TECHNICAL SPECIFICATION

ODISHA POWER TRANSMISSION CORPORATION LIMITED

(A Govt. Of Odisha Undertaking)

Regd. Office, Janpath, Bhubaneswar -751022

Design, manufacture & Supply of OPGW cable

Technical Specification for OPGW (24F/48F) With Approach Cable & Associated Hardware Fittings.

Approved by

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1. General Information and Scope

The broad scope of this tender includes design, engineering, manufacturing, supply, transportation, insurance, delivery at site of 24F/48F (DWSM) OPGW cable. The drum Schedule shall be intimated to the successful firm during the award of the contract.

Mostly, the OPGW Cable under this specification shall be installed against replacement of existing earth-wire/OPGW, under dead line/ live line conditions. All the transmission lines where OPGW shall be commissioned are combination of 400kV, 220kV and 132 kV voltage class.

All the materials shall be supplied as per the technical specification specified by OPTCL and from approved manufacturer Vendors list of OPTCL for this tender. The equipment for which GTP or selected Vendors is not specified by OPTCL, the same shall be supplied only after obtaining approval from OPTCL.

1.1 Training (OPGW)

The supplier shall provide all possible facilities for training of Purchaser's Technical personnel, when deputed by the Purchaser for acquiring first-hand knowledge in the production process, jointing, splicing, etc at the works of the manufacturer, wherein it is thought necessary by the purchaser.

2. OPGW cable

This section describes the functional & technical specifications of OPGW cable.

2.1 Fibre Optic Cable

This section defines the requirements for G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. Bidders shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

All optical fibre cable including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable & fibre shall be submitted by the Contractor during detailed engineering.

2.2 Required Optical Fibre Characteristics

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

2.2.1 Physical Characteristics

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1-1(a).

2.2.2 Attenuation

The 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 1-1 (a) shall be "guaranteed" fibre attenuation of any & every

fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below: Maximum attenuation @ 1550nm: 0.21 dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Maximum attenuation @ 1310nm: 0.35dB/km x total km + 0.05 dB/splice x no. of splices + 0.5 dB/connector x no. of connectors

Table 1-1(a)
DWSM Optical Fibre Characteristics

Fibre Description:	Dual-Window Single-Mode
Mode Field Diameter:	8.6 to 9.5 μm (± 0.6μm)
Cladding Diameter:	125.0 μm ± 1 μm
Mode field concentricity error	≤ 0.6μm
Cladding non-circularity	≤ 1%
Cable Cut-off Wavelength λ_{cc}	≤□□1260 nm
1550 nm loss performance	As per G.652 D
Proof Test Level	≥ 0.69 Gpa
Attenuation Coefficient:	@ 1310 nm ≤ 0.35 dB/km @ 1550 nm ≤ 0.21 dB/km
Chromatic Dispersion; Maximum: **Zero Dispersion Wavelength:** **Zero Dispersion Slope:**	18 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm 1300 to 1324nm 0.092 ps/(nm^{2}xkm) maximum
Polarization mode dispersion coefficient	≤ 0.2 ps/km^½
Temperature Dependence:	Induced attenuation ≤ 0.05 dB (-60ºC - +85ºC
Bend Performance:	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (30±1 mm radius Mandrel), 100 turns; Attenuation Rise ≤ 0.05 dB @ 1550 nm (32±0.5 mm dia Mandrel, 1 turn; Attenuation Rise ≤ 0.50 dB

2.2.3 Fibre Optic Cable Construction

Overhead Fibre Optic Cables shall be OPGW (Optical Ground Wire). The OPGW cable is proposed to be installed on the transmission lines of Orissa Power Transmission Corporation Ltd. (OPTCL). The design of cable shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of all the transmission lines. Normally the tower span of the lines shall not exceed 600 m, however, some of the spans may be up to around 1000 m or more. **(Tower structure given at Appendix-I)**

2.2.4 Optical Fibre Identification

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. 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 manufacturer's fibre number and parameters of the fibre. If more than the specified number 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.

2.2.5 Buffer Tube

Loose tube construction shall 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. Buffer tubes shall be filled with a water-blocking gel.

2.2.6 Optical Fibre Strain & Sag-Tension chart

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.

For the purpose of this specification, the following definitions shall apply:

Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is *no fibre strain*.

The *no fibre strain* condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ ETSI (FOTP) specified optical reflectometry techniques.

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

The cable *Maximum Allowable Tension (MAT)* is defined as the maximum tension experienced by the Cable under the worst case loading condition.

The cable *max strain* is defined as the maximum strain experienced by the Cable under the worst case loading condition.

The cable *Every Day Tension (EDT)* is defined as the maximum cable tension on any span under normal conditions.

The *Ultimate /Rated Tensile Strength (UTS/* RTS/ breaking strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing the Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT) / max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earth wire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- 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.
- The everyday tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The Sag-tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted along with the bid under various conditions mentioned below:

- 53° C , no wind and no ice
- 32° C, no wind and no ice
- 0°C, no wind and no ice
- 32° C, full wind and no ice
- 32° C, 75% full wind and no ice

- 0° C, 2/3rd / 36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to 600 m or higher span length in the range of 50 m spans. Max. vertical sag, max. tension and max sag at 0° C & no wind shall be considered for in line with the design parameter of transmission line. The typical details are indicated in the Appendices. The full wind load shall be considered as the design wind load for all the specified transmission lines as per relevant IS 802 version and the sag-tension chart shall be submitted considering the transmission lines. In case of any span higher than 600m, suitable OPGW cable meeting sag-tension requirement of transmission line shall also be provided by the Contractor. The Contractor shall submit the stringing chart for review of OPTCL.

2.2.7 Cable Materials

The materials used for optical fibre cable construction, shall meet the following requirements:

2.2.7.1 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 60794-1-F-5. The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non-hygroscopic, 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 waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

2.2.7.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

2.2.7.3 Marking, Packaging and Shipping

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

(a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendors' address, the Purchaser'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 & segment no., factory inspection stamp and date.

(b) Cable Drums:

- All optical fibre cabling shall be supplied on 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 be 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 is as specified and as shall be intimated during/after the award of the contract.

2.2.8 Optical Ground Wire (OPGW)

OPGW cable construction shall comply with IEEE-1138, 2009. 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 this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead ground wire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel with aluminium coating protective central fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no. of fibres. All fibres in single buffer tube or directly in central fibre optic unit is not acceptable. 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

2.2.8.1 Central 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 OPGW design of dissimilar materials such as stainless steel tube with aluminium or aluminium–clad-steel wire strands are not allowed. Central fibre optic unit may be of aluminium or stainless steel tube with aluminium protective coating. In case of aluminium protective coating, the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions, etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

2.2.8.2 Basic Construction

The cable construction shall conform to the applicable requirements of this specification, applicable clauses of IEC 61089 related to stranded conductors and Table 2.2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include 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 unless otherwise agreed to by the OPTCL and shall conform to all applicable clauses of IEC 61089 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.

2.2.8.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the 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 not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

2.2.8.4 Electrical and Mechanical Requirements

Table 1-2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to that of the earthwire being replaced such that there is no or minimal consequential increase in stresses on towers. For the purposes 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 this section shall also be satisfied. The Bidder shall submit sag-tension charts for the above cases with their bids.

Table 1.2(a)
OPGW Electrical and Mechanical Requirements

(1)	**Everyday Tension**	≤ 20% of UTS of OPGW
(2)	**D.C. Resistance at 20ºC:**	< 1.0 ohm/Km
(3)	**Short Circuit Current**	≥ 6.32 kA for 1.0 second

2.2.8.5 Operating conditions

Since OPGW shall be located at the top of the transmission line support structure, it will be subjected to Aeolian vibration, Galloping and Lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be same or similar as those required of conventional ground conductors.

2.2.8.6 48F HARDWARE FITTINGS

Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware such as Tension assembly,Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps,Downlead clamps, splice enclosure etc. The Bidder shall provide documentation justifying the adequacy and suitability of the hardware supplied. The quantity of hardware & fittings to meet any eventuality during site installation min@ 1% shall also be provided as part of set/km for each transmission line without any additional cost to OPTCL. The Contractor shall determine the exact requirements of all accessories required 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 clause 4.0 of EN 61284: 1997 (IEC 61284). The shear‘strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. 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 for OPGW installations and shall not necessarily be limited to the following:

(a) **Suspension Assemblies**: Preformed 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 25 KN. The suspension clamps slippage shall occur between 12kN and 17 KN 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 150 mm (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.

