Non-metallic Aerial Distribution Optical Cables for FTTH Networks

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One of the common practices to construct economical and efficient Fiber To The Home (FTTH) networks is to share "electric poles" by optical fiber networks and power lines. For safe deployment of optical cable close to power lines and lightning strike prevention, we have proposed the non-metallic FTTH networks solution.

To achieve the proposal solution, we have developed non-metallic self-supporting high-density aerial distribution optical cables that allow easy and simple mid span access installation in a short time and non-metallic drop optical cables that are compatible with conventional field assembled connectors. In particular, the lineup of the aerial optical cables is now extend to 48-fiber. This paper presents the details of these new non-metallic optical cables.

1. Introduction

The spread of smartphones and cloud services have explosively increased the amount of communications data worldwide. Fiber To The Home (FTTH) service, which is to install and to connect optical fiber to individual home, is expanding rapidly in the world. To catch up the rapid demand of high speed data transmission and suppression of huge advance investment, telecom operators seek construction of optical fiber networks more economically and efficiently.

We reported Ultra-High Density Wrapping Tube Cables (WTC) with Spider Web Ribbon (SWR)[1)], and achieved extreme reduction in outer diameter and weight of optical cables. In the field of aerial distribution optical fiber cables, our past IWCS paper reported 24-Fiber high-density aerial distribution optical cable with SWR.[2)] The key feature of this aerial optical cable is to allow quick mid span branching anywhere on the cable after wiring. Some of the markets which already introduced the cable requested to extend the lineup to higher fiber count.

On the other hand, in many countries, electric poles are shared with optical fiber networks and power lines to minimize capital expenditure especially in rural or even in cities. Local regulation normally allows only all dielectric communication cable to be deployed between electric poles.

We have proposed Non-metallic FTTH solution and have developed Non-metallic self-supporting high-density aerial optical cables with 12-fiber Spider Web Ribbon (SWR) as shown in Fig. 1. The cable structure is based on 24-fiber high-density aerial distribution optical cable which we previously developed.[2)] Non-metallic material supporting wire and strength member are applied to the developed cables, which allows installation between electric poles, prevention of lightning events and omitting the process of connecting the ground. The product lineup of the developed cables is extended to 48-fiber optical cable. In addition, we have developed Non-metallic 1, 2-fiber drop optical cables.

This paper describes these new non-metallic high-density aerial distribution optical cables and non-metallic drop optical cables.

2. Non-metallic self-supporting high-density aerial distribution optical cables

2.1 SWR

SWR is composed of single fiber parts and bonding parts where adjacent fibers are fixed together

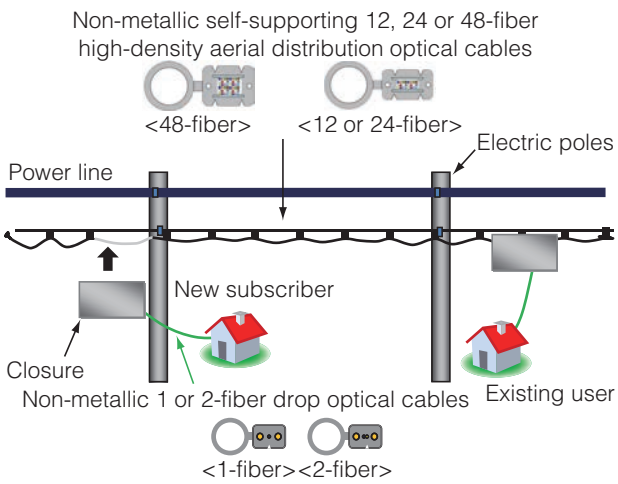

Fig. 1. Non-metallic aerial FTTH wiring.

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intermittently. SWR can change its shape easily like bundled fibers and can be packed in a cable with ultra-high density. The structure and the feature of SWR are shown in Fig. 2.

SWR can be spliced easily with existing fusion splicers or attached by connectors just like conventional rigid ribbon, and can be divided to individual fiber to easily pick up the target fiber. The fiber count of SWR applied to the developed cables is selected 12 to comply with the common fiber ribbons in overseas market. Fusion splicing of 12F-SWR is shown in Fig. 3(a), Split single fibers of 12F-SWR is shown in Fig. 3(b).

SWRs are printed with stripe ring markings for easy identification of each ribbon number and each fiber after ribbon split as shown in Fig. 4.

