representative:

- Economy class returns air ticket (from Nairobi or the Employer's representative's home office to Places of Test and/or Inspection).
- Visa expenses, airport taxes and other incidental travel expenses as required.
- Full board accommodation in a minimum 4-star hotel including laundry services, International calls expenses, FAT documentation
- Daily incidental stipend allowance for each representative for the total duration of FAT, 150 USD per person per day.
- Any internal transportation

At least 6 weeks notice of the date, time and place of all tests shall be given to the Employers so that arrangements can be made to have the test witnessed.

Prior to the tests, the Contractor shall submit an outline of the procedures and tests in its plans to demonstrate fulfilment of the requirements specified in the subsequent sections of the detailed technical specifications.

Any costs incurred by Employer's representative in attending a repeat type test brought about as a result of a failure of the subject under test and postponement of the test programme shall be to the account of the Contractor.

Type tests necessary for proving compliance with the Specification and not specifically mentioned in the Schedules shall be undertaken at no extra cost to KETRACO.

Uplift and compression tests on special foundations, including tests on piles, or other additional tests including bore holes and specialist soil tests, when instructed by the Employer's representative, shall be paid for at the rates stated in Price Schedules.

The cost of all routine or sample tests on materials and/or analyses shall be borne by the Contractor.

The cost of additional tests and/or analyses required by the Employer's representative and effected elsewhere than at the works of the Contractor or a subcontractor or on the Site will be borne by KETRACO should such tests prove satisfactory, but the Contractor will be called upon to pay all expenses incurred by KETRACO and/or Employer's representative in respect of any work or material found to be defective, of inferior quality, adulterated or otherwise unacceptable.

12. TESTS

12.1. General

The following tests shall be carried out in order to determine whether the materials and apparatus comply with the Specification.

Not less than six weeks' notice of all tests shall be given to the Employer's representative. As many tests as in the opinion of the Employer's representative are possible shall be arranged together. Four hard copies as well as one soft copy of the records of all tests shall be furnished to the Employer's representative.

All instruments shall be approved and shall, if required by the Employer's representative, be calibrated at the expense of the Contractor by an approved authority.

With the exception of the manufacturers' routine and sample tests, all type tests may, at the option of the Employer's representative, be waived providing satisfactory previous type testing records, issued by an approved internationally acknowledged reputable independent testing laboratory, are available and are approved by the Employer's representative.

12.2. Summary of tests

The following tests shall be carried out in accordance with the details as specified.

Tests to be carried out at the manufacturer's works (unless otherwise specified or approved):

- Line and earth conductors – type, routine and sample tests.
- OPGW earth conductors and underground fibre optic –qualification, field, routine acceptance, sample tests.
- Tension and suspension clamps and joints - type and sample tests.
- Insulators, insulator fittings and conductor mechanical protective fittings - type, routine and sample tests.
- Towers and metal fittings for towers - type and sample tests.
- Zinc coating - sample tests.

Tests to be carried out on the Site:

- Tests on cement and concrete - type and sample tests.
- Tests on foundations - type tests.
- Tower footing resistances - routine tests.
- OPGW earth conductors - routine tests.

- Tests on conductor joints and clamps - routine tests.
- Line insulation and conductivity - routine tests.
- Confirmation of as-built line parameters (line impedance)
- Such tests as are required by the Employer's representative to prove compliance with the Specification independently of any tests that may have already been carried out at the Manufacturer's Works, or elsewhere.

12.3. Details of tests

12.3.1. Line and earth conductors

12.3.1.1. Type tests

Conductor or earthwire shall be type tested in accordance with IEC 61089. Used grease shall be tested in accordance with Table 1 of BS EN 50326 to determine the characteristics of the grease, including the drop point as stated in the Technical Schedules and to confirm the absence of corrosive substances. Type test records and certificates for identical type of conductor may be accepted provided that those records and certificates are not older than five years and tests were carried in accredited laboratory.

12.3.1.2. Sample tests

Sample from 10% of lengths of finished line or earth conductor shall be taken and subjected to the tests stated in IEC 61089. In the event of the sample from any length not passing these tests a second and third sample shall be taken from the same length and if one of these also fails under test the length from which it has been taken shall be rejected.

12.3.1.3. Routine tests

Routine tests in accordance with IEC 61089 shall be carried out during the production on the complete conductor to prove compliance with the details in the Technical Schedules.

12.3.2. OPGW earth conductors

12.3.2.1. Qualification tests

Tests on complete composite fiber optic earth conductor shall be carried out in general accordance with the last version of the IEEE 1138/IEC 60793/TIA 455 and referenced standards. Lightning arc test shall be carried out for Class 2. Any deviation from these methods or any alternative methods proposed must have prior approval from the Employer's representative. The related standards are as below :

IEEE 1138- TESTING AND PERFORMANCE FOR OPTICAL GROUND WIRE (OPGW) FOR USE ON ELECTRIC UTILITY POWER LINES CORRIGENDUM 1: STRESS-STRAIN TEMPERATURE CORRECTION, AEOLIAN VIBRATION VELOCITY

*IEC 60793-1-20, Optical fibres – Part 1-20: Measure TESTING AND PERFORMANCE FOR OPTICAL GROUND WIRE (OPGW) FOR USE ON ELECTRIC UTILITY POWER LINES CORRIGENDUM 1: STRESS-STRAIN TEMPERATURE CORRECTION, AEOLIAN VIBRATION VELOCITY*nd test procedures – Fibre geometry

