2000-fiber Ultra-high Density Underground Cable

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In order to construct optical access networks economically and efficiently, we have successfully developed the ultra-high density 2000-fiber cable using innovative optical 8-fiber ribbon "Spider Web Ribbon (SWR) " for underground networks. By employing high packing technology of SWR with simple cable design, the 2000-fiber cable has achieved the same diameter as existing 1000-fiber slotted core cable and the highest level of fiber packing density in the world. In addition, the cable has advantage of fiber joint workability such as mass fusion splice and unit identification by optimizing ribbon and bundle unit structure.

1. Introduction

In recent years, the broadband services using optical access networks have been growing remarkably. Therefore, it is strongly required to install optical fiber cable economically. However, the existing underground ducts have become congested and the number of optical fiber cables which can be installed in a duct is limited. To improve this situation, the demand for smaller diameter and higher fiber count optical cable is increasing.

One of the methods to utilize the duct space effectively is to install multiple cables within an inner pipe in underground duct to increase total fiber count [1)]. Currently, the limit of the fiber count which can be installed in a duct is 3000 as 1000-fiber slotted core cable is the maximum size which can be installed within an inner pipe in Japan.

With this issue raised, we have been demanded to develop higher fiber count cable with the same diameter as existing 1000-fiber slotted core cable so as to install higher fiber count in the duct.

Several studies have already been reported for the high packing technology by using SWR [2)]. This time, we achieved development of 2000-fiber ultra high density cable with the same diameter as existing 1000-fiber slotted core cable [3)]. By introducing the new SWR structure and the bunching technology, new cable was able to obtain work and construction characteristics which are comparable with existing cables.

2. 8-fiber Spider Web Ribbon

2.1 The design of 8-fiber Spider Web Ribbon

The structure of 8-fiber SWR is shown in Figure 1. SWR consists of 2-fiber rigid ribbons which are formed out of 250 μm coated fiber, and these ribbons are fixed intermittently with UV curable resin. The physical layout of this ribbon can be formed like bundle easily. Therefore, it is extremely effective to pack more fibers in a cable.

In addition, this ribbon is superior in visibility and workability in optical closure because it can be divided into 2 or 4-fiber rigid ribbon.

2.2 Mass fusion splicing

8-fiber SWR can be spliced by mass fusion splicer similar to conventional 8-fiber rigid ribbon as shown in Figure 2, it also has good workability in optical closure. We compared the fusion splicing time both 8-fi-

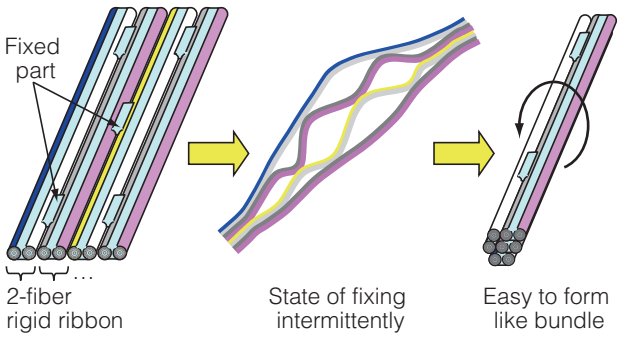

Fig. 1. Structure and feature of SWR.

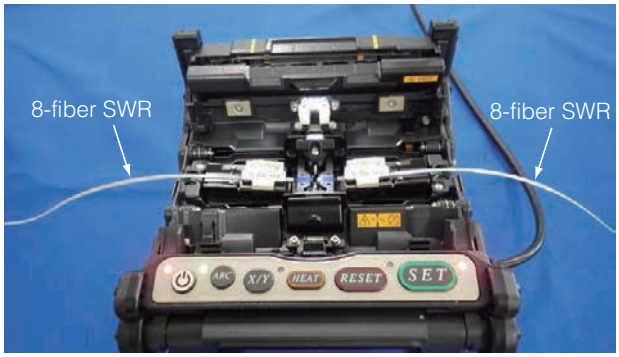

Fig. 2. Fusion splicing of SWR.

