FIBRE-OPTIC OVERHEAD GROUNDWIRE (OPGW)&FODP

2019

Engineering Department

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TECHNICAL SPECIFICATION FOR COMPOSITE FIBRE-OPTIC OVERHEAD GROUNDWIRE (OPGW)

1.0 GENERAL REQUIREMENTS

The requirement includes the design, supply, stringing and splicing of OPGW cable on 400KV, 220KV & 132KV Transmission Towers.

This specification defines the design, material, performance and test requirements for fibre optic cable to support the fibre optic telecommunication needs.

The work covered by this specification shall include the design, engineering, transfer of technology, manufacture, factory tests, supply, transportation, training, survey, installation, end to end field tests etc. complete for the 400KV, 220&132KV Transmission lines under this contract.

The Contractor shall be responsible for completing a survey of the designed OPGW cable routes, designing the fibre cable system, supplying the fibre cable and associated equipment (including termination of the fibres, jointing boxes and all related accessories), installing the OPGW and carrying out end to end tests on fibres for all links.

2.0 SCOPE OF WORK:

The scope of work includes, but are not limited to the following :

a) The provision of completing operational turnkey fibre system that shall include the overall project management, engineering design, transfer of technology, training of Employer's representatives, supply, testing, integration, delivery to the sites, unloading, storing, handling and moving to the final position, installation, testing and commissioning of the system complete. All hardware & accessories shall be field proven and should be latest modified version.
b) Design & installation of the mechanical assemblies and accessories including vibration dampers required for installation on the OPGW cable.
c) Development of installation guides and procedures for the stringing, mechanical installation and splicing of the OPGW cable, including testing & documentation. This includes termination of approach cable from OPGW at the terminal towers/gantry structure of Sub-Station end up to Fibre Optic Distribution Panel (FODP).
d) Supply, laying, jointing, termination etc. Fibre Optic Approach Cable from OPGW-Cable junction point to FODP through new and/or existing cable trench with suitable cable jacket and providing necessary cable protection from power & control cable by arranging cable tray/suitable hanger system in co-ordination with successful bidder of sub-station package and also with other suppliers' equipment.
e) Supply & installation of FODP at each Sub-station where fibre optic links are to be established.
f) Splicing required for the optical fibres.
g) Testing the fibre system end to end over several tandem paths.
h) Factory and field testing of fibre cable.

i) Providing documented evidence of satisfactory Type Test performance of similar type OPGW to employer.
j) Transportation/Shipment of all equipment and documentation to employer designated location and/or staging areas.
k) All documentation and drawings as specified.
l) All required spare parts, maintenance aid and test equipment.
m) Training of employer personnel in installation of fibre cable, splicing of fibres and use of test equipment

3.0 Optical Fibre Cable Link Lengths

For bidding purposes the estimated optical fibre link lengths i.e. length of OPGW has been mentioned in the bidding schedule. However, the Contractor shall supply and install the optical fibre cable as required based on detailed site survey (and keeping reasonable allowance for loops on Transmission Towers and splices) to be carried out by the Contractor during the project execution. The Cable length as finalized by the Contractor shall be duly ratified by the Employer. Contract price shall be adjusted accordingly as per unit rate.

4.0 Fibre Optic Cabling :

This section defines the minimum requirements for Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. Bidders shall furnish with their bids, detailed descriptions of the cables(s) proposed. As a minimum, the descriptions shall include information on the fibre manufacturer, cable configurations, fibre grade, optical characteristics, fault and lightning tolerances and any other pertinent information required for an accurate evaluation.

5.0Fibre Optic Cable Construction:

Fibre optic cable shall be of Optical Ground wire (OPGW) type suitable for stringing over 400KV, 220KV & 132KV Transmission Towers. OPGW termination at switch yard shall be done through suitable splicing JB to be placed suitably on switch yard Gantry structures. From splicing JB, fibre optic lead cable suitable for direct burial in trenches/pipes having identical fibre properties as the aerial cable, shall be drawn up to Fibre Optic Distribution panel (FODP) to be installed inside control room building.

The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. All optical fibre cabling and all associated installation hardware shall have a minimum guaranteed design life span of 25 years.

5.1 Required Optical Fibre Characteristics:

This section describes the characteristics of optical fibre to be provided under this specification.

5.1.1Physical Characteristics:

The OPGW cable shall consist of 24/48 fibres as mentioned in BOQ, all of which shall be of DWSM (Dual Window Single Mode) type for which optical characteristics are defined in table 2-1.