IEC 60793-1-21, Optical fibres – Part 1-21: Measurement methods and test procedures –Coating geometry

IEC 60793-1-22, Optical fibres – Part 1-22: Measurement methods and test procedures –Length measurement

IEC 60793-1-30, Optical fibres – Part 1-30: Measurement methods and test procedures –Fibre proof test

IEC 60793-1-31, Optical fibres – Part 1-31: Measurement methods and test procedures –Tensile strength

IEC 60793-1-32, Optical fibres – Part 1-32: Measurement methods and test procedures –Coating strippability

IEC 60793-1-33, Optical fibres – Part 1-33: Measurement methods and test procedures –Stress corrosion susceptibility

IEC 60793-1-34, Optical fibres – Part 1-34: Measurement methods and test procedures –Fibre curl

IEC 60793-1-40, Optical fibres – Part 1-40: Measurement methods and test procedures –Attenuation

IEC 60793-1-41, Optical fibres – Part 1-41: Measurement methods and test procedures –Bandwidth

IEC 60793-1-42, Optical fibres – Part 1-42: Measurement methods and test procedures –Chromatic dispersion

IEC 60793-1-43, Optical fibres – Part 1-43: Measurement methods and test procedures –Numerical aperture

IEC 60793-1-44, Optical fibres – Part 1-44: Measurement methods and test procedures – Cut-off wavelength

IEC 60793-1-45, Optical fibres – Part 1-45: Measurement methods and test procedures –Mode field diameter

IEC 60793-1-46, Optical fibres – Part 1-46: Measurement methods and test procedures –Monitoring of changes in optical transmittance

IEC 60793-1-47, Optical fibres – Part 1-47: Measurement methods and test procedures-Macro bending loss

IEC 60793-1-48, Optical fibres – Part 1-48: Measurement methods and test procedures –Polarization mode dispersion

IEC 60793-1-49, Optical fibres – Part 1-49: Measurement methods and test procedures –Differential mode delay

IEC 60793-1-50, Optical fibres – Part 1-50: Measurement methods and test procedures –Damp heat (steady state)

IEC 60793-1-51, Optical fibres – Part 1-51: Measurement methods and test procedures – Dry heat

IEC 60793-1-52, Optical fibres – Part 1-52: Measurement methods and test procedures –Change of temperature

IEC 60793-1-53, Optical fibres – Part 1-53: Measurement methods and test procedures –Water immersion

IEC 60793-1-54 Optical fibres – Part 1-54: Measurement methods and test procedures –Gamma irradiation

*IEC 60793-2, Optical fibres – Product specifications– General***12.3.2.2. Field routine acceptance tests**

The Contractor shall carry out attenuation tests to confirm the satisfactory condition of the optical fibers prior to erection. These will be compared against the values obtained prior to shipment.

Once installation of the fibre optic cable is complete a series of tests to be agreed with the Employer's representative shall be carried out to ensure the satisfactory operation of the cable. The tests shall be carried out in both directions.

The tests, using an optical time domain reflectometer (OTDR), shall include but not be limited to:

- Optical attenuation on the terminated cable in both directions carried out at the wavelengths given in the GTP.
- Loss distribution to measure the uniformity of loss in the fibre and joint losses.
- End to end attenuation tests including connectors at terminal stations prior to commissioning.
- Bit Error Rate (BER) test shall be carried out and the error rate shall not exceed 10^{-9} .

On completion of the tests three hard copies as well as one soft copy of the test reports shall be supplied to the Employer's representative.

At the end of the guarantee period the optical attenuation of the cable between terminal stations complete with end connectors shall be remeasured and recorded and it shall not be more than 102 per cent of the readings obtained at commissioning. BER tests shall also be repeated.

12.3.2.3. Sample tests

Sample from 10% of lengths of finished OPGW shall be taken, metallic conductor subjected to tests stated in ASTM B415/B416 and optical fibers subjected to attenuation test (in Iran only attenuation test perform on fibers) other related tests which have done in CASA project same as below table.

In the event of the sample from any length not passing these tests a second and third sample shall be taken from the same length and if one of these also fails under test the length from which it has been taken shall be rejected.

S. No.	Test Name	Test procedure
1	Attenuation Coefficient	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	EIA/TIA 455-59
3	Attenuation at Water Peak	EIA/TIA 455- 78A
4	Chromatic Dispersion	EIA/TIA 455-168A/169A/175A
5	Core – Clad Concentricity Error	EIA/TIA 455-/176
6	Cladding diameter	EIA/TIA 455-176
7	Fibre Tensile Proof Testing	EIA/TIA 455-31B

12.3.3. Tension and suspension clamps and joints

Testing shall be in accordance with IEC 61284. Tests on fittings for OPGW shall in addition comply with the recommendations given in the CIGRE Report 'Guide to fittings for optical cables on transmission lines: Part 2A Testing procedures - optical groundwire fittings and optical phase conductor fittings' ELECTRA No.188 February 2000. The following additions shall apply.

12.3.3.1. Type tests

All joints and clamps shall be submitted for examination before test and all assembly, cutting off of conductor, compound filling (where applicable) and insertion of a plug in a centralizing hole and any other work whatsoever necessary for the assembly of the clamps and joints shall be carried out in the presence of the Employer's representative with the erection methods and tools proposed for field use.

Approval of such methods and tools will be subject to inspection at the time of the tests. The Contractor shall ensure that a reasonable number of his supervising staff shall be present at the type tests or, alternatively, ensure the correct jointing techniques are demonstrated to his linesmen in the presence of the Employer's representative.