(b) **Dead End Clamp Assemblies:** All dead end clamp assemblies shall preferably be of 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**: 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 that clampin 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.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent,having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s, 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 as specified in technical specifications.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 400 meters. For alll other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminum alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed.Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanized steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent drop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendations of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shalll be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloy shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cables which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc

alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under alll service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 kN and 5 KN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The vibration analysis of the system, with and without damper and dynamic characteristics of the damper as detailed in Technical Specification, shall have to be submitted. The technical particulars for vibration analysis and damping design of the system are as follows:

SL.NO	Description	Technical Particulars
1	Span Length in meters Ruling design span : Maximum span : Minimum Span :	 400 meters 1100 meters 100 meters
2	Configuration :	As per Specifications
3	Tensile load in each :	As per sag tension calculations
4	‘Armour rods used :	‘Standard preformed armour rods/AGS
5	Maximum permissible dynamic strain :	+/- 150 micro strains

The damper placement chart for spans ranging from 100m to 1100m shall be submitted by the Bidder. Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following

(1) Location of the dampers for various combinations of spans and line tensions clearly indicating the number of dampers to be installed per OPGW cable per span.
(2) Placement distances clearly identifying the extremities between which the distances are to be measured.
(3) Placement recommendation depending upon type of suspension clamps (viz Free center type/Armour grip type etc.)
(4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of damper

2.2.8.7 Fibre Optic Splice Enclosures (Joint Box)

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required number of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 12 fibres shall be

terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures.

Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice

enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 metres from top of the tower and shall accommodate pass-through splicing. The actual mounting height and location shall be finalised after Survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

The Employer reserves the right to require the Contractor to perform, at the Employer's expense, any other reasonable test(s) at the Contractor's premises, on site, or elsewhere in addition to the specified Type, Acceptance, Routine, or Manufacturing tests to assure the Employer of specification compliance.

2.2.8.9 Optical Fibre Splices

Splicing of the optical fibre cabling shall be minimized through careful Contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur 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 fibre shall be neatly installed in covered splice trays.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For 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.

Fibre Optic Approach Cables

For purposes of this specification, a fibre optic approach cable is defined as the Armoured underground fibre optic cable required to connect Overhead Fibre Optic Cable (OPGW) between the final in line splice enclosure on the gantry / tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length requirements are indicated in the Annexure-V(A) & Annexure-V(B). However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

Basic Construction

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.

Jacket Construction & Material

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light,weathering and high levels of pollution. The jacket shall conform to ASTM D1248 for density.

Optical, Electrical and Mechanical Requirements

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

The fibre optic approach cable shall have a minimum outer jacket thickness of 3.0 milli meters and shall meet the following requirements.

i. Fire retardant and no acid gas evolution.

ii.Resistance to ultra-violet deterioration.

iii.Anti-moisture penetration.

1	Number of optical fibres in OFAC	48
2	Mode	DWSM (Dual Window Single Mode)
3	Optimised wavelength(nm)	1550/1310
4	Mode field diameter (um)	9.2 +/0.5
5	Outside (Clad) diameter (um) :	125+/0.5
6	Attenuation	0.22 dB / Km Max. at 1550 nm 0.36 dB / Km Max at 1310 nm
7	Chromatic Dispersion At 1310 nm At 1550 nm	 **2.8 ps/ (nm.km)** 18 ps/ (nm.km)
8	Polarisation Mode dispersion	≤0.1 ps Sqrt.Km

3.0 Inspection and & Training Equipment:

3.0 Testing Requirements

Following are the requirements of testing :

1. Type Testing
2. Factory Acceptance Testing
3. Site Acceptance Testing

3.0.1 Type Testing

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. Type Testing shall comply with the following:

(a) All cable & equipment being supplied shall conform to type tests as per technical specification.

(b) The test reports submitted shall be of the tests conducted within last seven (7) years for OPGW cable prior to the date of proposal/offer submitted. In case the test reports are older than seven (7) years for OPGW cable on the date of proposal/offer, the Contractor shall repeat these tests at no extra cost to the Employer.

(c) The Contractor shall submit, within 30 days of Contract Award, copies of test reports for all of the Type Tests that are specified in the specifications and that have previously (before Contract award) been performed. These reports may be accepted by the Employer only if they apply to materials and equipment that are essentially identical to those due to be delivered under the Contract and only if test procedures and parameter values are identical to those specified in this specifications carried out at accredited labs and witnessed by third party / customer’s representatives.

In the event of any discrepancy in the test reports or any type tests not carried out, same shall be carried out by Contractor without any additional cost implication to the Employer.

In case the Type Test is required to be carried out, then following shall be applicable:-

(d) Type Tests shall be certified or performed by reputed laboratories using material and equipment data sheets and test procedures that have been approved by the Employer. The test procedures shall be formatted as defined in the technical specifications and shall include a complete list of the applicable reference standards and submitted for Employer approval at least four (4) weeks before commencement of test(s). The Contractor shall provide the Employer at least 30 days written notice of the planned commencement of each type test.

(e) The Contractor shall provide a detailed schedule for performing all specified type tests. These tests shall be performed in the presence of a representative of the Employer.

(f) The Contractor shall ensure that all type tests can be completed within the time schedule offered in his Technical Proposal.

(g) In case of failure during any type test, the Supplier is either required to manufacture a fresh sample lot and repeat all type tests successfully or repeat that particular type test(s) at least three times successfully on the samples selected from the already manufactured lot at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

3.0.2 Type Test Samples

The Contractor shall supply equipment/material for sample selection only after the Quality Assurance Plan has been approved by the Employer. The sample material shall be manufactured strictly in accordance with the approved Quality Assurance Plan. The Contractor shall submit for Employer approval, the type test sample selection procedure. The selection process for conducting the type tests shall ensure that samples are selected at random. For optical fibres/ Fibre Optic cables, at least three reels/ drums of each type of fibre/cable proposed shall be offered for selection. For FO cable installation hardware & fittings at least ten (10) samples shall be offered for selection. For Splice enclosures at least three samples shall be offered for selection.

3.1.3. Type Tests for OPGW Cables

The type tests to be conducted on the OPGW cable are listed in Table 3-1 Type Tests for OPGW Cables. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 3-1
Type tests for OPGW Cable

No.	Name	Test Description	Test Procedure
1	Water Ingress Test	IEEE 1138-2009	IEEE 1138-2009 (IEC 60794-1-2 Method F5 or EIA/TIA 455-82B)

Table 3-1
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
			: Test duration : 24 hours	
2	Seepage of filling compound	IEEE 1138-2009	IEEE 1138-2009 (EIA/TIA 455-81B)	Preconditioning period:72 hours. Test duration: 24 hours.
3	Short Circuit Test	IEEE 1138-2009	IEEE 1138-2009	Fibre attenuationshall be continuously monitored and recorded througha digital data logging system or equivalent means. A suitable temperature sensor such as thermocouple shall be used to monitor and record the temperature inside the OPGW tube in addition to monitoring & recording the temperatures between the strands and between optical tube and the strand as required by IEEE 1138. Test shall be conducted with the tension clamps proposed to be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
		Or IEC60794-4-10 / IEC 60794-1-2 (2003) Method H1		Initial temperature during the test shall be greater than or equal to ambient field temperature.
4	Aeolian Vibration Test	IEEE 1138-2009 Or IEC60794-4-10 / IEC 60794 -1-2, Method E19	IEEE 1138-2009	Fibre attenuationshall be continuously monitored and recorded througha digital data logging system or equivalent means. The vibration frequency and amplitude shall be monitored and recorded continuously. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring. Test shall be conducted with

Table 3-1
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
				the tension/suspension clamps proposedto be supplied. The cable and the clamps shall be visually inspected for mechanical damage and photographed after the test.
5	Galloping test	IEEE 1138-2009	IEEE 1138-2009	Test shall be conducted with the tension/suspension clamps proposedto be supplied. The cable and clamps shall be visually inspected for mechanical damage and photographed after the test. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
6	Cable Bend Test	Procedure 2 in IEC 60794-1-2 Method E11		The short-term and long-term bend tests shall be conducted in accordance with Procedure 2 in IEC 60794-1-2 E11 to determine the minimum acceptable radius of bending without any increase in attenuation or any other damage to the fibre optic cable core such as bird caging, deformation, kinking and crimping.
7	Sheave Test	IEEE 1138-2009 OR IEC 60794-1-2 (2003) Method E1B	IEEE 1138-2009	Fibre attenuationshall be continuously monitored and recorded through a digital data loggingsystem or equivalent means. The Sheave dia. shall be based on the pulling angle and the minimum pulley dia employed during installation. All fibres of the test cable sample shall be spliced together in serial for attenuation monitoring.
8	Crush Test	IEEE 1138-2009	IEEE 1138-2009	The crush test shall be carried out on a sample of