5.1.2. Attenuation Variation:

This attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 db/km. The attenuation coefficient between 1285 nm and 1330 nm shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 db/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 db. The fibre attenuation characteristics specified in table 2-1 shall be "guaranteed" fibre attenuation of any and every fibre reel. Further the typical or average cabled fibre attenuation shall be as follows :

DWSM fibres : 0.35 dB/km @ 1310 nm
0.22 dB/km @ 1550 nm

The overall optical fibre path attenuation including all optical cable losses caused by bending, compression, splicing and terminations shall be less than 0.25 dB/km @ 1500 nm. Excessive splice or coupling losses demonstrated as resulting from fibre mismatch with dissimilar fibre, shall be documented and submitted to the purchaser.

Table 2-1

DWSM optical fibre characteristics

Fibre Description		Dual – Window Single – Mode
Mode Field Diameter		As per ITU –G.652 9.2 ± 0.4 µm at 1310 nm 10.4 ± 1.0 µm at 1550 nm
Cladding Design		Either matched or depressed
Clad Diameter		125.0 µm ± 1 µm
Core-Clad Concentricity Error		≤ 0.8 µm
Coating Diameter		245 µm ± 5 µm
Coating Concentricity		≤ 10 µm
Attenuation Coefficient		@ 1310 nm: ≤ 0.35 dB/km @ 1550 nm: ≤ 0.22 dB/km
Attenuation at water peak		@ 1393 ± 3nm ≤ 2.1 dB / km
Bend Performance		@ 1310 nm : (60 ± 2 mm dia Mandrel), 100 turns, Induced Attenuation ≤ 0.05 dB/km
		@ 1550 nm : (60 ± 2 mm dia Mandrel), 100 turns, Induced Attenuation ≤ 0.05 dB/km
		@ 1550 nm (32 ± 0.5 mm dia Mandrel), 1 turn, Induced attenuation ≤ 0.50 dB/km
Temperature Dependence		Induced attenuation ≤ 0.05 Db/KM (-60°c TO 85°c)
Temperature-humidity cycling – 10°C ± 85°C (85-95% RH)		Induced attenuation ≤ 0.05 dB/km
Cable Cutoff wavelength		≤ 1280 nm
Chromatic Dispersion	Maximum	20 ps / (nm x km) 1550 nm
		3.5 ps / (nm x km) 1285 – 1330 nm
		6.0 ps / (nm x km) 1270 – 1340 nm

	Zero Dispersion Wavelength	1295 to 1325 nm
	Zero Dispersion Slope	0.093 ps / (nm2 x km) maximum
Proof Test Level		≥ 100 Kpsi

5.2. Optical Fibre Identification

Colour coding is essential for identifying individual optical fibres and groups of optical fibres. Individual optical fibres within a fibre unit, and fibre units shall be identifiable as per IAW EIA-RS 598 colour-coding scheme. The colour coating shall be permanent thus withstanding normal handling e.g. during termination, testing or cable relocation throughout the design life of the cable.

Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing.

Each cable shall have traceability of each fibre back to the original fibre manufacture's fibre number and parameters of the fibre.

If more than the specified numbers of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

Each loose tube that contains 6 / 12 nos. Optical Fibres shall be of different colour.

5.3 Buffer Tube

Either loose tube or tight tube buffer construction may be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. If loose tube buffer construction is provided, buffer tubes shall be filled with a water-blocking gel.

5.4 Optical Fibre Strain

The cable strain margin is defined as the maximum cable strain at which there is no fibre strain.

The fibre optic cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep.

The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.

The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.

5.5 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC-794-I-F-5 up to 80°C.

The filling compound used shall be an non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, nonhygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The filling compound shall remain stable for ambient temp between - 20°C and + 80°C and shall not drip, flow or leak with age at high temperatures during short duration lightning strikes and short circuit currents. The filling compound shall meet the requirements of 'Seepage of Filling Compound test' as per EIA / TIA 455-81 for 80°C temperature.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, nonstaining and easily removable with a non-toxic cleaning solvent.

5.6 Outside Jacket Materials

The outer cable jacket for wrap around cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultraviolet light, weathering and high levels of pollution. The jacket shall conform to low density, medium density and high density polyethylene standards as defined in ASTM D1248.