12.3.3.1.1. Mechanical type tests

The following tensile tests shall be carried out on tension clamps and tension joints:-

- a. Two tension clamps shall be fitted to the ends of a length of conductor not less than 6 m long.
- b. A tension joint shall be fitted in the centre of a 6 m length of conductor, each end of which shall be held in an anchor clamp.

For both tests a. and b. a tensile load of about 50 per cent of the ultimate strength of the conductor calculated in accordance with IEC 61089 shall be applied and the conductor shall be

marked in such a way that movement relative to the fitting can easily be detected. Without any subsequent adjustment of the fitting, the load shall be steadily increased to 95 per cent of the ultimate strength and then reduced to 90 per cent of the ultimate strength and maintained for one minute. There shall be no movement of the conductor relative to the fitting due to slip during this one-minute period and no failure of the fitting.

Non-tension joints and clamps and non-tension parts of tension clamps shall be similarly tested to show compliance with the provisions of the Specification.

Slip tests shall be carried out on suspension clamps to demonstrate compliance with the Specification and to establish the torque to be applied to the clamp bolt nuts.

12.3.3.1.2. Electrical type test

Electrical type tests, including resistance and heating-cycle tests on tension joints and heating-cycle tests on non-tension joints, shall be made on one sample of each type of midspan joint, dead-end jumper lug and repair sleeve. The tests shall be carried out in accordance with IEC 61284 and the samples shall meet the requirements of the Standard with the following exceptions. For the heating cycle test the ambient temperature shall not be greater than 25°C and the test current shall be that current which raises the conductor to the maximum operating temperature specified. In addition the heating cycle test shall be carried out with a tensile load equal to approximately 20 per cent of the breaking load of the conductor and shall be recorded.

The corona type test specified under "Insulator units, insulator sets, insulator fittings and conductor mechanical protective devices", shall be applied to all conductor fittings, including dampers and these tests may be carried out simultaneously with the insulator set tests if this is found to be convenient.

12.3.3.2. Sample tests

Sample clamps and joints shall be submitted to such tests as the Employer's representative may require in order to demonstrate compliance with this Specification.

12.3.4. Insulator units, insulator sets, insulator fittings and conductor mechanical protective devices

Testing shall be in accordance with the relevant clauses of the latest editions of IEC 60383-1, IEC 60383-2, IEC 60437, IEC 60797, BS 5049:Part 2, IEC 61109, IEC 61284, IEC 61466, IEC 61854 and IEC 61897, ANSI C29-11, ANSI/IEEE Std 989 and CIGRE Report ELECTRA No.188 February 2000 for OPGW fittings, with the following additions.

12.3.4.1. Insulator Units

12.3.4.1.1. Type tests of insulator units

The type tests are as follows:

- verification of the dimensions

- dry lightning impulse withstand and flashover voltage test
- wet power frequency withstand voltage and flashover tests
- electromechanical failing load test or mechanical failing load test, as applicable
- thermal-mechanical performance test.
- all other composite insulator type tests as required by IEC 61109

12.3.4.1.2. Routine tests of insulator units

Routine tests shall be carried out in accordance with IEC 60383-1.

12.3.4.1.3. Sample tests of insulator units

Sample tests shall be carried out in accordance with IEC 60383-1.

12.3.4.2. Insulator sets

12.3.4.2.1. Type test of complete insulator set

- 50 per cent dry lightning impulse flashover voltage test
- wet power frequency withstands voltage test
- wet switching impulse withstand voltage test
- corona test
- radio interference test.

12.3.4.2.2. Routine test of insulator set fittings

All castings and fittings in which a weld is subject to a tensile load in service (including arcing horns) shall comply with the routine load test requirements of 50% of the specified minimum failing load to IEC 61284 "Overhead lines – Requirements and tests for fittings".

12.3.5. Towers and metal fittings for towers

12.3.5.1. Material Sample Tests

Samples of the material for the towers and fittings shall be tested in accordance with BS EN 10025 as modified by this Specification. Bolts and nuts shall be tested in accordance with the requirements of BS 4190, EN 20898-1, ISO 898 1 and 2.

12.3.5.2. Assembly test

In order to check the workmanship (detailing and fabrication) one tower of each standard type and any special tower, inclusive of all body and leg extensions shall be subject to a check assembly. The members employed for the check assembly shall be selected at random by the Employer's representative, and assembled to form complete towers, in the presence of the Employer's representative, at the manufacturer's works.

Check assembly should include anti-climbing devices, bird guards and anti-theft bolts to check the suitability.

12.3.5.3. Type test

As required by the Employer's representative, one tower of each standard type shall be assembled at approved place (accredited laboratories) and shall be tested on a rigid foundation.

If the Contractor, in carrying out erection of steel towers on the site, proposes to assemble the towers on the ground subsequently raising them to the vertical position, the sample towers submitted for test shall be so assembled and raised to the vertical position on the test foundation in the presence of the Employer's representative. Dimension and thickness of the members as well as plates to be checked and if found positive, same must be fabricated during fabrication of towers in the line.

Each tower shall then be tested in accordance with IEC 60652 and subjected to such test loads as the Employer's representative may specify in order to prove compliance with the ultimate loading conditions including the overload factor stated in the Technical Schedules, applied in an approved manner without showing signs of failure or permanent distortion in any part.

Tower type tests shall be performed for at least seven (7) load cases. Tests to destruction shall then be carried out up to 120% loadings in an approved manner on all tower types. No tower or parts of any tower submitted for destruction test shall be used on the contract Works, and steel members shall be destroyed or marked in an approved manner.

