Ultra-High-Density Optical Cable with Rollable Ribbons for Simple Installation and Cost Reduction

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This paper describes a newly developed ultra-high-density optical fiber cable containing rollable 4-fiber ribbons with a fiber adhesive part and a single-fiber part. The 24-fiber cable is an aerial distribution cable that has sheath configurations similar to a conventional optical thinner drop cable and can therefore be drastically downsized compared with a conventional aerial non-slotted core cable. The cable also has multiple notches on the sheath, with strength members, plastic tapes and yarns surrounding the rollable ribbons, offering easy fiber ribbons extraction from the cable. Moreover, we have also adopted 24MPO optical connectors for joint boxes and on both ends of the cable, which simplifies cable installation and reduces installation time and cost.

Keywords: rollable ribbon, ultra-high-density, cable downsizing

1. Introduction

The number of the fiber to the home (FTTH) subscribers in Japan has already reached 23 million and is forecast to increase at a consistent rate. As shown in **Fig. 1**, the typical FTTH cabling network is connected from the telecom building to underground cables, aerial cables and drop cables. Recently, to construct a FTTH network more economically, several studies for new aerial distribution cable with thinner diameter and higher density have been carried out. Easy cable connection and branching workability are also much in demand.

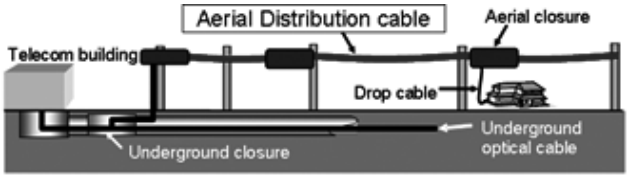


Fig. 1. Common wiring system in Japan

2. Cable design

2-1 Features of ultra-high-density optical fiber cable configurations

To construct a FTTH network, distribution cables with ribbon fibers are installed in advance, and then drop cables with a single fiber can be routed from any mid-span point upon requests for the FTTH service. We decided that the new cable's design would be more suitable for mid-span access.

The configurations of the new 24-fiber cable with rollable 4-fiber ribbons are shown in **Fig. 2** and **Table 1**. We kept similar configurations to the conventional drop cable which has two strength members at both sides of the 6 rollable fiber ribbons and rectangular jacketing, with the intention of downsizing the cable. This configuration results in drastically reducing the size by 70% and weight by 55%, while retaining the equivalent cable characteristics of conventional aerial non-slotted core cable.

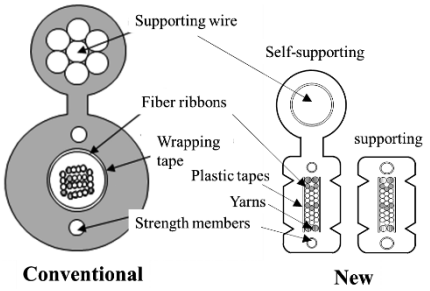


Fig. 2. Cable cross-section

Table 1. Cable configurations

Item	Conventional cable	New cable	
	Self-supporting type		supporting type
Supporting wire	7/1.4 mm	2.6 mm	—
Fiber	a single mode fiber		
Strength member	0.7 mm	0.5 mm	0.7 mm
Wrapping	Plastic tape	Plastic tapes & Soft yarns	
Jacket	Polyolefin		
Diameter	8.5 × 17 mm	3 × 10.5 mm	3 × 5.5 mm
Cross section Size (main cable)	1	0.3	0.3
Weight	0.16 kg/km	0.07 kg/km	0.02 kg/km

2-2 Rollable ribbon

As shown in **Fig. 3**, rollable ribbon consists of a fiber adhesive part and a single-fiber part. In addition, rollable ribbons can be connected by fusion splicing like conventional 4-fiber ribbons.

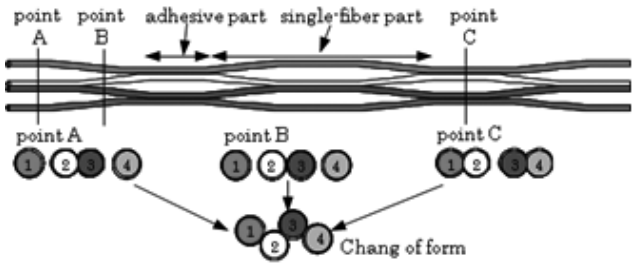


Fig. 3. Rollable ribbon

This configuration also enables the ribbons to change shape in order to reduce stress to the fibers in the cable. Thus, the cable will have a high tolerance against external stress, with the result that the fiber density inside it will be higher and the cable will be thinner and lighter.