Gel filled stainless steel tube meeting the criteria to protect the fibres from exposure to ultraviolet light, weathering, high levels of pollution etc. may also be offered

5.7Protection Tubes

The optical core, including fibres shall be contained and protected by a tube. The tube may be made of Aluminium alloy that is continuous, fully sealed, water tight and without mechanical joints. Both welded and unwelded tube is acceptable if the same meets the requirement of Water Penetration Test, as per IEC-794-1-F5. The tube shall have sufficient resistance in order to protect the Optical Fibres from radial compression, transmitted by the metallic wires of the external layers. Under the normal operating conditions, including aeolian vibration, sheeve pulling at Minimum / Maximum Temperature and Maximum Operating Tension, the tube shall not open, fissure and shall not be deformed. The internal surface of the tube shall be smooth, without smudges, notches, residues or roughness that may affect the Optical Fibres, or the P.E. sheathing. The internal and external surface of the tube shall be circular and the thickness shall remain constant, as specified earlier. No tube joints shall be allowed in the finished OPGW. Stainless steel tube is also acceptable if the same meets the requirements.

5.8 Metallic wires

a) The OPGW shall conform to the applicable Clauses of the IEC 1089 related to standard conductors. Adjacent wire layers shall be stranded with reverse lay directions. The direction of lay of the external layer shall be left hand.
b) Alluminium alloy / aluminium clad steel wires shall be smooth, uniform and free from all imperfections that are visible in the naked eye, such as spills and splits, die marks, scratches, abrasions and kinks.

5.9 Sheathing Removal

The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units.

6.0 OPTICAL GROUNDWIRE (OPGW)

The OPGW cable construction shall comply with IEEE-P 1138 and IEC publications 1396. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in earlier. There shall be no factory splices within the cable structure of a continuous cable length.

The OPGW structure shall be based on the following characteristics:

The composite fibre optic overhead ground wire shall be made up of buffered optical fibre units embedded in a water tight aluminium / aluminium alloy / stainless steel protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre.

Electrical characteristics of the OPGW must be equal to or better when compared to standard ground wire. The electrical conductivity must be designed to withstand the specified short circuit currents. The OPGW cable selected shall withstand the temperature increase caused by the maximum short circuit current. The Bidder shall describe the electrical parameters of the OPGW proposed.

The mechanical structure of OPGW shall be designed to withstand the wind and other environmental conditions in the routes, which have been specified in this document. The location of the fibres inside the structure shall be such that the application of the OPGW in the specified routes is possible. The selected OPGW cable shall tolerate the normal installation procedures. The Bidder shall list the mechanical parameters of the OPGW and describe the cable structure including how the fibres are located inside, and shall furnish the cross-sectional drawing of OPGW.

The cable structure shall be such that the fibres are protected against water, hydrogen ultraviolet radiation and other environmental hazards encountered in India.

The metallic wires have to give the OPGW, conductivity to carry fault currents and the strength to withstand mechanical stresses. Aluminium alloy, aluminium clad steel wires or a combination of them shall be used. The OPGW shall withstand, without change in its characteristics a lightning current of 150 kA (peak). The

minimum allowable radius of bending for OPGW within the specified temperature range should be 20 x D, where D is the outer diameter of the OPGW.

The fibre tubes shall have a high crush resistance and minimum permanent or temporary deformation under mechanical pressure. The fittings must be designed to prevent these pressures. OPGW elongation under different stress situations likely during wind loads or during ground faults shall be considered.

6.1 Basic Construction

The cable construction shall conform to the applicable requirements of applicable clauses of IEC 1809 related to stranded conductors and Table 2.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall included bare concentric-lay-stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices; however, in case the contractor feels that joints or splices are absolutely necessary, it should only be done upon obtaining approval from the Employer and conforming all applicable clauses of IEC 1089 as they pertain to stranded conductors.

The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

6.2Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen. The central fibre optic unit may include an aluminium tube/hermetically sealed stainless steel tube. If aluminium rod is used, it shall be fabricated with one or more channels or grooves and formed into a helix to house the buffered optical fibres. An outer protective shield shall be applied around the rod such as an aluminium tube or helically-applied overlapping aluminium tape to provide an additional mechanical and environmental barrier.

6.3Breaking Strength

The rates breaking strength of the complete OPGW shall be taken as no more than 90% of the sum of rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength.

The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

6.4Electrical and Mechanical Requirements

Table 2-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to the electrical & mechanical characteristics of the earthwire specified such that there is no or minimal consequential increase in stresses on towers. The standard GSS earthwire parameters are listed hereunder. For the purpose of determining the appropriate Max. working Tension limit for the OPGW cable, IS 802:1995 and IS 875:1987 shall be applied. However the OPGW installation sag & tension charts shall be based on IS 802 version to which the line is originally designed. For the OPGW cable design selection and preparation of sag tension charts the limits specified in **civil specification** shall also be satisfied. The Bidder shall submit sag-tension charts with their bids.