Steel towers submitted for test shall be galvanized unless specific approval is obtained. All tower tests for which the results are approved will be paid for at the rates stated in Volume 1. Towers shall be provided with anti-climbing devices on at least 1 leg to facilitate inspection of the proposed devices.

After type test, the Employer's representative has the right to choose some tower members, bolt, and nuts for sample tests. All sample tests results must be submitted to Employer for review.

Test station to be loaded tower for type test as per IEC 60652 for tolerances mentioned in the IEC 60652, and test station as well as designer and EPC shall note that 100% load to be applied with positive tolerance on the tower and test station shall maintain all the loads with positive tolerances otherwise test is rejected.

12.3.5.4. Zinc coatings

12.3.5.4.1. Sample tests

Samples, selected by the Employer's representative, of all zinc coated material shall, unless otherwise approved, be subject to the following tests:

For material other than wires, the tests specified in BS EN 1461 and BS 7371 Pt 6.

For wires, the tests specified in BS EN 10244 Part 2.

12.3.6. Tests on foundations

12.3.6.1. General

Type testing and proof testing of foundations shall be carried out in accordance with IEC 61773. The total number of each type of test may vary but it is generally considered that where foundation designs are more conservative less testing will be required and where foundation designs are more efficient greater testing will be required.

The location for each test and choice of foundation to be subjected to test shall be to the Employer's representative's approval. Method Statements, Testing Proposals, and Calibration Certificates, shall be submitted in advance to the Employer's representative for approval and shall include details of the following:

- Relevant ground investigation data
- Foundation type and installation procedure
- Proposed type and set-up of testing equipment
- Unique reference numbers of calibrated instruments and equipment
- Foundation testing procedure and test record sheets to be completed on site (record sheets should clearly include proposed loading/unloading targets and minimum monitoring periods)
- Proposed testing schedule and programme for contract

Additional foundation testing may be requested by the Employer's representative at his discretion. Any foundation tests requested by the Employer's representative for which the results are approved will be paid for at the rates stated in Volume 1.

12.3.6.2. Type tests (Design)

Type tests, or design tests, shall consist of site trials of sacrificial foundations installed to the same methodology as that intended for the working foundations. Design tests shall involve uplift and compression tests to ultimate design loadings or to destruction and shall be carried out on each class of standard foundation given in the Technical Schedules, or to the approval

of the Employer's representative. Standard foundation classes shall include each soil and rock type expected along the line route. Tests will be such to verify that the selected design parameters for foundations are suitable for the relevant range of ground conditions.

The results of each foundation test are to be correlated to soil properties at the same location to establish a routine procedure for ground testing and correlation of ground parameters to the foundation class for each tower site on the line route. The soil properties at each test site shall be determined primarily by Standard Penetration Tests (SPT) and triaxial compression tests on undisturbed samples taken from at least three different depths within the sphere of influence of the foundation. Special consideration shall be given to the correlation of disturbed backfill soil properties with the cohesion and/or internal friction of surrounding undisturbed soil.

Each foundation shall be subjected to test loads in order to prove compliance with the ultimate loading conditions stated in the Technical Schedules. Test loads may be specified by the Employer's representative. The maximum displacements for settlement and uplift shall be consistent with the type of structure to be supported and comply with the maximum allowable differential movement under simultaneous ultimate loadings given in the Technical Schedules.

The type testing schedule of any foundation design shall be completed in advance of any permanent works utilising that design and shall be used in the verification process of the Contractor's design. For this purpose he will be responsible for carrying out type testing or design testing in the most common ground conditions at an early stage of the Contract.

12.3.6.3. Proof tests

Proof tests shall be conducted on working foundations and individual rock anchors to verify performance for in-service working conditions and as a quality control check on construction. Test loads for proof testing shall be 60 % of the design load (approximately equivalent to 150 % of working load). Routine proof testing will not generally be carried out in compression or on gravity based foundation designs.

12.3.7. Tests on cement and concrete

12.3.7.1. Type tests

Samples from the cement to be used on site are to be taken to a laboratory or testing station approved by the Employer's representative to demonstrate compliance with BS 12 (BS EN 197-1) or BS 915 or BS 4027 as applicable.

Mix design for the concrete shall be proved by carrying out standard 28 day compressive strength testing to confirm the required characteristic strength of concrete can be obtained. When required by the Employer's representative, test results to confirm both the cement content and the dry density of the concrete shall be presented.

12.3.7.2. Sample tests

Tests on the concrete shall be made during the construction of foundations, to demonstrate compliance with this Specification, as required by the Employer's representative. Such tests shall include sampling the concrete and preparation and handling of specimens. The Contractor

shall provide cube moulds and slump cones as necessary. Curing of test cubes shall be made under laboratory conditions and tests shall be performed 28 days after sampling. The Employer's representative may specify tests at 7 days after sampling if the relation between these tests and the 28 day tests has been established.

12.3.8. Tower footing resistances

12.3.8.1. Routine tests

The resistance to earth of each tower shall be measured and recorded in an approved manner. Following the installation of an earthing system to any tower the new resistance to earth of the tower shall be measured, **prior to the erection of all the earth conductors.**

12.3.9. Tests on conductor joints and clamps

12.3.9.1. Routine tests

The electrical resistance of all joints and clamps shall be measured accurately by the Contractor. Measurements shall normally be made before erection of the conductors but where the joint consists of several parts bolted together, such as a dead-end anchor with a jumper terminal, the resistance to be measured is that of the complete assembly. The resistance of all joints shall be recorded and compared to the resistance of an equivalent length of conductor measured adjacent to the fitting. Joints with unacceptable resistances greater than 75 per cent of the resistances of the equivalent length of conductor shall be cut out and remade.

