SZ-slotted Core Cable with Two-step Splittable Ribbons

Keiko Mitsuhashi[1], *Masayoshi* Yamanaka[2], *Michio* Suematsu[2],
Naoki Okada[1] and *Nobuyuki* Misono[1]

To construct fiber to the home (FTTH) network economically, it is important to use the fiber efficiently. Ribbon-type optical cables are widely used in Japan. But nowadays, the splittable ribbon, which can be easily separated into individual fibers at any point where the user operates, is getting a lot of attention. On the other hand, considering the splicing with the ribbon in an existing cable, the ribbon structure will be preferred to the individual fiber structure.

We have developed the two-step splittable ribbon, which can be divided into 2-fiber or 4-fiber ribbon first, and then eventually separated into individual fibers. This two-step splittable ribbon can be applicable to the SZ-slotted core cable, which are often used for mid-span branching situation. We have developed the 100-fiber and 640-fiber SZ-slotted core cable using the two-step splittable ribbons, and these cables showed good performance.

1. Introduction

For economical construction of fiber to the home (FTTH) networks, the SZ-slotted core cable using 4-fiber ribbons that is excellent in mid-span access capability is widely used as access cables in Japan [1) 2)]. In addition, the high-fiber-count SZ-slotted core cable using 8-fiber ribbons has lately been developed to respond to the need for further increase in fiber count. The SZ-slotted rod structure features easy mid-span access because its slots are reverse (SZ) stranded at fixed intervals so as to enable fiber ribbons to be extracted at any location. With this structure, however, mid-span branching must be done ribbon by ribbon, resulting in increase of dark fibers. From this point of view, we have already developed the "easy-split ™" [3)]-type ribbon that is easy to split into individual fibers at the mid span, contributing to improved efficiency of ribbons. Moreover, we have lately developed a two-step splittable ribbon that can be temporarily split into sub-unit ribbons at the mid point and eventually into individual fibers. This two-step splittable ribbon provides easy mid-span access for splicing with each ribbon in an existing cable and enables flexible and efficient construction in a line configuration using a high-fiber-count cable.

This paper reports about the structure of the newly developed two-step splittable ribbon and the results of the evaluation thereof and also about the evaluation results on a 100-fiber ribbon type SZ-slotted core cable with two-step splittable 4-fiber ribbons and a 640-fiber ribbon type SZ-slotted core cable with two-step splittable 8-fiber ribbons.

1 Telecommunication Cable Research & Development Department
2 Telecommunication Cable System Department

2. Two-step splittable ribbon

2.1. Ribbon structure

We have already developed the easy-split ™ -type fiber ribbon that can be split at the mid span. This ribbon can be split into individual fibers easily and safely at any location by using the special tool (FSES-04) (Fig. 1). On the other hand, the 4-fiber ribbon that is splittable into two 2-fiber ribbons and 8-fiber ribbon that is splittable into two 4-fiber ribbons, which can be further split into sub-unit ribbons at a terminal, have been in practical use. Therefore, the need for a ribbon that is splittable into sub-unit ribbons at the mid span is considered great.

In view of this, we have lately started developing a two-step splittable ribbon. In order to represent a structure that enables the ribbon to be temporarily split into sub-unit ribbons at the mid span and eventually into individual fibers, we have applied the easy-

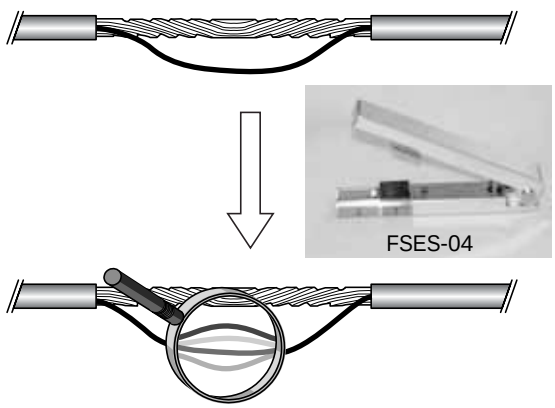

Fig. 1. The easy-split ribbon.

split ™ structure to the sub-unit ribbon. The two-step splittable ribbon was accomplished by optimizing the mechanical properties (Young's modulus and tensile strength) and dimensions of the ribbon material, which integrates sub-unit ribbons into one, and the adhesion between the sub-unit ribbon material and the integrating ribbon material. This ribbon can be initially split by the conventional special tool (FSES-04) into sub-unit ribbons, any of which can be further split into individual fibers by the same tool as is the case with the conventional easy-split ribbon (Fig. 2).