Table 2.2(a)
OPGW Electrical and Mechanical Requirements

1.	Everyday Tension at 32°C, no wind	≤ 20% of UTS of OPGW
2.	D.C. Resistance at 20°C	≤ 1.0 ohm / km
3.	Diameter	≤ 12 mm for 132KV & 220KV and ≤12.5 mm for 400KV
4.	Weight in kg / km	≤ 428 kg for 132KV & 220KV and ≤455kg for 400KV
5.	No. of fibre / tube	6/12
6.	No. of Tubes	4/8
7.	Short Circuit Current	≥ 6.32 KA for 1 second

Table 2.2(b)
Existing Galvanised Stranded Steel Wires (7/3.15mm&7/3.66mm) used as Earthwire.

Sl. No.	Description	Tchnical Particulars	
		132KV &220KV	400KV
1.	Grade of Steel wire	1100N/sq. Mm.	
2.	Total weight	428 Kg/Km (standard)	583 Kg/Km (standard)
3.	Maximum working tension at 32°C with full wind	2962 Kg	3705.2 Kg
3.	Maximum working tension at 32°C with No wind	1425.8 Kg	1326.4 Kg
4.	Standard of compliance	IS-2141/BS-183	
5.	Minimum breaking load	56 KN	68.34 KN
6.	Overall diameter	11.7 mm	10.98 mm
7.	Modulus of elasticity	787000 Kg/sq. cm.	1860000 Kg/sq.cm.
8.	Co-efficient of linear expansion	17.8 x 10^{-6} per deg C	11.5 x 10^{-6} per deg C

6.5Operating Conditions

Since OPGW shall be located at the top of the EHV transmission line support structure, it will be subjected to Aeolian vibration, galloping and lightning strikes. It will also carry ground fault current. Therefore, its electrical and mechanical properties shall be the same or similar as those required of conventional G.I. ground conductors (7/3.15 mm&7/3.66mm).

6.6Installation

OPGW shall be installed on the top of 400KV, 132KV & 220KV Transmission Towers. The installation shall be generally in accordance with the IEEE Guide to the installation of Overhead Transmission Line Conductors (IEEE STD, 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling.

6.7 Marking, Packaging and Shipping

This section describes the requirements for marking, packaging and shipping the fibre optic cable.

a] Drum Markings : Each side of every reel of cable shall be permanently marked in a minimum of 5cm high white lettering with the vendor's address, the Employer's destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line and segment no, factory inspection stamp and date.

b] Cable Drums : All optical fibre cabling shall be supplied on strong drums provided with lagging of strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.

There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a "schedule" prepared by the Contractor; however, the length of cable generally be 4km.

6.8 Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware used. To ensure their satisfactory performance, the Contractor shall determine the exact requirements of all accessories used to install and secure the OPGW.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in § 4.0 of EN 61284 1997 (IEC 61284). The shear strength of all holts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & GTP shall consist of all component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc. shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used of OPGW installations and will be used for payment purposes and any extra fittings if required are to be supplied & erected without any extra cost. The bidder should carry out an actual field survey and to assess such extra attachments so that their cost can be included in the supply rates of the specified items while quoting.

a) Suspension Assemblies :

Performed armour grip suspension clamps and aluminium alloy armour rods/reinforcing rods shall be used. The suspension clamps shall be designed to carry a vertical load of not less than 25KN. The suspension clamps slippage shall occur between 12KN and 17KN as measured in accordance with type test procedures.

The Contractor shall supply all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, etc. the total drop of the suspension assembly shall not exceed 150mm (measured from the centre point of attachment to the centre point of the OPGW). The design of the assembly shall be such that the direction of run of the OPGW shall be the same as that of the conductor. The designed length of the assembly should be such as not to violate the electrical clearance between OPGW & Live conductor.

b) Dead End Clamp Assemblies :

All dead end clamp assemblies shall be of the performed armoured grip type and shall include all necessary hardware for attaching the assembly to the tower strain plates. Dead end clamps shall allow the OPGW to pass through continuously without cable cutting. The slip strength shall be rated not less than 95% of the rated tensile strength of the OPGW.

c) Clamp Assembly Earthing Wire :

Earthing wire consisting of a 1500 mm length of aluminium or aluminium alloy conductor equivalent in size to the OPGW shall be used to earth suspension and dead end clamp assemblies to the tower structure. The earthing wire shall be permanently fitted with lugs at each end. The lugs shall be attached to the clamp assembly at one end and the tower structure at the other.