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ber SWR and conventional 8-fiber rigid ribbon. Time recorded for fusion splicing is based on operation steps of the following:

- Setting ribbon in a holder
- Removing coating of ribbon fibers
- Cutting fibers
- Setting ribbon fibers on the trenches

Comparison of the results is shown in Figure 3. In addition, the result of the fusion splicing loss is shown Figure 4. There is no difference between 8-fiber SWR and conventional 8-fiber rigid ribbon. Hence, we concluded that 8-fiber SWR exhibits good characteristic of mass fusion splice.

3. 80-fiber bundle unit

The new cable contain multiple fiber bundle units, each of 80 fibers and as much as 25 bundle units are packed in this cable. Hence, it is necessary to identify each bundle unit using tapes with limited color variations. The new proposed bundle unit can identify each target bundle unit by a combination of two different colored tapes. In addition, we added a new value-adding feature to identify the target unit easily. The new feature is to bond crossing points of the two colored tapes. This feature is effective to avoid loosening of the unit shape during the operation. The structure of the new bundle unit is shown in Figure 5. The newly developed bundle unit allows operator to easily identify individual bundle units during operations at cable end and mid-span as there is no confusion of colored bundle tapes as shown in Figure 6.

In addition, these bonded crossing points can be peeled off easily, and targeted SWR can be picked from the bundle unit.

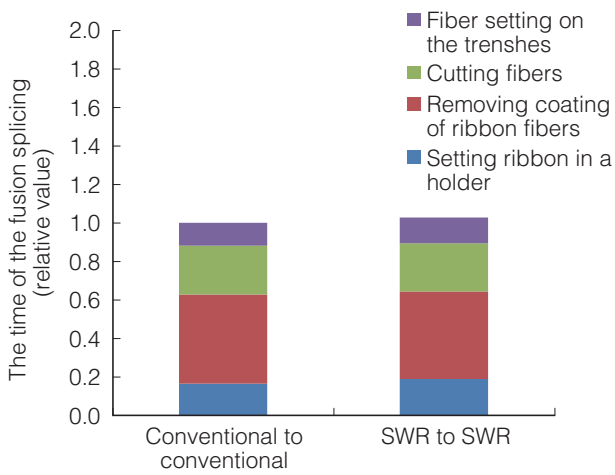


Fig. 3. Comparison of the fusion splicing time.

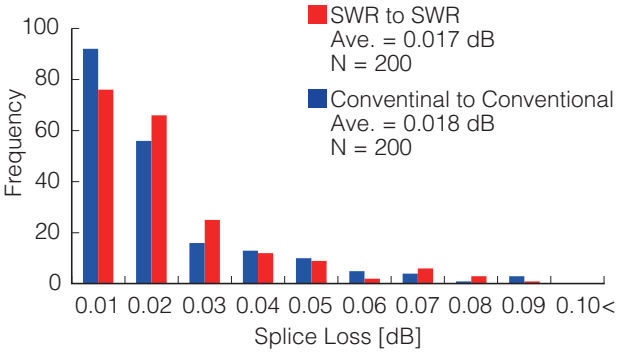


Fig. 4. Fusion splice loss of SWR.

4. 2000-fiber ultra-high density underground cable

4.1 The structure of new cable

The newly developed cable employed simple structure as shown in Figure 7. The new cable consists of

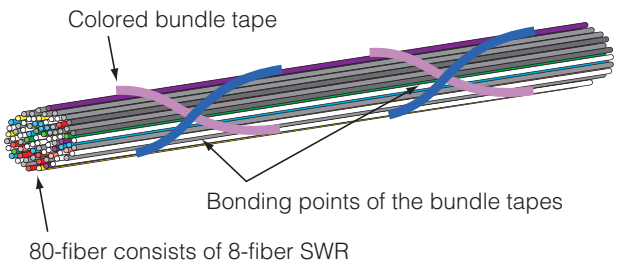


Fig. 5. Structure of the new bundle unit.

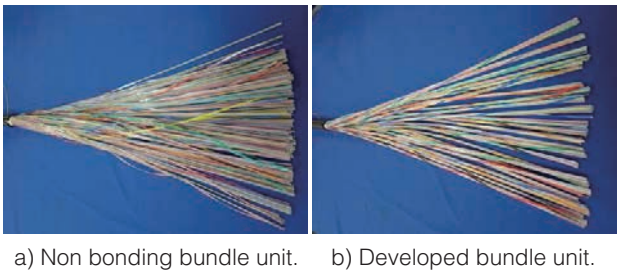


Fig. 6. Comparison of stability of bundle unit.