2.2 Cable design

These developed cables consist of 12F-SWRs and water blocking yarns wrapped by a plastic tape which are then sandwiched by separators, a supporting wire and strength members which are embedded in a sheath. The developed cables are shown in Fig. 5. Glass-FRPs are applied to the supporting wire and the strength members, and the cables are all composed of dielectric materials. The all-dielectric structure makes it possible to wire between electric poles, to prevent lightning accidents, and to omit the process of connecting the ground.

The cables have windows between the supporting wire part and the cable element, and the length of the optical element is longer than the supporting wire part. This structure prevents increase of the fiber strain when wind pressure and ice load are applied to cables, and suppresses cable galloping. The structure

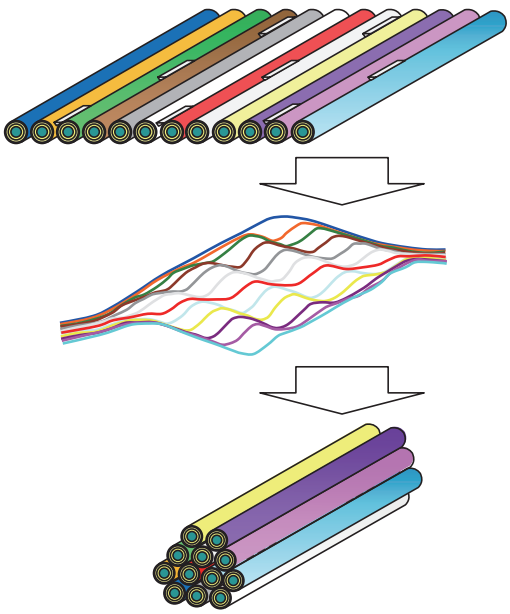


Fig. 2. Structure and feature of SWR.

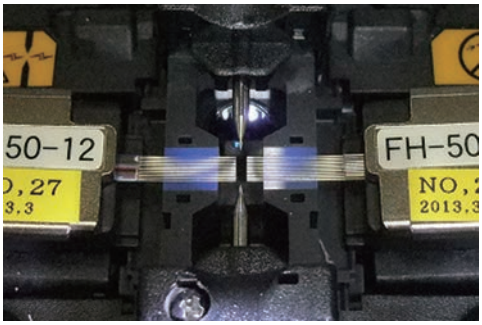


Fig. 3(a). Fusion splicing of SWR.

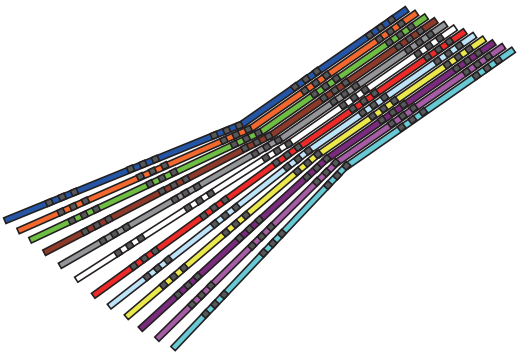


Fig. 3(b). Split single fibers of SWR.

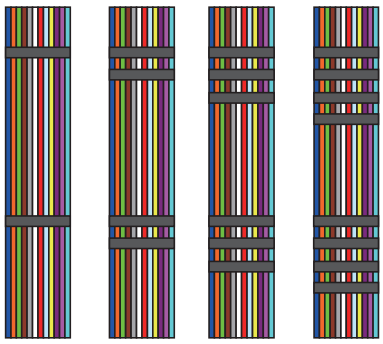


Fig. 4. Schematic of stripe ring marking.

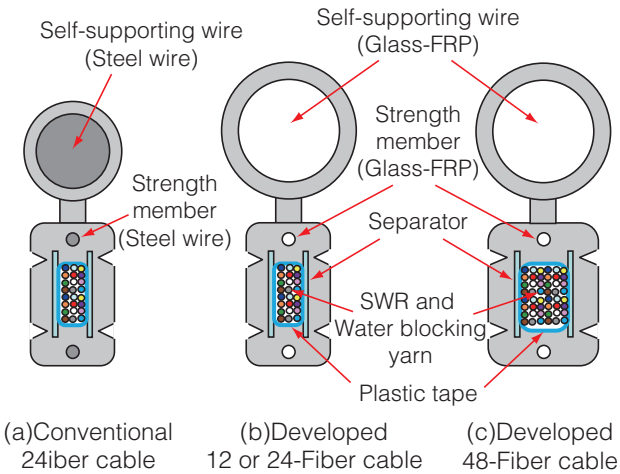


Fig. 5. Cross section views of high-density aerial distribution optical cables.

is shown in Fig. 6.