d) Structure Attachment Clamp Assemblies (for attachment with (a) Suspension Towers & (b) Tension Towers) :

Clamp assemblies used to attach the OPGW to the structures shall have two parallel grooves for the OPGW, one on either side of the connecting bolt. The clamps shall be such the clamping characteristics do not alter adversely when only one OPGW is installed. The tower attachment plates shall locate the OPGW on the inside of the tower and shall be attached directly to the tower legs/cross-members without drilling or any other structural modifications. Clamp assemblies earth wire should be

provided for attachment to each suspension/tension tower.

e) Vibration Dampers :

Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth, shall be used for suspension and tension points in each span. The Contractor shall determine the exact numbers and placement(s) of vibration dampers through a detailed vibration analysis, if required. Vibration damper clamps shall be made of aluminium or aluminium alloy, shall support the dampers during installation and shall maintain the dampers in position without damage to the OPGW and without causing fatigue. Armour or patch rods made of aluminium or aluminium alloy shall be provided as required to reduce clamping stress on the OPGW. The vibration damper body shall be hot-dip galvanized mild steel/cast iron or shall be permanent mould cast zinc alloy. Damper placement charts along with calculations need be submitted by the successful bidder.

7.0 Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach/lead cable is defined as the cable installed between the final in line splice enclosure on the gantry forming the termination of the fibre cable on the power line (OPGW) and the Fibre Optic Distribution Panel (FODP) installed within the terminal building. The Contractor shall supply and install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution.

Approach Cable shall be a UV resistant fire retardant rodent proof, armoured cable with steel tape, corrugated tube or galvanized wire type armour construction cable. The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways and shall have minimum 2.0 mm HDPE outer jacket thickness.

Approach cable shall contain fibres with identical optical/physical characteristics as those in the aerial cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

It will be the responsibility of the Contractor to arrange for splicing of the Approach Cable with the OPGW cable inside a splice box located at the base of the terminal towers at both ends.

The termination of the other end of the approach cable inside the building will be done by the Contractor.

8.0 Optical Fibre Termination and Splicing

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide appropriate sized Fiber Optic Distribution Panels (FODPs) and shall terminate the fibre optic cabling upto the FODPs. The Contractor shall be responsible for connectivity between the FODP and the terminal equipment. The location of FODP rack shall be fixed in suitable place preferably adjacent to the Optical equipment.

9.0 Fibre Optic Distribution Panels

At each location requiring the termination of at least one fibre within a cable, all fibres within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following :

a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and spile trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.

b) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass-through splicing and fibre terminations.

c) All FODPs shall be of corrosion resistant, robust construction and shall allow both top of bottom entry for access to the splice trays. Specific selection of the entry points shall be made at the time of installation. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP for indoor installation shall meet or exceed ingress protection class IP55 specifications.

d) **FODP will be of minimum 96 fibre**.

Table 2.2(c)
Technical details of FODP

Sl. No.	Description	Tchnical Particulars
1	Dimension (H*W*D) mm	1400*600*400
2	Construction Materials	Sheet Steel/ CRCA minimum 2mm thick
3	Installation clearance: Front Access (cm) Rear Access(cm): Top*Bottom*Sides(cm)	 60 60 60
4	Colour & Finish	Light Grey, RAL 7035
5	Coating thickness	75 µm
	FODP 96Fibres Sub-rack	
1	Construction Materials	Cold-Rolled Steel minimum 2mm thick
2	Cable Glanding & Fixing	Six Cable glanding & fixing
3	Locking Arrangement	Two slots for door snap-on/ Two slots with Nylatch
4	Total no. Of optical couplings	96 FC/PC connectors
5	Provision for pass through splicing	yes
6	No. of cables that can be accommodated	6 (each of 48Fibre)
7	Diameter of cable that can be accommodated	8-30mm
8	Cable entry	Suitable for all 24 & 48 Fibre approach cable
9	Method of mounting	19" rack mounting in cabinet
	Splice Trays	
1	Material	Acrylonitrile Butadiene Styrene(ABS)

2	Method of mounting	Sub-rack containing all splice trays or individual splice trays to be of sliding and detachable type.
3	No. of splice Trays	8
4	Maximum no. of splices per tray	12

10.0 Optical Fibre Connectors

Optical fibres shall be connectorised with **FC-PC type** connectors. Fibre optic coupling supplied with FODPs shall appropriate for the fibre connectors to be supported. **There shall be no adapters allowed**.