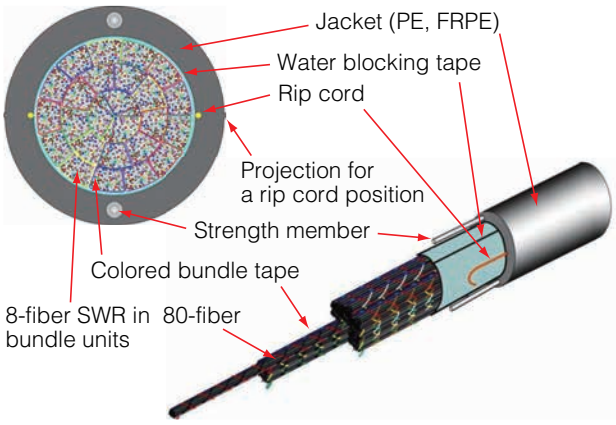
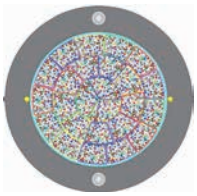


Fig. 7. Structure of 2000-fiber ultra-high density underground cable.

Table 1. Comparison of new cable and slotted core cable.

Item		Existing 1000-fiber slotted core cable	2000-fiber ultra-high density underground cable
Cable structure			
Fiber count		1000	2000
Diameter		23.5 mm	23.5 mm
Weight	PE	430 kg/km	430 kg/km
	FRPE	470 kg/km	500 kg/km

strength members, ripcords, water blocking tape and 80-fiber bundle units and each bundle unit include a colored bundle tape and multiple SWRs. These bundle units are wrapped by a water blocking tape with absolutely no gels. Therefore, the new cable allows easier and faster cable preparation.

4.2 Comparison of cable structure

Table 1 shows comparison of new 2000-fiber ultra high density underground cable and existing 1000-fiber slotted core cable. We managed to keep the diameter of 2000-fiber cable as the same diameter as existing 1000-fiber slotted core cable and to achieve highest level of fiber packing density in the world.

4.3 Characteristics of new cable

Table 2 shows the transmission, mechanical, water penetration and flame retardant test results of new 2000-fiber ultra high density underground cable. Test methods are based on IEC 60794-1-2 while test conditions are in accordance with requirements of a specific customer. Test wavelength for mechanical test was 1550 nm. The development cable exhibits excellent characteristics.

5. Conclusion

We have developed a new type of 2000-fiber ultra high density underground cable with the same diameter as existing 1000-fiber slotted core cable by using the new 8-fiber SWR technology. The new developed cable has good workability through the means of technological innovation of the new SWR structure and new bundle unit. Therefore, the new cable will allow us to increase drastically the maximum fiber count in a duct, which improves the fiber packing density of underground network.

Table 2. Characteristics of new cable.

Item	Method	Result *	
		PE	FRPE
Attenuation	IEC 60793-1-40	< 0.25 dB/km	< 0.25 dB/km
Temperature cycling	IEC 60794-1-2 −30°C / +70 °C, 3 cycle	< 0.05 dB/km	< 0.05 dB/km
Crush	IEC 60794-1-2 196 N	< 0.05 dB	< 0.05 dB
Impact	IEC 60794-1-2 10 J	< 0.05 dB No damage	< 0.05 dB No damage
Torsion	IEC60794-1-2 ±90 deg. / 1 m	< 0.05 dB No damage	< 0.05 dB No damage
Repeated bending	IEC60794-1-2 R: 240 mm	< 0.05 dB No damage	< 0.05 dB No damage
Bending under tension	IEC60794-1-2 3 kN, R: 600 mm, 90 deg.	< 0.05 dB	< 0.05 dB
Water penetration	IEC60794-1-2 Height of water: 1 m, Sample length: 40 m, Artificial sea water	No water detected at unsealed end	No water detected at unsealed end
Flame retardant	JIS C 3521	–	Pass

* Measurement wavelength: 1550 nm

References

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