Table 3-1
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure	
			(IEC 60794-1-2, Method E3/ EIA/TIA 455-41B)	approximately one (1) metre long in accordance with IEC 60794-1-2 E3. A load equal to 1.3 times the weight of a 400-metre length of fibre optic cable shall be applied for a period of 10 minutes. A permanent or temporarily increase in optical attenuation value greater than 0.1 dB change in sample shall constitute failure. The load shall be further increased in small increments until the measured attenuation of the optical waveguide fibres increases and the failure load recorded along with results.
9	Impact Test	IEEE 1138-2009	IEEE 1138-2009, (IEC 60794-1-2 E4/ EIA/TIA 455-25B)	The impact test shall be carried out in accordance with IEC 60794-1-2 E4. Five separate pacts of 0.1-0.3kgm shall be applied. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporaryincrease in optical attenuation value greater than 0.1 dB/km change in sample shall constitute failure.
10	Creep Test	IEEE 1138-2009	IEEE 1138-2009	As per Aluminium Association Method, the best-fit straight line shall be fitted to the recorded creep data and shall be extrapolated to 25 years. The strain margin of the cable at the end of 25 years shall be calculated. The time when the creep shall achieve the strain marginlimits shall also be calculated.
11	Fibre Strain Test	IEEE 1138-1994	IEEE 1138-1994	

Table 3-1
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
12	Strain Margin Test	IEEE 1138-2009	IEEE 1138-2009
13	Stress strain Test	IEEE 1138-2009	IEEE 1138-2009
14	Cable Cut-off wavelength Test	IEEE 1138-1994	IEEE 1138-1994
15	Temperature Cycling Test	IEEE 1138-2009	IEEE 1138-2009 Or IEC 60794-1-2, Method F1
16	Corrosion (Salt Spray) Test	EIA/TIA 455-16A	
17	Tensile Performance Test	IEC 60794-1-2 E1 / EIA/TIA 455-33B	The test shall be conducted on a sample of sufficient length in accordance with IEC 60794-1-2 E1. The attenuation variation shall not exceed 0.05 dB/Km up to 90% of RTS of fibre optic cable. The load shall be increased at a steady rate up to rated tensile strength and held for one (1) minute. The fibre optic cable sample shall not fail during the period. The applied load shall then be increased until the failing load is reached and the value recorded.
18	Lightning Test	IEC 60794-4-10 / IEC 60794-1-2 (2003)	The OPGW cable construction shall be tested in accordance with IEC 60794-1-2, Method H2 for Class 1.
19	DC Resistance	On a fibre optic cable sample of minimum 1 metre length, two contact clamps shall be fixed with a predetermined bolt torque. The	

Table 3-1
Type tests for OPGW Cable

S. No.	Test Name	Test Description	Test Procedure
	Test (IEC 60228)	resistance shall be measured by a Kelvin double bridge by placing the clamps initially zero metre and subsequently one metre apart. The tests shall be repeated at least five times and the average value recorded after correcting at 20°C.	
-End Of Table-			

3.1 Factory Acceptance Tests

Factory acceptance tests shall be conducted on OPGW Cable.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's standard FAT testing program. In general the FAT shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

3.1.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

3.1.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the

Contractor’s standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

3.1.3 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 3-2
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

3.3. Minimum Site Acceptance Testing Requirement for OPGW Cable

During delivery of the materials at the desired site, required tests shall be carried out in the presence of the site in-charge to ensure the materials to be in good condition. Minimum requirements for OPGW cable site testing are provided in Table 3-4 below.

Item:	Description:
1.	Physical Inspection of the cable along with the drum for any damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3.	Fibre Optic Cable length measurement using OTDR

48 Fibre OPGW:

The specification for the 48 fibre DWSM OPGW is as follows.

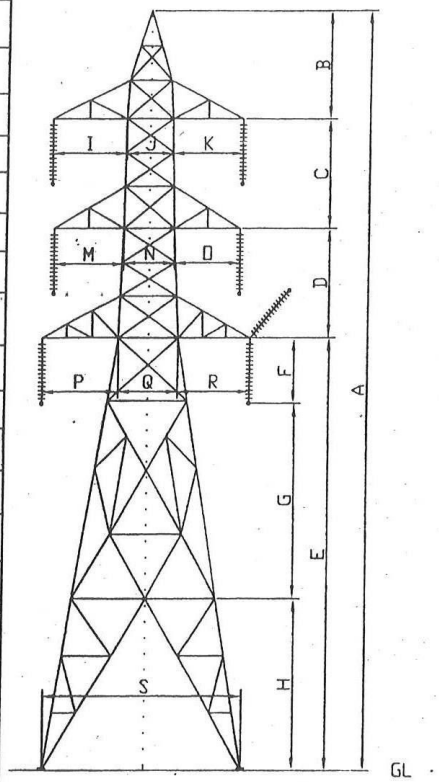
Sl.	Parameter	Technical requirement
1	No. of fibres (DWSM)	48
2	Buffer type	Loose tube
3	Buffer Tube material	Non-matallic
4	No of Buffer tubes	Minimum four(4)
5	No. of fibres per buffer tube	Maximum Twelve(12)

All other parameters are same/proportionate as that of the specification of 24Fibre OPGW.

Appendix-I

132kV tower (Normal span- 300m,Conductor 37/3.15 mm AAA,EW-7/3.15mm GS wire)

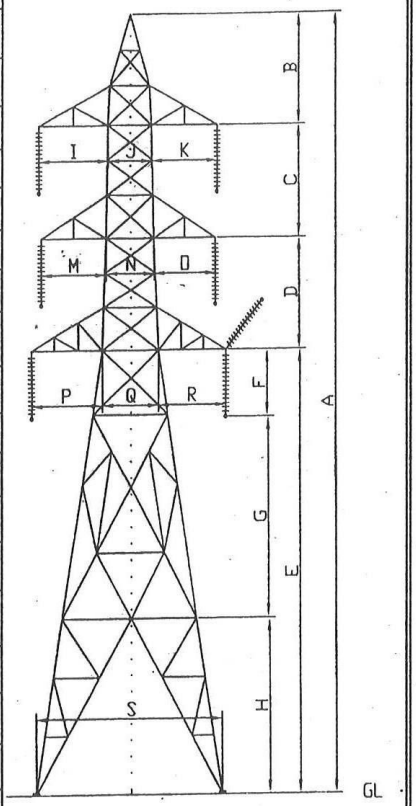
	DA (0-2 Deg)	DB (0-15 Deg)	DC (15-30 Deg)	DD (30-60 Deg)
A	28908	27550	27810	28280
B	4193	5890	6150	5990
C	4170	3900	3900	4130
D	4230	3900	3900	4300
E	16315	13860	13860	13860
F	2455	0	0	0
G	7606	7606	7606	7606
H	6100+150	6100+150	6100+150	6100+150
I	3150	2600	2650	2475
J	850	1600	1800	1850
K	3150	2600	2350	2475
L	-	-	-	-
M	3028	2525	2770	2291
N	1024	1750	1900	2217
O	3028	2525	2130	2291
P	3045	2560	2905	2665
Q	1200	1900	2000	2600
R	3045	2560	2100	2665
S	5890	6700	7000	8600



All dimensions are in mm.

220kV(Normal span 350m,Conductor-37/4mm AAA, Earth wire-7/3.15mm GS Wire)

	DA (0-2 Deg)	DB (0-15 Deg)	DC (15-30 Deg)	DD (30-60 Deg)
A	35505	34490	35390	35255
B	5540	7940	7940	8405
C	5175	4900	5350	5050
D	5275	4900	5350	5050
E	19515	16750	16750	16750
F	2768	0	0	0
G	9582	9582	9582	9582
H	7015+150	7015+150	7015+150	7015+150
I	3600	3705	3466	3650
J	1400	1750	2068	2400
K	3600	3025	3166	3650
L	-	-	-	-
M	3591	3612	3757	3450
N	1598	1975	2285	2800
O	3591	3012	2667	3450
P	3900	3475	3950	3250
Q	1800	2200	2500	3200
R	3900	3095	3180	3250
S	7502	7830	8500	9900



All dimensions are in mm.