3. Improvement for Cable Jointing

3-1 Application to mid-span access

Figure 4 shows how to dissect the conventional cables to extract the fibers. First of all, peel off the sheath with a tool like a peeler. As you continue to peel, the rip cord appears. By taking out the rip cord, the jacket is pulled apart and the inside core can be taken out. After taking out the core, remove the thread and core wrap wrapped in a spiral manner, and then finally the optical fibers appear.

The handling procedures to extract rollable ribbons from the cable are shown in **Fig. 5**. The new cable has four notches on the rectangular jacket. By using these notches as guide grooves, we can accurately slit at any longitudinal position using the blade on the special tool. Furthermore, because the ribbons are circumscribed on all four sides by the plastic tapes and yarns, ribbons can be extracted safely without the fibers being left in the polyolefin jacket.

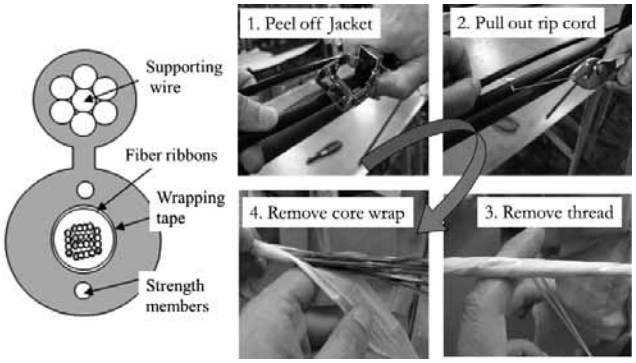


Fig. 4. Dissection of conventional cable

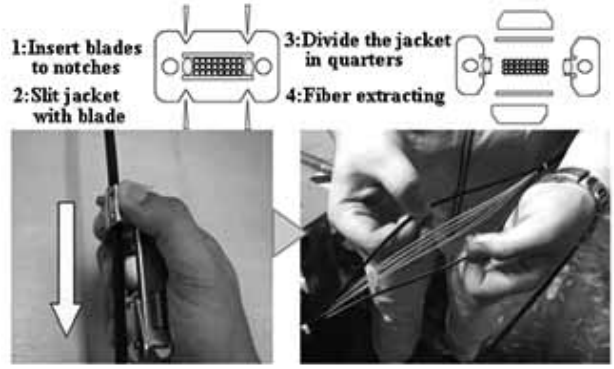


Fig. 5. Fiber extracting procedures

With conventional cables, it can take more than 3 minutes to take out the fibers, but with this new cable, the handling process is very simple and it takes less than 30 seconds. With this method, the fibers can be taken out very easily at any location after cables are installed in a very short time.

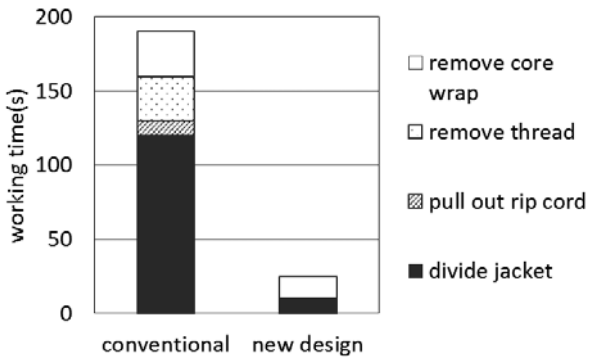


Fig. 6. Working time to extract fibers

3-2 Connecting method for the new cable

To construct the FTTH more economically, more simplified construction methods and products are required. To do so we attached 24MPO optical connectors on both ends of the new cable and each cable with 24MPO connectors is jointed in a newly developed "Joint Box."

The assembled configuration of the new 24-fiber cable with Joint Box is shown in **Fig. 7**. Special skills are not needed to connect the two new 24-fiber cables.