We have designed the cable element dimensions of the developed 12 and 24-fiber cable equal to the conventional 24-fiber metallic cable for the compatibility of dividing tools and closures. In addition, we have designed the height of the 48-fiber developed cable element equal to the conventional cable and optimized the width of cable element. Thus, the wind pressure loads of these developed cables are equal regardless of fiber count, since the projection area of the 12 or 24-fiber cables and the 48-fiber cable are equal.

We have designed the diameter of the Glass-FRP supporting wire to withstand wind pressure load and ice load. The developed cables have the same reliability as the conventional cable with a steel wire.

The cable dimensions and weights are listed in Table 1.

2.3 Cable design for mid span access installation

The mid span access is one of the most important characteristics for the aerial access cable. Mid span access is to branch off target fiber at an intermediate of cables and to connect to other distribution optical cables or optical drop cables. The developed cables have three excellent features for mid span access installation. The first feature is that closures can be installed anywhere on the developed cables after wiring straight without storing cable loops beforehand. The second feature is that SWR can be picked up easily from the developed cables. The third feature is that SWR can be easily spliced and be divided to individual fiber. These three features are described below in more detail.

First, the aerial deployment of general optical cables such as loose tube cables require storing cables (cable loops) near poles for mid span access installation as shown in Fig. 7. By contrast, the developed cables have windows between the supporting wire part and the cable element, and the length of the cable element is longer than the supporting wire part. This structure makes it easy to separate the support wire part and the cable element, and provides the sufficient cable length for installing closures at an intermediate of cables. The schematic of closure installation on the developed cables are shown in Fig. 8.

Second, the cable element part of the developed cables is flat structure with four notches and separators. The developed cables can be divided easily by one action with a simple dividing tool having blades place at a position corresponding to the notches of the developed cables regardless of installer's individual skills. This tool can separate the supporting wires part from the cables as well. The installation procedure for the separation of the self-supporting wire and picking

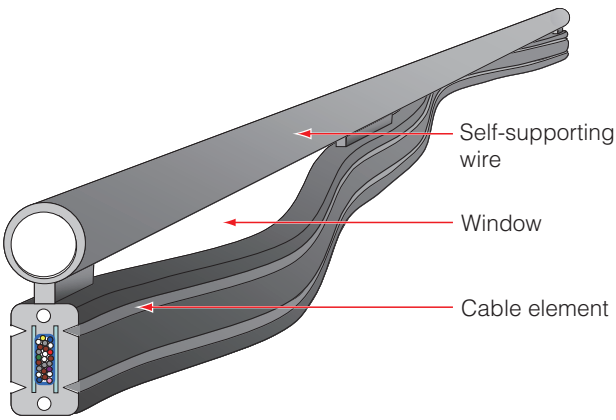


Fig. 6. Structure of self-supporting with window optical cable.

Table 1. Weight and dimension of high-density aerial distribution optical cables

	Conventional 24-fiber cable	Developed 12 or 24-fiber cable	Developed 48-fiber cable
Cable weight	68 kg/km	65 kg/km	73 kg/km
Cable element dimension	3.5×5.5 mm	3.5×5.5 mm	5.0×5.5 mm

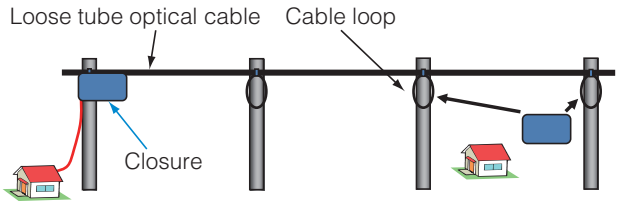


Fig. 7. Wiring of loose tube optical cables.

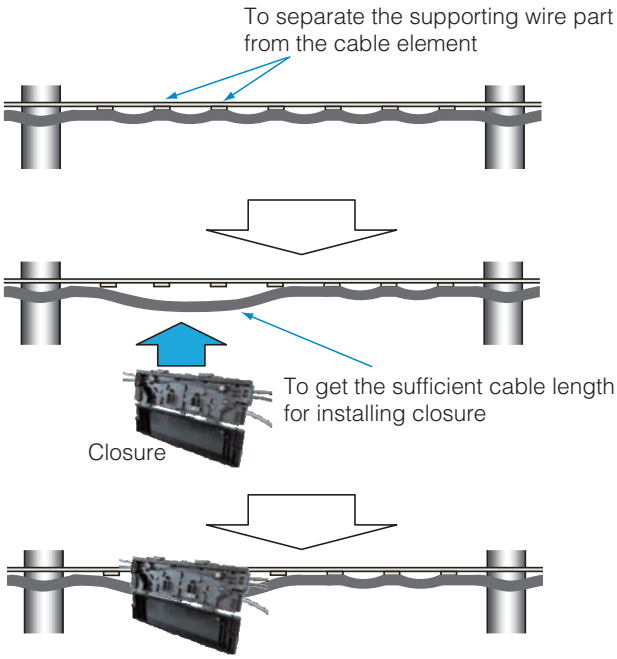


Fig. 8. Schematic of installing closure.

off SWR is shown in Table 2.