The Contractor shall provide a micro ohmmeter, preferably a digital model for making the above tests, and shall submit details of the proposed instruments to the Employer's representative for approval. Suitable clamps are to be supplied for connecting the current leads of the measuring instrument to the test sample to provide adequate surface contact at the interfaces. Test probes as used for potential contacts are unsuitable for current connections. Stringing of line and earth conductors shall not commence until the instruments are on site and ready for use.

12.3.10. Line insulation and conductivity

12.3.10.1. Routine tests

Tests shall be made on all lines after erection to establish continuity and absence of accidental earth connections.

13. DRAWINGS, DOCUMENTATION AND SAMPLES

13.1. Drawings and documentation

13.1.1. General

All drawings shall be to scale and comply in full with the Technical Specification and be fully detailed. Drawings shall not exceed 1189 x 841 mm (ISO A0 size) and shall bear approved Contract references.

13.1.2. Submittals to be attached to the Bid

13.1.2.1. Drawings

The following are the drawings to be submitted with the Bid.

- a. Tower outlines with clearance diagrams for all the tower types listed in the Technical Schedules.
Each tower outline drawing shall show a route for the step bolts, position of anti-climbing guard, bird guards and notice plates for all standard towers and extensions.
- b. Diagram of external loads:
 - Suspension towers
 - Tension towers
- c. General arrangement of:
 - Suspension insulator sets and fittings
 - Tension insulator sets and fittings
- d. Detailed drawings of:
 - Insulator unit
 - Line conductor tension anchor clamp and midspan joint
 - Line conductor suspension clamp
 - Cross-section of the complete OPGW including the aluminium tube and fibre cable indicating the dimensions of each element, the design and make-up of the cable.
 - Earth conductor tension clamps and midspan joints
 - Earth conductor suspension clamps
 - Line conductor non-tension joint
 - Line conductor vibration damper
 - Earth conductor vibration dampers
- e. Foundation outlines for all standard designs.
- f. Shoring design for all class of foundation
- g. Testing arrangements (foundation test, pile test, tower test etc)
- h. Layouts with proposals of line entries at the respective substations

13.1.2.2. Documentation with bid

The following is a list of documentation to be submitted with the Bid.

- a. Programme of anticipated works, to conform with completion times required in the Special Conditions of Contract.
- b. Details of the method of working to demonstrate that the specified Quality Assurance requirements will be complied with.
- c. Record of previous service experience of the fibre-optic earth wire offered.
- d. Documentary evidence of the successful service history of the proposed aviation warning lights and the proposed damping system for line and earth conductors in environments at least as hostile as that for the present project.
- e. Documentary evidence of satisfactory service history of the polymeric insulators.
- f. Other supporting documentation considered appropriate by the Bidder.
- g. Copies of any standards proposed in substitution for International Electro-technical Commission Standards or Recommendations or British Standards accompanied where necessary by English translations of the appropriate sections.
- h. Tower design booklet (stress calculation table) showing loading considerations, tower base reactions, member sizes, allowable stresses and maximum computed forces in members.

13.1.3. Submittals during contract period

13.1.3.1. Programme of submittals

The Contractor shall arrange his design and drawing programme so that the works can be properly co-ordinated by the Employer's representative. The Contractor shall provide the documentation as specified below as per project time schedule, together with any drawings and information considered necessary by the Contractor or Employer's representative.

- a. Confirmation of contract documentation
- b. A detailed schedule of all plant to be supplied under the Contract. This schedule shall have space for the following information as a minimum requirement in respect of each item :
 - i Manufacturer
 - ii Country of origin
 - iii Planned FOB delivery date
 - iv Planned date of arrival on site
 - v Sub-order number (as applicable)
 - vi Allocated drawing numbers
- c. A preliminary document list and schedule of drawings to be submitted to the Employer's representative for approval in respect of all items of equipment to be supplied under the Contract. The schedule shall include a programme for submittal of all drawings required by the Specification. The schedule shall have space for at least the following information to be added at a later date :
 - i Drawing number
 - ii Drawing title
 - iii Proposed date of submission
 - iv Actual date of submission

- v Resubmissions
- vi Revision numbers
- vii Date of approval
- viii Release as a working drawing
- ix Date to site
- x Date to Employer's representative
- xi Date of as-built drawing

13.1.3.2. Drawing numbers

The Contractor will apply drawing numbers to all drawings, including those from sub-contractors and those issued for information before they are submitted to the Employer's representative. The Contractor's drawing office will be expected to issue the numbers in batches that will cover broad subject areas. For instance the Contractor might propose batches for towers, foundations, insulators, conductors, profiles, etc. The Contractor shall submit to the Employer's representative for approval the subject areas he proposes to use prior to the issue of any drawing. The Contractor shall each month issue an up-to-date drawing list to the Employer's representative.