11.0 IN-LINE FIBRE OPTIC SPLICE ENCLOSURES

All in-line splices shall be enchased in In-Line Fibre Optic Splice enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in a protective enclosure and dust free environment. The splice enclosures shall be designed for the storage and protection of a minimum of 144 optical fibre splices and shall provide access through lockable doors. They shall be fitted with suitable encapsulant that is easily removable, should re-entry be required into the enclosures.

In-line splice enclosures shall be suitable for outdoor use specifications and shall be suitable for tower mounting. with the OPGW cable provided under this contract.
The OPTIC SPLICE ENCLOSURES for outdoor installation shall meet or exceed ingress protection class IP66

Splice enclosures shall be appropriate for mounting on EHV Transmission towers above anti-climb guard levels at about 10 meters from ground level and shall accommodate pass-through splicing.

12.0 OPTICAL FIBRE SPLICES

Splicing of the optical fibre cabling shall be minimised through careful contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur within facilities or on tower structures. All optical fibre splicing shall comply with the following :

a) All fibre splices shall be accomplished through fusion splicing.
b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
c) All splices and bare fibres shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.
d) Attenuation of single mode fusion splices shall not average 0.05 dB and no single splice attenuation shall exceed 0.1 dB when measured at 1310 / 1550 nanometers.
e) For in-line splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

13.0 Methodology for installation and Termination

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture.

Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage, the complete span shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work of modifications required to attach the fibre cabling to the overhead transmission/distribution line towers shall also be carried out by the Contractor. The Contractor shall supply all tools and accessories required for installation. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

14.0 Service Loops

For purpose of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

a) Outdoor Cable Service Loops :

FODPs and in-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

b) Indoor Cable Service Loops :

FODPs shall provide at least three (3) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius are maintained.

c) Fibre Units Service Loops :

For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out or fibre units shall provide for at least one (1) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.

d) Pigtail Service Loops :

Connectorized pigtails spliced to bare fibres shall provide a least 0.5 metre of service loop installed in the FODP fibre organizer and at least 1(one) metre of service loop to the couplings neatly stored behind the FODP coupling panels.

e) Fibre Service Loops :

At least 0.5 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

The Contractor shall supply and install this fibre optic cable, including design, supply & installation of all required installation hardware fittings & accessories and including any custom designed hardware fittings & accessories as required. The installed unit shall be used mainly as the pilot wire suitable for the numerical pilot wire current differential protection system to be operated between concerned line terminals. The Contractor shall supply and install the optical fibre cable and approach cable & other accessories as required based on the actual requirement. The specified items will be paid as per the unit rates quoted. **Un-specified items shall be included in the supply rates after actual site visit.** Termination of fibres to FODPs through appropriate connectors shall be done by the Contractor at no extra cost. Cost of supply of connectors & other termination materials as along with termination work, shall be included in rate for "laying & termination" of fibre optic cables.

15.0 Installation of Approach Cable :

A network of cable trenches and / of ducts may exist at some sites but shall require expansion and / or new construction at stations. It shall be a responsibility of the Contractor to co-operate fully with the Employer and all other on-going project Contractors in the planning and efficient use of existing and new-construction infrastructure supporting on-station communications cabling. The existing cable trenches / cable raceways proposed to be used shall be identified in the survey report. The contractor shall make its best effort to route the cable through the existing available cable trenches. Where suitable existing cable trenches are not available, suitable alternatives shall be proposed for Employer's approval. The contractor shall provide any additional outdoor cable raceways and / or cable trenches required for such approved alternative.

It may be noted that in order to utilise the existing trenches, the approach cable may be required to be co-located with HV and LV cables. Accordingly, the approach cable shall be installed in corrosion resistant flexible conduit. Suitable provisions shall be made by the Contractor to ensure adequate safety earthing and insulated protection for the approach cable.

Approach cables existing from the ground or passing through floors shall be protected against mechanical damage.

Approach Cables will be laid within HDPE cable duct throughout from Gantry-joint box to FODP. Approach cables shall penetrate buildings through cable ducts. The cabling shall route within buildings in cable raceways or under raised floors. The Contractor may utilise existing ducts, building penetration, cable trays, racks, etc. where appropriate and approved by the Employer. The cables shall be affixed to cable supports using approved ties, clips or cleats at regular intervals.

On short approach cable runs for which cable supports are not required, the Contractor shall fix the cable to the structure of the building using approved fixing and cable cleats.

The Contractor shall be responsible for new building penetrations required for approach cabling. Caution shall be taken to ensure that existing equipment and site personnel are protected from dust and debris incident to the cable penetration work.

Penetrations shall be neatly formed and sealed for protection from moisture, dust, wind and vermin intrusion.