Finally, SWR can be spliced and divided to individual fiber as described in item 2.1. Thus, the developed cables are excellent in connectivity to other aerial optical cables or drop optical cables.

2.4 Cable fixing at poles

The fixing method of the conventional cables with steel supporting wire is to peel off and expose the steel wire from outer sheath and insert it into a C-type wire clamp. The C-type wire clamp with conventional cable is shown in Fig. 9(a). By contrast, we have adopted a different fixing method that the helical dead-ends grip the sheath of the supporting wire part. This method prevents Glass-FRP buckling or the surface of Glass-FRP scratching when attaching helical dead-ends.

We have optimized the design of size, grip length and number of steel wire of helical dead-ends for sufficient cable-gripping force and easy installation workability. The helical dead-end attached to the developed cable is shown in Fig. 9(b).

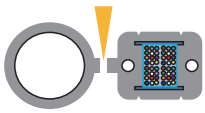
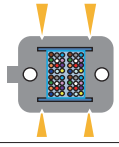
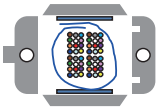
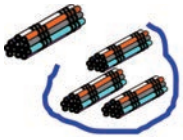
3. Non-metallic drop optical cables

The developed drop optical cables consist of one or two optical fiber, two strength members of Aramid FRP, and a supporting wire of Glass-FRP. These components are jacketed with flame retardant polyolefin. These drop optical cables are shown in Fig. 10.

We have designed the dimension of cable element equal to a conventional drop optical cable [3] for the compatibility of existing tools and accessories, such as stripper, closure and field assembled connector.

The cable fixing method is that the helical dead-ends grip the sheath of the supporting wire part.

Table 2. Procedure of mid span access installation.

Procedure	Schematic	Picture
Separate the supporting wire		
Divide the jacke		
Remove the jacket and the tape		
Pick out the target SWR		

The cable dimensions and weights are listed in Table 3.

4. Cable characteristics

4.1 Optical and mechanical characteristics

The optical and mechanical test results of the developed aerial distribution optical cables are listed in Table 4. One of the drop optical cables are listed in Table 5. Test methods are based on IEC60794. A measurement wavelength for mechanical test is 1550nm. The developed aerial distribution optical cables and drop optical cables showed good performances.

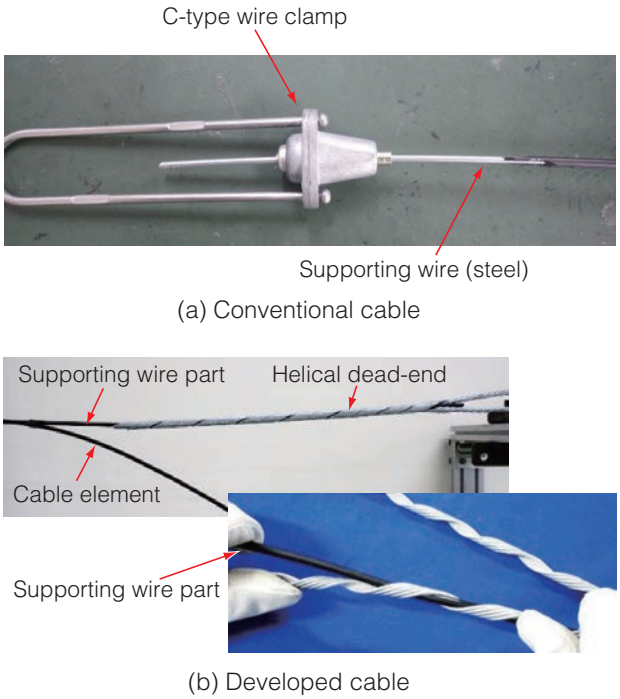


Fig. 9. Cable fixing method.

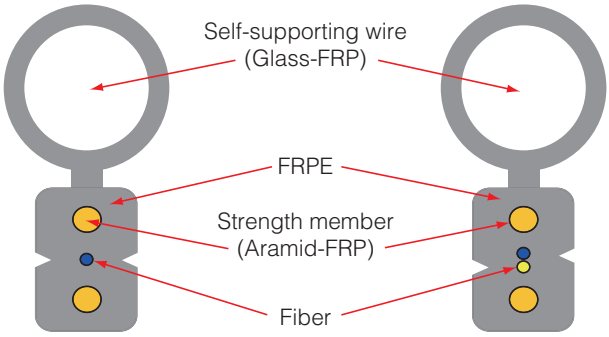


Fig. 10. Cross section views of non-metallic drop optical cables.