13.1.3.3. Drawings and documents to be submitted during the contract period.

The documents that shall be submitted by the Contractor, for approval, shall include but not be limited to the following documents and drawing :

- a. Detailed project programme :
To cover all aspects of the Contract : design, procurement, manufacture, testing, shipment and transport, delivery to site, all site operations related to construction, erection and installation, testing at site, commissioning and completion of the transmission line project. This detailed programme shall be submitted within 28 days from the Contract effectiveness.
- b. Design drawings and documents detailing :
 - Calculations giving the design basis to be employed for the sags and tensions for the line and earth conductors for both final and erection conditions and calculations providing data for the manufacture of the sag templates.
 - Derivation of applied loads for all towers including wind on structure.
 - Detailed live metal or wire clearance diagrams for each type of tower.
 - Basis to be employed for the design of structures.
 - Analysis of maximum member and connection loads and capacities for all members in standard towers, body and leg extensions.
 - Structure foundation loads for all loading cases demonstrating that the critical condition for any combination of body and leg extension has been considered.
 - Foundation designs for all standard classes, including stub and cleat designs.
 - Concrete mix design.
 - All equipment (e.g. conductor, shield wire, OPGW, insulator, etc) datasheet

These shall be submitted as per project time schedule.

c. Arrangement drawings of :

- Each type of standard tower, body and leg extension showing connection to foundations, insulator and earth conductor attachments and complete with all necessary erection information and part list including weight.
- Stubs, foundations (including details of reinforcement, excavation, stub setting).
- Special towers, extensions and foundations (as required).

These shall be submitted as per project time schedule.

d. Detail drawings of :

- Suspension and tension insulator sets, with all fittings and securing devices.
- Insulator units, showing cross section and details of securing device.
- Line conductor tension clamps and joints.
- Tension make-offs and suspension clamps for earth conductors.
- Vibration dampers for line and earth conductors including calculations to demonstrate the efficacy of the proposed system.
- All OPGW ancillary equipment.
- Tower earthing arrangements.
- Tower obstruction lighting and marking.
- Proposed live-line maintenance equipment.
- Danger and property, route and tower number, circuit colour, phase and aerial number plates.
- Curves showing the initial and final sags and tensions of the line and earth conductors at different spans and temperatures, all in accordance with the Specification.
- Route plans, schedules and profile drawings all in accordance with the Specification.

These shall be submitted as per project time schedule.

The general documents titles to be submitted for approval are as follows. It should be noted that contractors document list shall include but not be limited to this list, and contractor shall provide any documents that the Employer's representative finds necessary for the project design, procurement, construction and operation.

No.	Title
1	Design Criteria
2	Route Map
3	Access Road Plan
4	Geology Study Report
5	Surveying (Original Plan & Profile)
6	Spotted Plan & Profile
7	Structure list
8	Check Survey Report

No.	Title
9	Cross/Diagonal Profile
10	Sag - Tension Calculation For Conductor
11	Sag - Tension Calculation For Shieldwire
12	Sag - Tension Calculation For OPGW
13	Conductor Stringing Tables
14	Shieldwire Stringing Tables
15	OPGW Stringing Tables
16	Tower Loadings Calculation
17	Tower & Stub Single Line Drawings
18	Back To Back & Diagonal Tables
19	Tower Design Booklet
20	Tower & Stub Assembly Drawings
21	Tower Bill Of Material (BOM)
22	Tower Application Charts
23	Tower Accessories Drawings
24	Tower Type Test Procedure
25	Tower Type Test Report
26	Tower Sample Test Procedure
27	Tower Sample Test Report
28	Gantry Load Calculation
29	Foundation Calculation
30	Foundation Drawing
31	Foundation Type test procedure
32	Foundation Type test report
33	Concrete Mix Design
34	Concrete test report
35	Earthing System Drawing
36	Insulator Drawings
37	Insulator Type Test Procedure
38	Insulator Type Test Report
39	Insulator Sample Test Procedure
40	Insulator Sample Test Report

No.	Title
41	Conductor Detail Fittings Drawings
42	Shieldwire Detail Fittings Drawings
43	OPGW Detail Fittings Drawings
44	Fittings Type Test Procedure
45	Conductor Fittings Type Test Report
46	Shieldwire Fittings Type Test Report
47	OPGW Fittings Type Test Report
48	Fittings Sample Test Procedure
49	Conductor Fittings Sample Test Report
50	Shieldwire Fittings Sample Test Report
51	Opgw Fittings Sample Test Report
52	Placement Chart For Vibration Damper
53	Conductor Datasheet
54	Conductor Type Test Procedure
55	Conductor Type Test Report
56	Conductor Sample Test Procedure
57	Conductor Sample Test Report
58	Shieldwire Datasheet
59	Shieldwire Type Procedure
60	Shieldwire Type Test Report
61	Shieldwire Sample Procedure
62	Shieldwire Sample Test
63	OPGW Datasheet
64	OPGW Type Procedure
65	OPGW Type Test Report
66	OPGW Sample Procedure
67	OPGW Sample Test Report
68	Method Statement For Construction (Surveying, Foundation, Erection, Stringing, etc.)

13.1.4. Final records

“Records” shall include calculations, drawings, commissioning and pre-commissioning procedures, manuals, and other design documents.

After completion of work on Site all Contract records shall be revised where necessary to incorporate changes made at site and submitted for review. A complete set of the contract records shall be provided for review comprising, one full size reproducible copy and one full size print. After review, the contract records shall be endorsed “As Built” and shall be correctly titled and carry the Employer’s representative’s review number, Contractor’s drawing number and where appropriate KETRACO’s number allocated to the item.