3.3.1 Type Test on OPGW Cable Fittings

The type tests to be conducted on the OPGW Cable fittings and accessories are listed below:

(i) Mechanical Strength Test for Suspension/Tension Assembly
Applicable Standards: IEC 61284, 1997.

Suspension Assembly

The armour rods /reinforcement rods are assembled on to the approved OPGW using the Installation Instructions to check that the assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:
The suspension assembly shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. The angle between the cable, the Suspension Assembly and the horizontal shall not exceed 16^{o}. This load shall then be removed in a controlled manner and the Protection Splice disassembled. Examination of all the components shall be made and any evidence of visual deformation shall be documented.

Part 2:
The Suspension clamp shall then be placed in the testing machine. The tensile load shall gradually be increased up to 50% of the specified Minimum Failure Load of the Suspension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Tension Assembly

The Tension Assembly is correctly fitted and is the same that will be carried out during installations.

Part 1:

The tension assembly (excluding tension clamp) shall be increased at a constant rate up to a load equal to 50% of the specified minimum Failure Load increased at a constant rate and held for one minute for the test rig to stabilise. The load shall then be increased at a steady rate to 67% of the minimum Failure Load and held for five minutes. This load shall then remove in a controlled manner and the Tension Assembly disassembled. Examination of the Tension Dead-End and associated components shall be made and any evidence of visual deformation shall be documented.

Part 2:

The Tension Dead-End and associated components shall then be reassembled and bolts tightened as before. The tensile load shall gradually be increased up shall gradually be increased up to 50% of the specified Minimum Failure Load of the Tension Assembly and held for one minute for the Test Rig to stabilise and the load shall be further increased at a steady rate until the specified minimum Failure Load is reached and held for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value shall be documented.

Acceptance Criteria for Tension/Suspension Assembly:

- No evidence of binding of the Nuts or Deformation of components at end of Part 1 of Test.
- No evidence of Fracture at the end of one minute at the minimum failure load during Part 2 of the Test.

Any result outside these parameters shall constitute a failure.

(ii) Clamp Slip Strength Test for Suspension Assembly

The suspension assembly shall be vertically suspended by means of a flexible attachment. A suitable length fibre optical cable shall be fixed in the clamps. Once the Suspension Clamp has been assembled, the test rig is tensioned to 1 kN and the position scale on the recorder 'zeroed'. The test rig is then tensioned to 2.5 kN and the relative positions of the Reinforcing Rods, Armour Rods and Suspension Clamp shall be marked by a suitable means to confirm any slippage after the test has been completed. The relative positions of the helical Armour Rods and associated Reinforcing Rods at each end shall be marked and also 2 mm relative position between clamp body and Armour Rods shall be marked on one side. The load shall be increased to 12 kN at a loading rate of 3 kN/min and held for one minute. At the end of this one minute period, the relative displacement between clamp body and the armour rods shall be observed. If the slippage is 2 mm or above, the test shall be terminated. Otherwise, at the end of one minute the position of the clamp body and 2 mm. relative positions between clamp body and armour rods shall be marked on the other side. After the one minute pause, the load shall be further increased at a loading rate of 3 kN/min, and recording of load and displacement shall continue until either the relative Position displacement between clamp body and armour rods reaches more than 2 mm or the load reaches the maximum slip load of 17 kN. On reaching either of the above values the test is terminated. Visual examination of all paint marks shall be recorded, and a measurement of any displacement recorded in the Table of Results.

Acceptance Criteria:

The Suspension Clamp has passed the Slip Test if the following conditions are met:

- No slippage* shall occur at or below the specified minimum slip load.

  * Definition of no slippage in accordance with IEC 61284, 1997:- Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the cable as a result of the test itself are not regarded as slippage.

- Slippage shall occur between the specified maximum and minimum slip load of 12 - 17 kN.

- There shall be no slippage of the Reinforcing Rods over the cable, and no slippage of the Armour Rods over the Reinforcing Rods.

- The relative movement (i.e. more than 2 mm between Armour Rods & Clamp body) between minimum 12 kN and maximum slip 17 kN, shall be considered as slip.

- The Armour Rods shall not be displaced from their original lay or damaged**.

  ** Definition of no damage in accordance with convention expressed in IEC 61284: 1997 no damage, other than surface flattening of the strands shall occur.

Any result outside these parameters is a failure.

(iii) Slip Strength Test of Tension Clamp

Tension clamps shall be fitted on an 8 m length of fibre optic cable on both ends. The assembly shall be mounted on a tensile testing machine and anchored in a manner similar to the arrangement to be used in service. A tensile load shall gradually be applied up to 20 % of the RTS of OPGW. Displacement transducers shall be installed to measure the relative movement between the OPGW relative to the Reinforcing Rods and Tension Dead -End relative to Reinforcing Rods. In addition, suitable marking shall be made on the OPGW and Dead-End to confirm grip. The load shall be gradually increased at a constant rate up to 50 % of the UTS and the position scale of the recorder is zeroed. The load shall then gradually increased up to 95 % of the UTS and maintained for one minute. After one minute pause, the load shall be slowly released to zero and the marking examined and measured for any relative movement.

Acceptance Criteria:

- No movement* shall occur between the OPGW and the Reinforcing Rods, or between the Reinforcing Rods and the Dead-End assembly.
- No failure or damage or disturbance to the lay of the Tension Dead-End, Reinforcing Rods or OPGW.

* Definition of no movement as defined in IEC 61284: Any relative movement less than 2 mm is accepted. The possible couplings or elongations produced by the conductor as a result of the test itself are not regarded as slippage.

Any result outside these parameters shall constitute a failure.

(iv) Grounding Clamp and Structure Mounting Clamp Fit Test

For structure mounting clamp, one series of tests shall be conducted with two fibre optic cables installed, one series of tests with one fibre optic cable installed in one groove, and one series of tests with one fibre optic cable in the other groove. Each clamp shall be installed including clamping compound as required on the fibre optic cable. The nut shall be tightened on to the bolt by using torque wrench with a torque of 5.5 kgm or supplier's recommended torque and the tightened clamp shall be held for 10 minutes. After the test remove the fibre optic cable and examine all its components for distortion, crushing or breaking. Also the fibre optic cable shall be checked to ensure free movement within the core using dial callipers to measure the diameter of the core tube. The material shall be defined as failed if any visible distortion, crushing, cracking or breaking of the core tube is observed or the fibre optic cable within the core tube is not free to move, or when the diameter of the core tube as measured at any location in the clamped area is more than 0.5 mm larger or smaller of the core diameter as measured outside the clamped area.

(v) Structure Mounting Clamp Strength Test

The clamp and mounting assembly shall be assembled on a vertical 200 mm x 200 mm angle and a short length of fibre optic cable installed. A vertical load of 200 kg shall be applied at the end of the mounting clamp and held for 5 minutes. Subsequently, the load shall be increased to 400 kg and held for 30 seconds. Any visible distortion, slipping or breaking of any component of the mounting clamp or assembly shall constitute failure.

3.3.2 Type Test on Vibration Damper

The testing standard of vibration damper for OPGW shall be as per applicable international standard i.e. IEC 61897.

(a) Dynamic Characteristic Test

The damper shall be mounted with its clamp tightened with torque recommended by the manufacturer on shaker table capable of simulating sinusoidal vibrations for Critical Aeolian Vibration frequency band ranging from 0.18/d to 1.4/d – where d is the OPGW cable diameter in meters. The damper assembly shall be vibrated vertically with a ±1 mm amplitude from 5 to 15 Hz frequency and beyond 15 Hz at 0.5 mm to determine following characteristics with the help of suitable recording instruments.

(i) Force Vs frequency

(ii) Phase angle Vs frequency

(iii) Power dissipation Vs frequency

The Force Vs frequency curve shall not show steep peaks at resonance frequencies and deep troughs between the resonance frequencies. The resonance frequencies shall be suitably spread within the Aeolian vibration frequency-band between the lower and upper dangerous frequency limits determined by the vibration analysis of fibre optic cable without dampers.

Acceptance criteria for vibration damper:

(i) The above dynamic characteristics test on five damper shall be conducted.

(ii) The mean reactance and phase angle Vs frequency curves shall be drawn with the criteria of best fit method.

(iii) The above mean reactance response curve should lie within following limits:

V.D. for OPGW - 0.060 f to 0.357 f kgf/mm*

Where “f “ is frequency in Hz.

(iv) The above mean phase angle response curve shall be between 25^{o} to 130^{o} within the frequency range of interest.

(v) If the above curve lies within the envelope, the damper design shall be considered to have successfully met the requirement.