All required fittings, supports accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for lay and installation of approach cables shall be supplied and installed by the Contractor.

16.0 Cable Raceways:

The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system the cable raceways shall conform with the following :

a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.
c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information and review.

17.0 INSPECTION AND TESTS

17.1 TYPE TESTS:

Type Test for Indigenous or fully Imported Materials:

The offered equipment must have fully type tested as per relevant ISs and / or any other specified international standards, during the last five years period reckoned from the date of opening of the tender. Photocopy of such type test reports/certificates must be submitted along with the tender bid. The type test certificates of prototype manufactured and tested by foreign collaborators of the tenderers at their works shall not be acceptable for indigenously manufactured equipment.

17.2 Inspection

The material for final inspection shall be offered by the Contractor only under packed condition. The employer shall select samples at random from the packed lot for carrying our acceptance test.

Certificate of manufacturing tests shall be maintained by the Contractor and be produced for verification as and when desired by the Employer.

Materials shall not be transported/shipped from its point of manufacture before it has been satisfactorily inspected and tested.

The acceptance of any quality of materials shall in no way relieve the contractor of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

The Contractor shall give the Employer thirty (30) days written notice of any material being ready for testing.

17.3 General Condition for Tests

a) **The entire cost of testing for acceptance and routine test and test during manufacture specified herein shall be treated as included in the quoted unit price of materials**.

b) The Contractor shall submit for the Employer's approval a Test Procedure Specification at least three(3) months before each individual test will be performed. Fully approved test procedures shall be submitted to Employer at least 4 weeks prior to the commencement of testing. The test procedure specification shall specify the details test in accordance with the requirement of this specification.

c) The Employer reserves the right to require the Contractor to perform any other reasonable test(s) at the Contractors premises, on site or elsewhere in addition to the aforementioned Acceptance, Routine or manufacturing tests to assure Employer of specification compliance.

17.4 Test Plans

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

There shall be two factory and field tests shall be submitted for Employer's approval at least three months before the start of testing.

17.5 Factory Acceptance Tests

Factory tests shall be conducted on selected sample of equipment to be supplied. Equipment shall not be shipped until required Factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer and the Employer has approved for shipment/transportation. Successful completion of the Factory tests and the Employer's approval to ship/transport shall in no way constitute final acceptance of the system or any portion thereof.

Factory tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer. In addition, upon the approval of the test documents by the Employer, the Contractor-supplied maintenance and operators manuals will be used during the tests as guide and as a check that each manual is correct and complete.

1. Acceptance Test of OPGW

10% of all offered items of each LOT shall be selected for witnessing acceptance tests.

A) Tests on finished Cable

1) Cable dia
2) Attenuation of Fibers at 1310nm & 1550nm
3) Attenuation coefficient at water peak
4) Chromatic Dispersion
5) Cable Cut-off wavelength
6) Rated/Ultimate Tensile Strength for 1 Sample from selected OPGW drums/Lot
7) Cable lay length & lay ratio
8) Rewinding Test
9) Cable bend Test
10) Weight of Cable
11) Strain Margin Test

B) Tests on Aluminium Alloy wires and Aluminium Cladded Steel wires

1) Dia of wire
2) Tensile sterength
3) Elongation at break
4) Resistivity at 20°C
5) Winding/wrapping test for Al. Alloy wires and Torsion test for Al. Cladded Steel wires
6) Thickness of Aluminium coating for Al. Cladded Steel wires
7) No. of ACS Strands

C) General Tests on Optical Unit

1) Total no. of Fibers, No. of fibers per buffer tube & color coding of optical fibers in each tube
2) No. of buffer tubes, colour of buffer tubes, material of buffer tube
3) Aluminium tube (Outer and inner dia)
4) Binding Yarn /Tape (Thermal barrier)
5) Filling Material
6) Strengthening Member (FRP)

D) Chemical compositions of Al. Alloy wire, Al. Cladded Steel wire and Aluminium tube

2. Acceptance Test of OPGW Hardwares:

A) Suspension Clamp Assembly

i) Visual & dimensional verification
ii) Mechanical Strength (UTS) of the Assembly
iii) Clamp Slip Strength Test
iv) Mechanical Strength Test of each component
v) Electrical Conductivity Test and UTS Test on Outer Rods and Structural reinforcing rods
vi) Galvanising Test
vii) Chemical Test to know material composition