After final review of the “As Built” record drawings the Contractor shall submit three (3) complete sets of electronic editable records on external hard disks and three (3) full size print versions. Electronic copies of the drawings shall be in editable electronic format suitable for reproduction on paper using preferred software packages to be approved by KETRACO. Each hard disk shall provide a comprehensive drawing list containing the drawing number, sheet, revision and title of every drawing. Each single file drawing record shall be self-supporting without referencing other files. If compression techniques are applied to files, then any software necessary to decompress the files shall be included on the disks. The Contractor shall ensure that all information contained on the disks has been checked for virus contamination. Each hard disk shall be supplied suitably encased and accompanied with printed documentation describing the contents.

Final record copies shall be handed over before the issue of the Operational Acceptance Certificate.

The list of drawings required for final record purposes is given below (not limited to):

- Tower and foundation designs and calculations
- Tower and foundation details including all types of extensions
- Insulator sets plus component parts
- Earth conductor suspension and tension sets plus component parts
- All types of connectors, dampers and joints
- Earthing details
- Line conductor and earth conductor initial/final sag-tension charts
- Sag templates
- Wire clearance diagrams
- Material lists for each tower
- Stub setting templates
- Foundation installation details
- Foundation setting level diagrams
- Profiles and strip plans
- Route maps
- Line schedules
- Tower footing resistance chart
- Tower notice plates and accessories.

13.1.5. Installation and maintenance instructions

The Contract Price shall be deemed to include illustrated installation and maintenance instructions written in English.

Before commencement of conductor stringing the Contractor shall submit to the Employer's representative for review fully detailed operating and maintenance instructions for compressors and any other working equipment. Also to be included are instructions on the method of making compression joints and the methods to be used for the erection of all fittings on the line together with the necessary tests and checks to ensure fitting has been successfully effected. The instructions are to be as simple and clear as possible, fully illustrated with drawings and diagrams as necessary and detailed with part numbers for ordering of replacements.

Three (3) hard copies of ALL the installation and maintenance instructions are to be reproduced as a book or books of approximately A4 size and bound into strong black durable imitation leather covers inscribed upon the front generally in the form of the title page to this document except that the references to Specification, Conditions of Contract, drawings, etc., will be replaced by "Installation and Maintenance Instructions".

The name of the main Contractor, but not that of any subcontractor, may also be inscribed upon the cover after the description of the plant. The name of KETRACO shall be inscribed upon the spine.

The finished books are to be handed to the KETRACO not later than 1 month before the Operational Acceptance Certificate is issued.

13.2. SAMPLES

The Contractor shall submit samples of material as required from time to time by the Employer's representative.

14. Appendices

Appendix A- Loading Cases

Appendix B- Normal Loading Condition for Tower Design

Appendix C- Unbalanced Loading Condition for Tower Design

Appendix D- Construction and Maintenance Loading Condition for Tower Design

Appendix E- Foundation design Particulars

14.1. Appendix A- Loading Cases

Item	Load case	Weather condition	Design factor
1	Maximum wind (Perpendicular)	Minimum temperature + full wind	2
2	Maximum wind (Perpendicular)	Every Day Temperature + full wind	2
3	Maximum wind (Oblique at 45°)	Minimum temperature + full wind	2
4	Maximum wind (Oblique at 45°)	Every Day Temperature + full wind	2
5	Maximum wind (Long at 0°)	Minimum temperature + full wind	2
6	Maximum wind (Long at 0°)	Every Day Temperature + full wind	2
7	Broken wire *	Minimum temperature + full wind	1.5
8	Cascading	Every Day Temperature + no wind	1
9	Maintenance and Erection	Every Day Temperature + no wind	2
10	Temporary Dead-End (for tension tower)	Every Day Temperature + no wind	1.5

* Remarks

- Following conditions are considered in broken case calculation:
 - Span at broken condition is 0.75 of the normal condition.
 - For double circuit tension tower, simultaneous breakage of two points of any combination among phase conductors and shield wires on the same side of the tower shall be considered.
 - For suspension tower, breakage of one point either one phase conductor or a shield wire shall be considered.
 - Breakage of phase conductor shall mean breakage of all conductors in one phase.
 - In case of a conductor breakage the pull on a suspension tower will be assumed to be reduced to 70% of the specified maximum working tension (due to insulator swing). This reduction shall not be assumed in the case of earth wire breakage.
- For erection and maintenance condition, an additional live vertical load of 150kg for weight of linesman with tools on all tower members shall be considered, that will also be multiplied by the design factor.

14.2. Appendix B- Normal Loading Condition for Tower Design

Tower Type	Load case	Transverse	Verticle	Longitudinal
Straight Line (Suspension insulators)	1	Wind Perpendicular	Maximum	-
	2	Wind at 45°	Maximum	-
	3	Wind Perpendicular	Minimum	-
	4	Wind at 45°	Minimum	-
Angle (Tension insulators)	1	Wind Perpendicular	Maximum	Section
	2	Wind at 45°	Maximum	Section
	3	Wind at 0°	Maximum	Section
	4	Reversed Wind	Maximum	Section
	5	Wind Perpendicular	Uplift	Section
	6	Wind at 45°	Uplift	Section
	7	Wind at 0°	Uplift	Section
	8	Reversed Wind	Uplift	Section
Terminal (Tension insulators)	1	Wind Perpendicular	Maximum	Normal
	2	Wind at 45°	Maximum	Normal
	3	Wind at 0°	Maximum	Normal
	4	Reversed Wind	Maximum	Normal
	5	Wind Perpendicular	Uplift	Normal
	6	Wind at 45°	Uplift	Normal
	7	Wind at 0°	Uplift	Normal
	8	Reversed Wind	Uplift	Normal