(vi) Visual resonance frequencies of each mass of damper is to be recorded and to be compared with the guaranteed values.

(b) Vibration Analysis

The vibration analysis of the fibre optic cable shall be done with and without damper installed on the span. The vibration analysis shall be done on a digital computer using energy balance approach. The following parameters shall be taken into account for the purpose of analysis.

(i) The analysis shall be done for single fibre optic cable without armour rods. The tension shall be taken as 25% of RTS of fibre optic cable for a span ranging from 100 m to 1100 m.

(ii) The self-damping factor and flexural stiffness (EI) for fibre optic cable shall be calculated on the basis of experimental results. The details to experimental analysis with these data shall be furnished.

(iii) The power dissipation curve obtained from Damper Characteristics Test shall be used for analysis with damper.

(iv) Examine the Aeolian Vibration level of the fibre optic cable with and without vibration damper installed at the recommended location or wind velocity ranging from 0 to 30 Km per hour, predicting amplitude, frequency and vibration energy input.

(v) From vibration analysis of fibre optic cable without damper, antinode vibration amplitude and dynamic strain levels at clamped span extremities as well as antinodes shall be examined and thus lower and upper dangerous frequency limits between which the Aeolian vibration levels exceed the specified limits shall be determined.

(vi) From vibration analysis of fibre optic cable with damper(s) installed at the recommended location, the dynamic strain level at the clamped span extremities, damper attachment point and the antinodes on the fibre optic cable shall be determined. In addition to above damper clamp vibration amplitude and antinodes vibration amplitudes shall also be examined.

The dynamic strain levels at damper attachment point, clamped span extremities and antinodes shall not exceed the specified limits. The damper clamp vibration amplitude shall not be more than that of the specified fatigue limits.

(c) Fatigue Tests

(i) Test Set Up

The fatigue tests shall be conducted on a laboratory set up with a minimum effective span length of 30m. The fibre optic cable shall be tensioned at 25% of RTS of fibre optic cable and shall not be equipped with protective armour rods at any point.

Constant tension shall be maintained within the span by means of lever arm arrangement. After the fibre optic cable has been tensioned, clamps shall be installed to support the fibre optic cable at both ends and thus influence of connecting hardware fittings are eliminated from the free span. The clamps shall not be used for holding the tension on the fibre optic cable. There shall be no loose parts, such as suspension clamps, U bolts, on the test span supported between clamps mentioned above. The span shall be equipped with vibration inducing equipment suitable for producing steady standing vibration. The inducing equipment shall have facilities for step less speed control as well as step less amplitude arrangement. Equipment shall be available for measuring the frequency, cumulative number of cycles and amplitude of vibration at any point along the span.

(ii) Fatigue Test

The vibration damper shall be installed on the test span with the manufacturer's specified tightening torque. It shall be ensured that the damper shall be kept minimum three loops away from the shaker to eliminate stray signals influencing damper movement.

The damper shall then be vibrated at the highest resonant frequency of each damper mass. For dampers involving torsional resonant frequencies, tests shall be done at torsional modes also in addition to the highest resonant frequencies at vertical modes. The resonance frequency shall be identified as the frequency at which each damper mass vibrates with the maximum amplitude on itself. The amplitude of vibration of the damper clamp shall be maintained not less than ±25/f mm where f is the frequency in Hz.

The test shall be conducted for minimum ten million cycles at each resonant frequency mentioned above. During the test, if resonance shift is observed, the test frequency shall be tuned to the new resonant frequency.

The clamp slip test as mentioned herein shall be repeated after fatigue tests without retorquing or adjusting the damper clamp, and the clamp shall withstand a minimum load equal to 80% of the slip strength for a minimum duration of one minute.

After the above tests, the damper shall be removed from fibre optic cable and subjected to dynamic characteristics test. There shall not be any major deterioration in the characteristics of the damper. The damper then shall be cut open and inspected. There shall not be any broken, loose, or damaged part. There shall not be significant deterioration or wear of the damper. The fibre optic cable under clamp shall also be free from any damage.

For purposes of acceptance, the following criteria shall be applied:

(1) There shall not be any resonant frequency shift before and after the test by more than ± 20%

(2) The power dissipation of the damper before and after test at the individual resonant frequencies do not differ by more than ± 20%

Beside above tests, the type tests listed below in the table shall also be conducted on Vibration Damper

Sl No.	**Test Name**	**Test Procedure**
1	Visual examination & Dimensional and material verification	IEC 61897 Clause 7.1 & 7.2
2	Clamp Slip test	IEC 61897 Clause 7.5
3	Clamp bolt tightening test	IEC 61897 Clause 7.7
4	Attachments of weights to messenger cable	IEC 61897 Clause 7.8
5	Attachment of clamps to messenger cable	IEC 61897 Clause 7.8
6	Damper effectiveness evaluation	IEC 61897 Clause 7.11.3.2

3.3.3 Type Tests for Splice Enclosures (Joint Box)

Following Type tests shall be demonstrated on the Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 60794-1 procedures).

(i) Temperature Cycling Test

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of -40˚C to +65˚C with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20 / IEC 60794-1-C10. The variation in attenuation shall be less than ±0.05dB. The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

(ii) Humid Heat test

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of +55˚C ±2˚C with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than
±0.05dB, and the internal humidity rate measured, less than 2%.

(iii) Rain Withstand Test / Water Immersion test

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60060 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than ±0.05dB.

(iv) Vibration Test

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than ±0.05dB. The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

(v) Bending and Torsion test

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

a) 3 torsion cycles of ±180° shall be exercised on the cable. Each cycle shall be less than one minute.

b) 3 flexure cycles of the cable, of ±180° with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than ±0.05dB. The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure

(vi) Tensile test

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 N for a period of two minutes. No fissure shall be noted in the connections or on the box.

(vii) Drop Test

With 2 lengths of 11 metres of cable fixed to the box, it shall be dropped five times from a height of 10 metres. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test surface shall be carried out in accordance with IEC 60068-2-32.

3.3.4 Type Tests for Fibre Optic Approach Cable

The type tests to be conducted on the Fibre Optic Approach cable are listed in Table 2-3: Type Tests for Fibre Optic Approach Cable. Unless specified otherwise in the technical specifications or the referenced standards, the optical attenuation of the specimen, measured during or after the test as applicable, shall not increase by more than 0.05 dB/Km.

Table 3-3:
Type Tests Fibre Optic Approach Cable

S.NO.	Test Name	Test Procedure
1	Water Ingress Test	(IEC 60794-1-F5 / EIA 455-82B) Test duration : 24 hours
2	Seepage of filling compound	(EIA 455-81A) Preconditioning : 72 hours, Test duration : 24 hours.
3	Crush Test	(IEC 60794-1-E3/ EIA 455-41)
4	Impact Test	(IEC-60794-1-E4/ EIA 455-25A)
5	Stress strain Test	(EIA 455-33A)
6	Cable Cut-off wavelength Test	(EIA 455-170)

Table 3-3:
Type Tests Fibre Optic Approach Cable

S.NO.	Test Name	Test Procedure
7	Temperature Cycling Test	(IEC60794-1-F1/EIA-455-3A) – 2 cycles

-End Of Table-

3.3.4.Impact Test

The Impact test shall be carried out in accordance with IEC:60794-1-E4. Five separate impacts of 2.0 kg shall be applied at different locations. The radius of the intermediate piece shall be the reel drum radius ± 10%. A permanent or temporary increase in optical attenuation value greater than 0.05 dB/km shall constitute failure.

3.4 Factory Acceptance Tests

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on OPGW Cable and associated hardware & fittings, Approach Cable, Joint Box, FODP etc. and all other items for which price has been identified separately in the Bid Price Schedules.

Material shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued Material Inspection & Clearance Certificate (MICC). Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof. These tests shall be carried out in the presence of the Employer's authorised representatives unless waiver for witnessing by Employer’s representatives is intimated to the contractor.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance tests for the supplied items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's / supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces etc.

For Test equipment FAT shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer’s final inspection certificate/ report.

3.4.1 Sampling for FAT

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, all required FAT tests in the approved FAT procedures, shall be performed on all samples. The Sampling rate for the Factory acceptance tests shall be minimum 10% of the

batch size (minimum 1) for all items. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

For the OPGW cable hardware fittings & accessories, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The Sampling rate for the Factory acceptance tests shall be 10% of the batch size (minimum 2) for FO cable drums, FODPs, Joint box and other similar items.