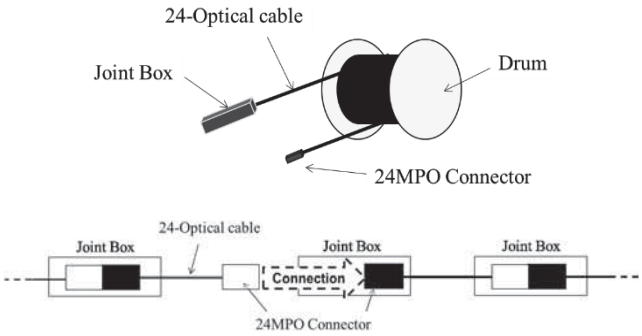
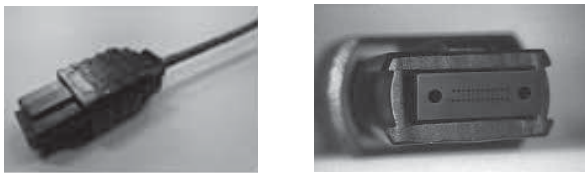


Fig. 7. New 24-optical cable with Joint Box

3-3 24MPO connector

To realize easy connection in the field, we selected the 24MPO optical connector. MPO optical connectors have been used worldwide over ten years, the reliability in the field is proven, and it is possible to connect all of optical fibers in new cable in one operation. The configuration of 24MPO optical connector is shown in **Fig. 8** and the 24-fiber cable's terminal with a 24MPO connector is shown in **Fig. 9**, respectively.



Appearance End face

Fig. 8. 24MPO optical connector

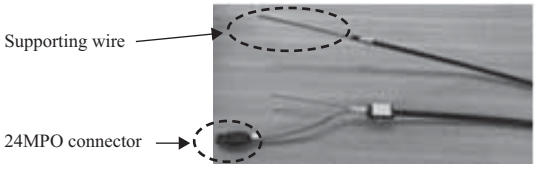


Fig. 9. Cable terminal

3-4 Design of the Joint Box

The Joint Box is connected to one end of the cable as shown in **Fig. 10**. For outdoor and long term use, the Joint Box has to be robustly designed: the outer configurations of the Joint Box adhere fundamentally to conventional aerial closure which is waterproof and resistant to ultraviolet light. A 24MPO connector is also attached on the opposite end of new cable.

The Joint Box consists of three main parts as shown in **Fig. 10**: the first is holding the cable; the second is holding the supporting wire; the third is connecting the optical fibers.

Appearance of the Joint Box

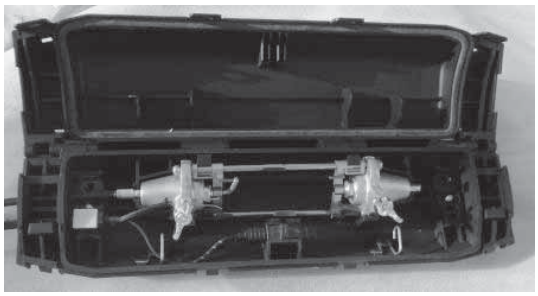


Fig. 10. Joint Box

3-5 Procedures to assemble the Joint Box

The procedures to connect to a Joint Box are shown in **Fig. 11**. All operations can be carried out within 3 minutes without using special tool.