Remarks:

- For more details refer to clause 4.7

14.3. Appendix C- Unbalanced Loading Condition for Tower Design

Tower Type	Unbalanced Conditions In Any One Span (I.E., In Same Direction)		Transverse		Vertical	Longitudinal
			Due to Wind	Due to angle deviation		
Straight line (suspension insulators)	Broken at any one attachment	Phase	75%	100%	75%	70% of Tension at related case*
		Earth	75%	100%	75%	Tension at related case
	Cascade collapse conditions at all attachments	Phase	75%	100%	75%	70% of EDT
		Earth	75%	100%	75%	EDT
Angle (tension insulators)	Broken at any two attachments	Either Phase	75%	100%	75%	Tension at related case
		or Earth	75%	100%	75%	Tension at related case
	Cascade collapse conditions at all attachments	Phase	75%	**	75%	EDT
		Earth	75%	**	75%	EDT

Remarks:

- For more details refer to clause 4.7
- EDT (EDS) = Every Day Tension (Stress)
- * Broken condition must be considered at Minimum temperature + full wind case
- **The transverse component of the conductor/earthwire tension at any line deviation between minimum and maximum.
- Min weight span one side and both side for suspension towers to be considered as zero

14.4. Appendix D- Construction and Maintenance Loading Condition for Tower Design

Tower Type	Loading Condition		Loads at phase and earth conductor attachment points		
			Transverse	Vertical	Longitudinal
Straight line (suspension insulators)	Maintenance condition	Phase:	-	2 * Maximum + 150kg	-
		Earth:	-	2 * Maximum + 150kg	-
Angle and terminal tower (tension insulators)	Temporary terminal condition	Phase:	*	Maximum	EDT
		Earth:	*	Maximum	EDT
	Maintenance condition	Phase:	-	2 * Maximum + 150kg	-
		Earth:	-	2 * Maximum + 150kg	-

Remarks:

- For more details refer to clause 4.7
- EDT (EDS) = Every Day Tension (Stress)
- 150kg should be added for lineman and tools
- *The transverse component of the conductor/earthwire tension at any line deviation between minimum and maximum.

14.5. Appendix E- Foundation design Particulars

Foundation Class	1	2	3	4	4W	5	5W	6
Foundation types	Rock anchor	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Concrete pad and chimney	Special: Piling, raft, enlarged concrete pad and chimney
Approximate soil description	Homogeneous rock	Fractured rock/hard clay/ very dense sand	Stiff clay/ dense sand	Firm clay/ medium dense sand	Firm clay/ medium dense sand	Soft clay/ silt/ loose sand	Soft clay/ silt/ loose sand	Subject to detailed soil investigation
Net allowable design bearing capacity under ultimate load (kN/m ²)	>750	>400	>250	>150	>100	>50	>50	Subject to detailed soil investigation
Design uplift frustum angle	30°	25°	20°	15°	10°	10°	0°	As above
Approximate sub-soil investigation parameters:#								
Cohesive soil,N (blows/300mm)	-	>30	>19	>12	>8	>4	>4	As above
Cohesive soil, qc (kg/cm ²)	-	>80	>50	>30	>20	>10	>10	
Frictional soil, N (blows/300mm)	-	>40	>25	>17	>12	>7	>7	As above
Frictional soil, qc (kg/cm ²)	-	>160	>100	>60	>40	>20	>20	
Allowable lateral earth pressure # to (kN/m ²)								
Backfilled/disturbed soil:	Nil	Nil	Nil	Nil	Nil	Nil	Nil	As above
Undisturbed soil:	400	50 + 50H	50 + 25H	Nil	Nil	Nil	Nil	As above

Foundation Class	1	2	3	4	4W	5	5W	6
Water table level	>0.5 m below Fdn level	>0.5 m below Fdn level	>0.5 m below Fdn level	>0.5 m below Fdn level	Grd level to <0.5 m below Fdn level	>0.5 m below Fdn level	Grd level to <0.5 m below Fdn level	As above
Concrete density kg/m ³	2240	2240	2240	2240	2240/1200*	2240	2240/1200*	As above
Undisturbed Soil density kg/m ³	>2000	>1800	>1600	>1500	>1500/1000*	>1400	>1400/960*	As above
Backfill Soil Density kg/m ³	>1600	>1600	>1500	>1400	>1400/960*	>1400	>1400/960*	As above

* Submerged density is subject to verification by foundation test

Notes:

1. Allowable toe pressures for concrete mono block foundations may be 25 per cent higher than the specified bearing pressures shown.
2. Sub-soil investigation limits based upon results of Standard Penetration Test or Dutch Cone penetrometer tests use correlations between N (blows/300mm) or cone resistance q_c (kg/cm²) and allowable bearing capacity generally accepted for most soils.
3. Lateral earth pressure to be considered ignoring first 1.0 m below ground level. H = depth below ground level.
4. Fdn : Foundation. Grd : Ground.
5. For augered shaft foundations the maximum ultimate friction/adhesion stress assumed between concrete and soil, averaged over the depth of the foundation, shall be 60 kN/m².
6. Plain concrete density shall be 2240 Kg/m³, and Reinforced concrete density shall be 2400 Kg/m³.
7. Minimum concrete compressive strength (f'_c) shall be 300 Kg/cm² on Standard Cylinder Sample, or 350 Kg/cm² on Standard Cubic Sample.
8. Minimum rebar yield point (F_y) shall be 4000 Kg/cm².