Since FAT testing provides a measure of assurance that the Quality Control objectives are being met during all phases of production, the Employer reserves the right to require the Contractor to investigate and report on the cause of FAT failures and to suspend further testing/ approvals until such a report is made and remedial actions taken, as applicable.

3.4.2 Production Testing

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

3.4.3 Factory Acceptance Tests on Optical Fibre to be supplied with OPGW

The factory acceptance tests listed in table below are applicable for the Optical fibres to be supplied. The listed tests follow testing requirements set forth in IEEE standard 1138/IEC 60794. The referenced sections specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standards unless specified otherwise in the technical specifications.

Table 3-4
Factory Acceptance Tests for Optical Fibres: Optical Tests

S. No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	T S,Table 1-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	TS, Section 1.1.2	EIA/TIA 455-59
3	Attenuation at Water Peak	TS ,Table 2-1(a)	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
-End of table-			

The test report for the above tests for the fibers carried out by the Fiber Manufacturer and used in the OPGW cables shall be shown to the inspector during OPGW cable FAT and shall be submitted along with the OPGW cable FAT report.

3.4.4 Factory Acceptance Test on OPGW Cable

The factory acceptance tests for OPGW cable specified below in Table follow the requirements set forth in IEEE standard 1138 / IEC 60794. The FAT shall be carried out on 10% of offered drums in each lot as specified in technical specifications and the optical tests shall be carried out in all fibres of the selected sample drums. The Rated Tensile Strength test shall be carried out on one sample in each lot.

Table 3-5
Factory Acceptance Tests on OPGW
Applicable standard: IEEE 1138 / IEC 60794

S. No.	Factory Acceptance Test on Manufactured OPGW
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Rated Tensile Strength
5	Lay Length Measurements

3.4.5 Factory Acceptance Test on OPGW Fittings

The factory acceptance tests for OPGW Fittings as specified below in Table 2-6. The sampling plan shall be as per relevant standard:

Table 3-6

Factory Acceptance Tests On OPGW Fittings

Sl. No.	Factory Acceptance Test
Suspension Assembly	
1	UTS/Mechanical Strength of the assembly
2	Clamp Slip Test
3	Visual Material verification and dimensional checks as per approved DRS/Drawings
4	Mechanical strength of each component
5	Galvanising test
Tension Assembly	
6	Clamp Slip Strength test
7	Visual Material verification and dimensional checks as per approved DRS/Drawings
8	Mechanical strength of each component
9	Galvanising Test
Vibration Damper	
10	Galvanising test on damper, masses and messenger wires
11	Damper response (resonant frequencies)
12	Clamp Slip test
13	Strength of messenger wires
14	Attachments of weights to messenger cable
15	Attachments of clamps to messenger cable
16	Clamp bolt tightening test
17	Clamp bolt torque test
18	Dynamic characteristic test.
19	Visual Material verification and dimensional checks as per approved DRS/Drawings
Structure Mounting Clamp	
20	Clamp Fit Test
21	Clamp Strength Test
22	Visual Material verification and dimensional checks as per approved DRS/Drawings
End of Table	

3.4.6 Factory Acceptance Test on Approach Cable

The factory acceptance tests for Approach Cable specified below in Table 2-7:

Table 3-7
Factory Acceptance Tests On Approach Cable

S. No.	Factory Acceptance Test
1	Attenuation Co-efficient at 1310 nm and 1550 nm
2	Point discontinuities of attenuation
3	Visual Material verification and dimensional checks as per approved DRS/Drawings

3.4.7 Factory Acceptance Test on Splice Enclosure (Joint Box) /FODP

The factory acceptance tests for Splice Enclosures/FODP as specified below in Table: 2-8

Table 3-8
Factory Acceptance Tests on Splice Enclosures (Joint Box)/FODP

S. No.	Factory Acceptance Test
1	Visual check of Quantities and Specific Component Number for each component of Splice Enclosure/FODP and dimensional checks against the approved drawings.

3.4.8 Factory Acceptance Test on Test Equipment & other items

As per technical specification.

3.5 Site Acceptance Tests

The Contractor shall be responsible for the submission of all material & test equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. At a minimum Site Acceptance Testing requirement for FO cable etc. is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for FO installation.

During the course of installation, the Employer shall have full access for inspection and verification 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.

3.5.1Minimum Site Acceptance Testing Requirement for FO Cabling

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.

3.5.2Phases of Site Acceptance Testing

SAT shall be carried out link by link from FODP to FODP. SAT may be performed in parts in case of long links.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

Sag and tension of OPGW shall generally be as per approved sag-tension chart and during installation, sag and tension of OPGW shall be 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 site testing minimum requirements are provided in Table 2-9(a) through 2-9(c) below:

Table 3-9(a)
Fibre Optic Cable Pre-Installation Testing

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm
3.	Fibre Optic Cable length measurement using OTDR

Table 3-9(b)
Fibre Optic Cable Splicing Testing

Item:	Description:
1.	Per splice bi-directional average attenuation with OTDR
2.	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

Table 3-9(c)
Fibre Optic Cable Commissioning Testing

Item:	Description:
1.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
2.	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
3.	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
4.	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
-End of Table-	

4.GUARANTEED TECHNICAL PARTICULARS OF OPGW CABLE

Sl.No.	Description.	Technical Particulars	
1.	Make & Model		
2.	No. of Fibres in OPGW	24	48
3.	Mode	DW-SM	DW-SM
4.	Buffer type	Loose	Loose
5.	Buffer tube diameter	2.2mm	2.3 mm (Approx)
6.	Buffer tube material	PBT	PBT
7.	No. of buffer tubes	4	4
8.	No. of fibres per tube	6	12
9.	Identification/numbering of individual tubes	Red, green blue and natural.	Different Color/4 Tube Blue, Orange, Green Brown.
10.	No.of empty tubes (if any)	1	N/A
11.	Filling material	Moisture proof & Hydrogen adherent jelly.	Moisture proof & Hydrogen adherent jelly.
12.	Strength members	1	1
13.	Binding yarn/tape	Tapes	Tapes
14.	(i)10% Aluminium clad steel wire	(i) 2.25mm (Dia) & 12 Nos.	(i) 2.45mm, 13 Nos

	(ii)20.3% IACS	(ii) 2.6 mm (Dia) & 11 Nos. (iii) Other design meeting to the electrical & mechanical parameters as per detail technical specification.	
15.	Aluminium alloy wires (Diameter & Number)	2.25mm & 3 Nos.	na
16.	Aluminium tube inner diameter	Design dimensional parameters of OPGW should meet the SAG-Tension criteria as enclosed at **Appendix-II**	6.2mm
17.	Aluminium tube outside diameter (Approx.)		7.9mmj
18.	Cable diameter		12.6 ± 0.13
19.	Cable cross section area		80mm^2
20.	Maximum Breaking load/ Ultimate Tensile Strength	82.10kN	84.9 KN
21.	Fibre Strain margin	0.6%	25% (Zero fibre strain up to 33.96KN Load)
22.	Weight Kgs/Km	488 kgs/km	477
23	Crush strength	1000kg with a 10cm^2 piste	4Kg/mm
24.	Equivalent Modulus of Elasticity	135.8kN/mm^2	137.1 KN/mm^2
25.	Minimum bending radius	300mm	384mm
26.	Maximum bending radius	Short term 300mm Long term 400mm	Short term 512mm Long term 384mm
27.	Maximum permissible tensile stress	-	0.42 KN/mm2
28.	Permissible CTS Tensile stress	0.669kN/- mm^2	0.21 KN/mm^2
29.	Coefficient of linear expansion	15.3 X 10^{-6} per ^{0}C	14.0 X 10^{-6} per ^{0}C
30	Coefficient expansion Cladding Core	6.3 X 10^{-6} per ^{0}C	23.0 X 10^{-6} per ^{0}C 11.5 X 10^{-6} per ^{0}C
31	Nominal operating temperature range	-10 ^{0}C to 70 ^{0}C	-10 ^{0}C to 70 ^{0}C
32	SC current transient peak temperature	41 KA	200^{0}C
33	Maximum allowable temperature for lightning strike	200	200^{0}C
34	Available length of cable per drum: Min Max	2500 mtrs 3500 mtrs or as per site requirement.	As per drum schedule