Table 3. Weight and dimension of drop optical cables.

	Conventional cable	Developed cable
Cable weight	19 kg/km	23 kg/km
Cable element dimension	2.0×3.1 mm	2.0×3.1 mm

Table 4. The characteristics of non-metallic high-density aerial distribution optical cables (12, 24 or 48 fiber cable).

	Condition	Result
Attenuation	1310 nm	≤0.40 dB/km
	1550 nm	≤0.25 dB/km
Crush*	IEC60794-1 1500 N / 100 mm	≤0.05 dB
Impact *	EC60794-1 3 J	≤0.05 dB
Repeated bending*	IEC60794-1 25 cycle 12 or 24 ; R100mm 48 ; R150mm	≤0.05 dB
Torsion*	IEC60794-1 ±90 ° / 1 m	≤0.05 dB
Temperature cycling*	IEC60794-1 −40/+70 °C 2 cycle	≤0.10 dB/km
Water penetration	IEC60794-1 Height of water 1m Sample length 3m	No leaking after 24h

*Measure wave length ; 1550 nm

Table 5. The characteristics of non-metallic drop optical cables.

	Condition	Result
Attenuation	1310 nm	≤0.40 dB/km
	1550 nm	≤0.25 dB/km
Crush*	IEC60794-1 1500 N / 100 mm	≤0.05 dB
Impact *	EC60794-1 3 J	≤0.05 dB
Repeated bending*	IEC60794-1 300 cycle R 180 mm	≤0.05 dB
Torsion*	IEC60794-1 ±90 ° / 1 m	≤0.05 dB
Temperature cycling*	IEC60794-1 −40/+70 °C 2 cycle	≤0.05 dB/km

*Measure wave length ; 1550 nm

4.2 Mid span access installation characteristics

The mid span installation, which is the feature of the non-metallic self-supporting high-density aerial distribution optical cables, were verified under installation temperature of both +40 degree C and −10 degree C, assuming the actual installation environment. We measured the installation time of picking up target fiber from the developed cables. The result is listed in Table 6. It was confirmed that the developed cables are capable of being deployed in a short time regardless of environment temperature.

4.3 Characteristics of cable fixing

We have adopted the cable fixing method that the supporting wire part is gripped with helical dead-ends for the first time. The reliability tests of the cable fixing were conducted under various conditions, assuming the relatively harsh operating environment such as summer, winter, rain and wind which causes galloping. We applied the permissible tension calculated from wind pressure and ice load to the supporting wire part with helical dead-end. The tensile test conditions and results are listed in Table 7. The developed cables showed good characteristics of fixing without slipping from helical dead-end or breaking of supporting wire.

Table 6. The mid span access operation time of non-metallic high-density aerial distribution optical cables.

Condition	Developed 12 or 24-fiber cable	Developed 48-fiber cable
−10 °C	<60 sec	<60 sec
+40 °C	<60 sec	<60 sec

Table 7. Cable fixing test conditions and results.

	Condition	Aerial cables	Drop cable
High temperature	+70 °C	no slip no breakage	no slip no breakage
Low temperature	−30 °C	no slip no breakage	no slip no breakage
Reliability (High temperature and high humidity)	85 °C 85% After 1 month	no slip no breakage	no slip no breakage
Reliability (Vibration)	Frequency 10 Hz Amplitude 10 mm/1 m Cycle 1million	no slip no breakage	no slip no breakage

5. Conclusion

We have developed non-metallic self-supporting high-density aerial distribution optical cables and non-metallic drop optical cables. The new aerial distribution optical cables showed excellent Mid-span access installation workability.

The aerial FTTH solution with the developed cables can be applied for construction of FTTH network that utilize existing electric poles and greatly contribute to suppression of installation costs in many countries and regions.

Reference

1) M.Isaji, S.Yagi, Y,Takahashi, K.Osato, M,Yamanaka, N.Okada," Ultra-high density wrapping tube optical fiber cable with 12-fiber spider web ribbon," Proceedings of 62nd IWCS, pp.605-609, 2013.
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3) M.Ohno, D.Takeda, T.Sayama, S.Shiobara, N.Okada, "Development of the new cicada resistant aerial optical drop cables," Proceedings of 59nd IWCS, pp.164-169, 2010.