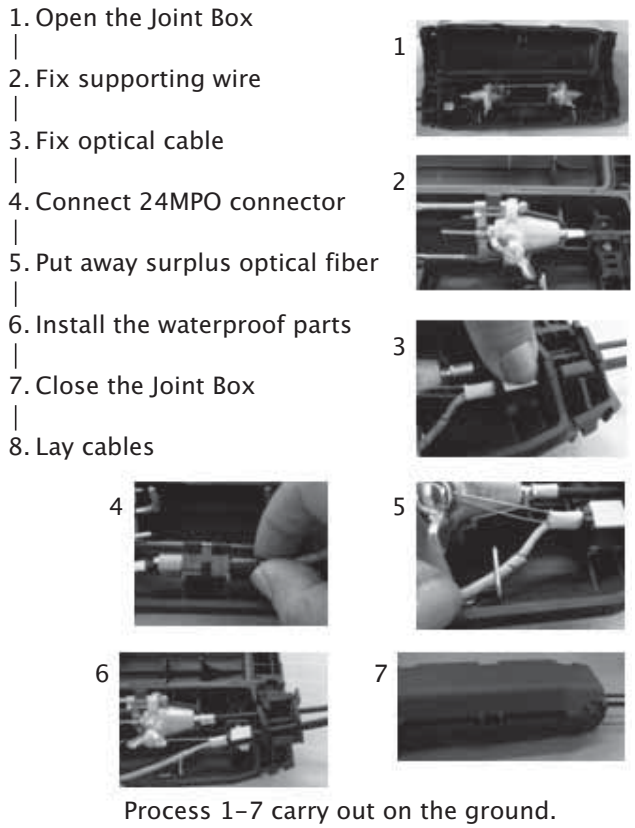


Fig. 11. Procedures of jointing

4. Characteristics

4-1 Cable characteristics

Table 2 shows the transmission, temperature and mechanical characteristics of the newly developed cable. All of the test results were positive. In the test cable, a single mode fiber complying with ITU-T G.657 class A1 was used.

Table 2. Transmission and mechanical performance

Item	Methods	Test Results
Attenuation Coefficient	IEC60793-1-40 λ = 1,550 nm	< 0.25 dB/km
Temperature Cycling	IEC60794-1-2 -30 ~ +70 degrees C, 3 cycles λ = 1,550 nm	< 0.10 dB/km
Crush	IEC60794-1-2 1960N/100 mm λ = 1,550 nm	< 0.05 dB
Impact	IEC60794-1-2 300 g, 1 m , λ = 1,550 nm	< 0.05 dB
Repeated Bending	IEC60794-1-2 Bending radius:100mm 10 cycles, λ = 1,550 nm	< 0.05 dB
Torsion	IEC60794-1-2 +/-90 degrees/1 m λ = 1,550 nm	< 0.05 dB
Bending under tension	700N, R=250 mm λ = 1,550 nm (self-supporting type)	< 0.05 dB

4-2 Connector characteristics

We have conducted various mechanical and environmental tests on the 24MPO connectors in the Joint Box shown in **Fig. 12** and **Table 3**. As representative results, the insertion loss when using a master connector plug was 0.22dB average, 0.57dB max and the insertion loss fluctuation during the environmental tests (Temperature cycle, Temperature and humidity cycle, High temperature, Low temperature, Salt spray, Continuous temperature Humidity cycle) were within 0.11dB. All other test results were positive.

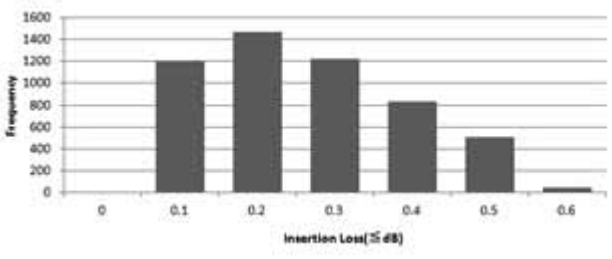


Fig. 12. Insertion loss results of 24MPO connector

Table 3. Tests results of 24MPO Connector

Test item	Methods	Test Results
Insertion Loss	Vs. Master plug connector	Avg. 0.22 dB Max. 0.57 dB
Return Loss	Vs. Master plug connector	> 60 dB
Durability	100 times	< 0.19 dB
Vibration	1.5 mm PP 10~55 Hz 3 axis 2 hours	< 0.02 dB No damage
Impact	100 G 6ms, 5 times	< 0.18 dB No damage
Proof (90˚)	0.5 N 10times	< 0.17 dB No damage
Proof (0˚)	5.9 N	< 0.19 dB No damage
Temperature Cycle	-40~70 degrees C 10 cycle	< 0.11 dB
Temperature and Humidity Cycle	-10~25~65 degrees C 93% at 65 degrees C 10 cycles	< 0.04 dB
High Temperature	70 degrees C 240 hours	< 0.04 dB
Low Temperature	-40 degrees C 240 hours	< 0.08 dB
Salt Spray	35 degrees C 5% salt water 24 hours	< 0.05 dB No damage
Continuous Temperature Humidity Cycle	85 degrees C, 336 hours 95%/ at 60 degrees C 336 hours -40~23~75 degrees C 42 cycles	< 0.10 dB

5. Conclusion

We have developed an ultra-high density 24-fiber cable with rollable 4-fiber ribbon. This cable results in drastically reducing the size by 70% and weight by 55%, while retaining the equivalent cable characteristics of conventional aerial non-slotted core cable.

Furthermore, we have created a Joint Box with 24MPO connectors which will contribute to simplifying installation work saving installation time and cost.

References

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