35	Splice loss (Min. & Max. Allowable)	0.05 dB. 0.01 dB	0.1dB (Max) 0.05dB (Average)
36	Operating Temperature range-	-10 ^{0}C to 70 ^{0}C	-10 ^{0}C to 70 ^{0}C
37	Expected Cable Life	25 years.	25 years.
38.	Fibre production method	-	
39.	Core diameter.	9.2 +/-0.5 µm	8.2 ± 0.4 µm
40	Core non circularity	-	≤0.8 %
41.	Cladding diameter	125+/-0.5 µm	125 ± 0.7 µm
42	Core Clad Concentricity Error	< 1 µm	≤ 0.5 µm
43	Cladding non circularity	< 2%	≤ 1.0%
44	Protective coating type & material Primary Secondary.	Acrylate PBT	Acrylate PBT
45	Protective coating Diameter	-	245±5 µm
46	Coating concentricity	>70%	≤ 6µm
47	Colour Coding scheme compliant with EIA 395/IEC3047		
48	Attenuation Coefficient @ 1310nm – @1559nm-	.36 dB/km .22 dB/km	≤ 0.35 dB/km ≤ 0.21 dB/km
50	Mode field non Circularity	< 2%	
51	Chromatic Dispersion 1310 nm 1550 nm	2.8 ps/ (nm.km) 18 ps/(nm.km)	2.8 ps/(nm.km) 18 ps/(nm.km)

4.1 GUARANTEED TECHNICAL PARTICULARS OF OPGW HARDWARE FITTINGS:

GUARANTEED TECHNICAL PARTICULARS FOR TENSION ASSEMBLY FOR OPGW			
S.NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Tension assembly for OPGW
2	Minimum slip load	kN	95% of UTS of OPGW Conductor
3	Suitable for (Cable size)	mm	12.1
4	Part no		MF50266 / MF50328 / MF50269 / MF50101
5	Length (nominal)		
	a) Reinforcing rods	mm	1600 + 5%
	b) Dead end grip	mm	1200 + 5%
6	Weight (nominal)		
	a) Reinforcing rods	kg	0.9 (Approx)
	b) Dead end grip	kg	1.3 (Approx)
7	Breaking Strength (Minimum)- Single rod		
	a) Reinforcing rods	N/mm2	1340
	b) Dead end grip	N/mm2	1280
8	Wire diameter		
	a) Reinforcing rods	mm	2.59+0.1
	b) Dead end grip	mm	3.66+0.1
9	Lay Direction		
	a) Reinforcing rods	mm	Right hand lay
	b) Dead end grip	mm	Left hand lay
10	UTS of OPGW conductor	kN	70.1

GUARANTEED TECHNICAL PARTICULARS FOR VIBRATION DAMPER OPGW			
S.NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Vibration damper for OPGW
2	Part no		MF50053
3	Suitable for (Cable size)	mm	Ø11.1-14
4	Total weight	Kg	1.6 (Approx)
5	Weight of cach damper mass	Kg	0.6 & 0.4 ±5%
6	Material of damper weight		Cast iron (HDG)
7	Clamp material		Aluminium alloy
8	Clamp bolt tightening torque	Nm	46
9	Clamp bolt material		MS (5.6 Grade) (HDG)
10	Massenger cable material		Massenger cable material
11	No of strands in massenger cable		19
12	Braking strength of massenger cable	KN	>45
13	Resonance frequiencies:		
	a) First frequency	Hz	14±3
	b) Second frequency	Hz	23±4
	c) Third frequency	Hz	50±10
	d) Fourth frequency	Hz	90±18
14	Minimum slip strength of damper clamp (Damper to		
	a) Before fatigue test	KN	2.5
	b) After fatigut test	KN	2
15	Max slip strength of damper clamp	KN	5

GUARANTEED TECHNICAL PARTICULARS FOR SUSPENSION ASSEMBLY FOR OPGW FOR OPGW			
S.NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Suspension assembly for OPGW
2	Suitable for (Cable size)	mm	Ø12.1
3	Part no		MFS0325
4	Minimum Vertical strength	KN	50
5	Slip load	KN	12 to 17
6	Total drop incudes shackle	mm	130
7	Tightening torque (nominal)	Nm	58
8	Details of armour set		
	a) No. Of rods per set		11
	b) Direction of lay		Right hand lay
	c) Overall length	mm	1795
	d) Diameter of each rod	mm	3.71
	e) Tolerances (i) Dia of each rod mim (ii) Length of each rod mm	 mm mm	±0.1 ±5%
	f) Material of wire		Aluminum alloy
	g) UTS of each rod	KN	35kg/mm2
	h) Weight	Kg	0.6 (Approx)
9	UTS of OPGW conductor	KN	70.1

GUARANTEED TECHNICAL PARTICULARS FOR DOWN LEAD CLAMP			
S.NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Downlead clamp
2	Part no		TF16110
3	Suitable for OPGW	mm	07-13
4	Tightening torque	Nm	40(TOWER HOLDING PART) 10(CABLE HOLDING PART)
5	Material of downlead clamp		Hot Dip Galvanised Steel
6	Filler details:		
	a)Material		MS
7	Tower attachment arrangement		Bolt & nut
8	Weight of assembly	Kg	0.8 (Approx)

GUARANTEED TECHNICAL PARTICULARS FOR OPGW JOINT BOX 3WAY 24F/48F

S. NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Joint Box for OPGW - 3 way- 24F/48F
2	Part no		MF50064
3	Height (H)	mm	462 ± 5
4	Diameter (D)	mm	200 ± 5
5	Weight	Kg	5 ± 2%
6	Colour & finish		Aluminium
7	Cable Glanding & fixing		Adjust Plate & screws (Included)
8	Construction materials & gauge		Aluminium alloy & Steel
9	Installation clearances		
10	Front Access	mm	1000
11	Rear access	mm	1000
12	Top *Bottom* Sides	mm	1000
13	IP Protection	Class	IP66
14	Max. No. of optical splicing per tray		12 Nos
15	No. of splice tray		4
16	Provision of passthrough splicing	Yes/No	Yes
18	Method for mounting with the tower		Mounting on tower above anti climb guard levels at 10mtr from top of the tower with bolt & nut
Optical Fiber Cable Accomodations			
19	Cable Glanding		Aluminium bushing & aluminium hose gasket
20	Maximum number of cables that can be accomodated	Each	3 No of cables (OPGW/ADSS/Approach Cable)
21	Diameter of cables that can be accomodated	mm	Ø8.0-18.0
22	Details of Splice Trays:		
23	Dimension (Length x Width x Thickness x Depth)	mm	234 ± 5 x 110 ± 5 x 10 ± 0.5
24	Material/Guage		Acrylonitrite Butadiene Styrene (ABS)
25	Weight of each splice tray	kg	0.074 ± 5%
26	Colour & Finish		Black and Transparent
27	Number of splices per tray	ea	4
28	Provision of Splice organisors		4 x 12
29	Excess length of fiber service loops	m	1.5 to 3
31	Minimum bending diameter for fiber coils inside tray	mm	≥75
32	Life of Joint Box		25 years

GUARANTEED TECHNICAL PARTICULARS FOR LOOP BRACKET

S. NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Loop Bracket
2	Part no		MF47541
3	Material		Mild Steel
4	Weight	kg	11.5 ± 2%
5	Breaking strength	kN	NA
6	Bolt Size	mm	M12
7	Bolt grade		5.6
8	Nut size	mm	M12
9	Nut grade		5
10	Washer size	mm	M12
11	Tightening Torque	Nm	34
12	Shear strength of bolt	N/mm2	≥88.2

GUARANTEED TECHNICAL PARTICULARS FOR FODP

S. NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		FODP-48F (1400 X 900X400mm)
2	Part no		MF50340
3	Dimensions H * W * D	mm	1400 ± 30 x 900 ± 10 x 400 ± 10
4	Weight	Kg	70 ± 5%
5	Colour & finish		Light Grey, RAL7035
6	Rack Description/Model		FODP 48 - Fiber Optic Distribution Panel 48Fibers
7	Construction materials		CRCA, ROHS COMPLIANT
8	Locking arrangements		3-point lock system
9	Installation clearances		
10	Front Access	mm	600
11	Rear access	mm	600
12	Top *Bottom* Sides	mm	600
13	IP Protection	Class	IP55
14	Coating thickness	um	Minimum 70 microns
15	No. of 48F sub rack		1
FODP 48 Fibers (Sub Rack)			
16	Dimensions H * W * D	mm	88 ± 5 x 486 ± 5 x 234 ± 5
17	Weight	Kg	4.7 ± 5%
18	Colour & finish		Light Grey
19	Cable Glanding and Fixing:		Cable Glands provided along with the sub rack
20	Construction materials & Guage		CRCA Steel, 1.2 mm without powder coating, 1.3 - 1.5mm after powder coating.
21	Locking arrangements		Two Slots with Nylatch
22	Total number of optical couplings	ea	48 FC/PC Connections after powder coating.
23	Provision of pass through splicing	Yes/No	Yes, 48 Spicing per patch panel
24	Whether filled with suitable	Yes/No	NA
25	Method(s) for mounting 19" rack		19" rack mounting in cabinet
Optical Fiber Cable Accommodations			
25	Cable Glanding and Fixing:		Minimum 2 PG Gland and cable arresters
26	Maximum number of cables that can be accomodated	Each	6-12 from bottom and provision for 4 hole impression on top which can be modified into entry for 0-4 cables by fixing PG glands
27	Diameter of cables that can be accomodated	mm	Ø10.0-18.0
28	Describe cable entries		Suitable for all 24 - 48 fiber approach cables. Allows entry from the bottom and top of the cabinet and the back side of the sub rack.