B) Tension Clamp Assembly

i) Visual & dimensional verification
ii) Mechanical Strength (UTS) of Tension Assembly
iii) Clamp Slip Strength Test
iv) Mechanical Strength Test of each component of tension clamp assembly
v) Electrical Conductivity Test and UTS Test on Dead end Rods and Structural reinforcing rods
vi) Galvanising Test
vii) Chemical Test to know material composition

C) Vibration Damper

i) Visual & dimensional verification
ii) Calmp slip Test
iii) Attachment of Weights of Messenger Cable
iv) Attachment of Clamp to Messenger Cable Test
v) Clamp Bolt Tightening Test & Clamp Bolt Torque Test

vi) Vibration Damper Response (Resonant Frequencies) Test and dynamic Characteristics Test
vii) Strength of Massenger wire Test
viii) Galvanising Test

D) Down Lead Clamp & Earth Lead Assembly
i) Clamp Fit Test
ii) Clamp Strength Test
iii) Visual Material Verification and Dimensional Check
iv) Galvanising Test

E) In Line Splice Enclosures (Joint Box) Visual Material Verification and Dimensional Check

3. Acceptance Test of Approach Cable

i) Physical Check of the cable
ii) Optical fiber continuity
iii) fiber attenuation with OTDR (≤ 0.20DB/km @ 1550nm & ≤ 0.35dB @ 1310 nm.
iv) Max. Tensile Strength As per IEC60794-1-E1
v) Cable Bend Test As per IEC60794-1-E11
vi) Repeated Bending Test As per EIA-455-104
vii) Crush Strength As per IEC60794-1-E3
viii) Impact Test As per IEC60794-1-E4
ix) Torsion resistance As per IEC60794-1-E7
x) Kink Test As per IEC60794-1-E10
xi) Drip Test on cable As per TEC procedure
xii) Sheath/Inner Jacket i) Material, ii) Thickness
xiii) Outer Jacket i) Material, ii) Thickness
xiv) Armouringi) Material, ii) Thickness
xv) Rewinding Test
xvi) Starin Margin Test

17.6 Site Acceptance Tests

During the course of installation the Employer shall have full access for inspection of the progress of the work and for checking workmanship and accuracy as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer to demonstrate that it is entirely suitable for commercial operation.

The tests shall be carried out in the presence of and to the satisfaction of the Employer by the qualified technical representatives of the Contractor.

Prior to installation every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

During the installation, spliced cable segments shall be tested and documented. Upon completion of a continuous cable path all fibres within the cable path shall be

demonstrated for acceptance of the cable path. Fibre Optic cable field testing minimum requirements are provided in the following tables.

Fibre Optic Cable Pre-Installation Testing

Item	Description
1	Physical Inspection of the cable assembly for damage
2	Optical fibre continuity end-to-end
3	Per fibre OTDR

Fibre Optic Cable Splice Testing

Item	Description
1	Per Splice Attenuation
2	Per splice OTDR
3	Physical inspection of splice box/enclosure for proper fibre routing techniques.
4	Physical inspection of sealing techniques, weatherproofing, etc.

18.0 MISCELLANEOUS SUPPLIES

The Contractor shall provide all required consumable and non-consumable supplies necessary to support all installation and test activities through final operational acceptance.

19.0 MAINTENANCE SUPPORT FACILITIES IN INDIA

The Bidder shall describe his own maintenance support capabilities and facilities in India in his technical bid.

20.0 Other Services

The following services shall be included in the proposal.

a) An experienced, English speaking instructor shall hold training sessions on installation, commissioning, operation and maintenance of OPGW.
   - One week training for installation, commissioning, jointing, splicing, maintenance etc. for about 5 to 6 persons shall be held at site.

b) WBSETCL shall bear all necessary charges for boarding and lodging at the place of training for the above engineers/working personnel of WBSETCL or authorised representatives for attending the above mentioned training programme at onwers' premises. The training programmes shall be of class room training as well as on job training as mentioned in Clause (a), above. Bidder also to submit training programme and schedule including context of training well in advance (minimum one month) for deputing engineer/working personnel).

c) Factory inspection/acceptance test : The vendor shall bear all necessary charges for inspecting personnel (2 persons)including to and fro journey by air from purchasers headquarters to manufacturers works. This also includes boarding, lodging, medical insurance (in case of inspection to be carried out outside India)etc. at the manufacturers' place and transit, if any for the purpose of inspection and testing.

d) If inspection call raised by the bidder more than one time, they shall have to be borne necessary inspection charges in each inspection.

21.0 Optional Testing Instruments

Price of testing instruments shall have to be quoted by the bidder as per price schedule. Price of testing instruments shall be considered for the purpose of evaluation to consider the most competent bidder.