29	Details of Splice Trays:		
30	Dimension	mm	160± 5 x 105± 5 x 10±1.5
31	Material/Guage		Acrylonitrile Butadiene Styrene (ABS) 1-4 mm thickness
32	Weight	Kg	0.085 ± 5%
33	Colour & Finish		Blue/ grey/ white
34	Method of mounting		Snaps on to the base tray in the sub rack and comes with hinge mechanism for easy access to fibers.
35	Maximum number of Splice trays	ea	4
36	Number of splices per tray	ea	12
37	Provision of Splice organisors		Yes
38	Excess length of fiber service loops	m	3m, Provision of Service loops provided
39	Connecterised Pigtails spliced to bare fibres at least 1 mtr at service loop installed in FODP fibre organiser and atleast 1 mtr at service loop to the coupling neatly stored behind the FODP coupling panel provided All cable and fibre service loops provided meeting the Technical Specification requirement.	Yes/No	Yes
40	Provision for ground legs	Yes/No	Yes

GUARANTEED TECHNICAL PARTICULARS FOR OPGW JOINT BOX 2WAY 48F

S. NO.	DESCRIPTION	UNIT	PARTICULARS
1	Component Description		Joint Box for OPGW - 2way- 48F
2	Part no		MF50172
3	Height (H)	mm	462 ± 5
4	Diameter (D)	mm	200 ± 5
5	Weight	Kg	5 ± 2%
6	Colour & finish		Aluminium
7	Cable Glanding & fixing		Adjust Plate & screws (Included)
8	Construction materials & gauge		Aluminium alloy & Steel
9	Installation clearances		
10	Front Access	mm	1000
11	Rear access	mm	1000
12	Top *Bottom* Sides	mm	1000
13	IP Protection	Class	IP66
14	Max. No. of optical splicing per tray		12 Nos
15	No. of splice tray		4
16	Provision of passthrough splicing	Yes/No	Yes
18	Method for mounting with the tower		Mounting on tower above anti climb guard levels at 10mtr from top of the tower with bolt & nut
Optical Fiber Cable Accomodations			
19	Cable Glanding		Aluminium bushing & aluminium hose gasket
20	Maximum number of cables that can be accomodated	Each	2 No of cables (OPGW/ADSS/Approach Cable)
21	Diameter of cables that can be accomodated	mm	Ø8.0-18.0
22	Details of Splice Trays:		
23	Dimension (Length x Width x Thickness x Depth)	mm	234 ± 5 x 110 ± 5 x 10 ± 0.5
24	Material/Guage		Acrylonitrite Butadiene Styrene (ABS)
25	Weight of each splice tray	kg	0.074 ± 5%
26	Colour & Finish		Black and Transparent
27	Number of splices per tray	ea	4
28	Provision of Splice organisors		4 x 12
29	Excess length of fiber service loops	m	1.5 to 3
31	Minimum bending diameter for fiber coils inside tray	mm	≥75
32	Life of Joint Box		25 years

48F APPROCH CABLE

TECHNICAL DETAILS OF 48F (G652D -SM)
MULTI LOOSE TUBE DESIGN, SINGLE SHEATH ARMORED OPTICAL FIBRE CABLE

(1) MECHANICAL CHARACTERISTICS:

Temperature Range (IEC 60794-1-2-F1)

Laying and Installation	-20° to +70°C
Operation	-20° to +70°C
Transport and Storage	-20° to +70°C

Cable Bending Radius (IEC 60794-1-2-E11A)	20 D, **D= Diameter of Cable**
Repeated Bending (IEC 60794-1-2-E6)	30 Cycle, r= 20 X D, 5 Kg Load, D = Cable Diameter
Tensile Force (IEC 60794-1-2-E1)	2500N
Torsion Resistance (IEC 60794-1-2-E7)	10 Cycles, (± 180°), 10 Kg Weight, 2 Mtr Length
Crush Resistance (IEC 60794-1-2-E3)	2000N (100 X 100 mm)
Impact Resistance (IEC 60794-1-2-E4)	25Nm
Kink Resistance (IEC 60794-1-2-E10)	10 D, D is cable diamter
Water Penetration (IEC 60794-1-2-F5B)	1 Mtr Water Head, 3 Meter Cable Sample, 24 Hours

(2) OPTICAL CHARACTERISTICS:

Fibre used in the cable manufacturing fully comply to ITU-T-Rec G 652D.

at 1310 nm	≤ 0.36 dB/Km
at 1550 nm	≤ 0.23 dB/Km

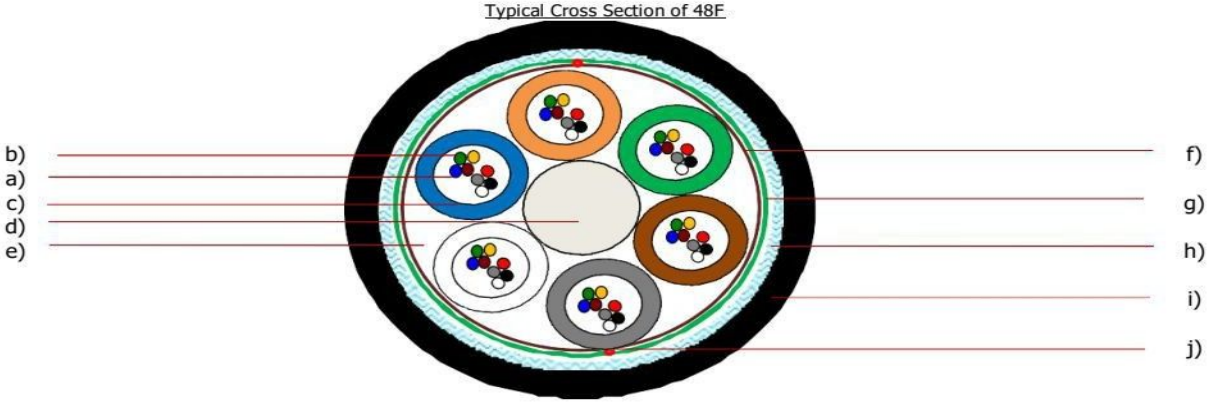
(3) COLOUR CODING:

Colour of Fibres in a Tube :	Blue, Orange, Green, Brown, Grey, White, Red & Black
Colour of Loose Tubes:	Blue, Orange, Green, Brown, Slate, White

(4) CABLE CONSTRUCTIONAL DETAILS:

a)	Primary Coated Fibre	Single Mode- **G652D (8 Fibrer per tube)**
b)	Tube Filling Compound	Thixotropic Jelly
c)	Loose Tube(s)	PBTP
d)	Central Strength Member	FRP Rod
e)	Water Blocking Element	Thixotropic Jelly
f)	Core Wrapping	Polyester Tape & Water Swellable Tape
g)	Peripheral Strength Member	Glass Roving Yarn
h)	Armouring	ECCS-Corrugated, Chrome Plated Steel Tape
i)	Outer Sheath **(T = 1.6 mm Nominal)**	HDPE Black
j)	Rip Cords	3 Ply, suitable to rip open Armoure & outer sheath

Typical Cross Section of 48F



(5) DELIVERY INFORMATION:

Nominal Cable Weight (Kg/Km)	130 ± 15
Nominal Cable Diameter (mm)	11.8 ± 0.5
Standard Length per Drum (Mtr)	2000 +/- 10%

(6) CABLE SHEATH MARKING:

Cable sheath shall be marked in white colour with Hot Foil Indentation method. **Marking details can be customized**. Below mentioned details are generally marked on the cable sheath.

Telephone Symbol, Laser Symbol, Number of Fibres, Type of Fibre , Type of Cable , Month & Year of Manufacturer, Manufacturer Name, India, Sequential Meter Marking & Drum Number

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