2.2. Mechanical properties of ribbon

The mechanical properties of this ribbon were evaluated. The evaluation criteria were strippability, resistance to twist and reliability of split. The results are given in Table 1. As seen from the table, the ribbon not only can be handled in the same manner as conventional ribbons, but also can be split easily and safely at the mid span. Moreover, the ribbon was confirmed to show no change in splittability before and after various reliability conditions, proving that it can be split at any time as is the case in the initial state (origin).

2.3. Transmission properties of ribbon

The transmission properties of the two-step splittable ribbon were evaluated. According to the results of lateral pressure performance, temperature cycling and reliability with application of varying environmental conditions, attenuation changes were 0.02 dB/km or less (at 1.55 μm). Therefore, the ribbon was confirmed to have excellent characteristics equivalent to those of conventional ribbons (Table 2).

3. SZ-slotted core cable

Any ribbon structure is usable for SZ-slotted core cable. The sub-unit structure can be selected and applied according to the purpose of use.

Trial cables fabricated and evaluated this time are a 100-fiber SZ-slotted core cable with 4-fiber ribbons splittable each into two 2-fiber ribbons and a 640-fiber SZ-slotted core cable with 8-fiber ribbons splittable each into four 2-fiber ribbons. Being easy to split into 2-fiber ribbons at the mid span, these cables feature easy splicing of each individual ribbon with an existing SZ-slotted core cable or drop cable with 2-fiber ribbons.

The 100-fiber cable has a slotted rod structure with

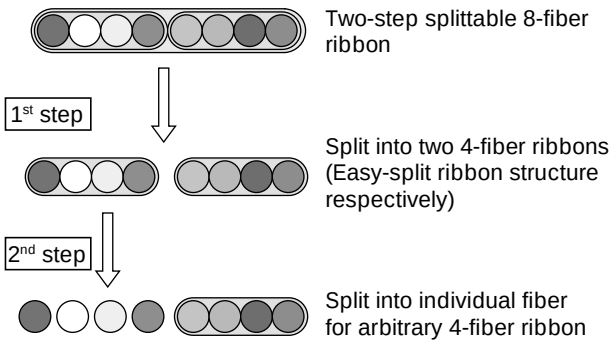

Fig. 2. The two-step splittable ribbon.

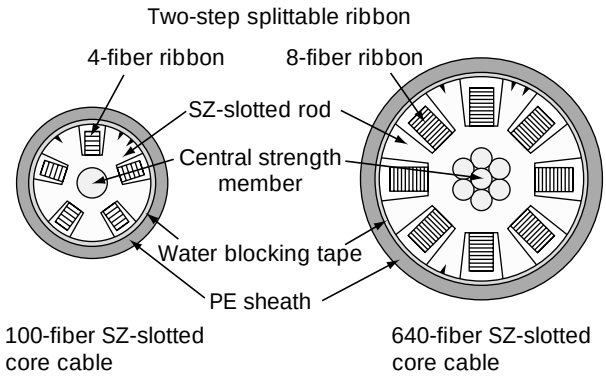

Fig. 3. Cross secctional view of 100-fiber and 640-fiber SZ-slotted core trial cable.

Table 1. Mechanical properties of two-step splittable ribbon.

Item	Test condition		Results			
			4-fiber ribbon		8-fiber ribbon	
Coating strippability	HJS(HJS-02)		No fiber breakage		No fiber breakage	
Resistance to twist	98 N/fiber ± 180° 20 cycles		No separation		No separation	
Reliability of split			1st step	2nd step	1st step	2nd step
	Origin (FSES-04)		No damage of fiber	No damage of fiber	No damage of fiber	No damage of fiber
	Temperature/ Humidity aging	85°C,85%RH 30 days	Equivalent of origin	Equivalent of origin	Equivalent of origin	Equivalent of origin
	Temperature aging	120°C 30 days	Equivalent of origin	Equivalent of origin	Equivalent of origin	Equivalent of origin
	Water soak	23°C 30 days	Equivalent of origin	Equivalent of origin	Equivalent of origin	Equivalent of origin
	Low temperature aging	0°C 90 days	Equivalent of origin	Equivalent of origin	Equivalent of origin	Equivalent of origin

Table 2. Attenuation properties of two-step splittable ribbon.

Item	Test condition		Results	
			4-fiber ribbon	8-fiber ribbon
Lateral pressure	490 N/100 mm		<0.02dB	<0.02 dB
Temperature cycling	– 40°C to + 85°C 2 cycles		<0.02 dB/km	<0.02 dB/km
Reliability of attenuation	Temperature/ Humidity aging	85°C, 85%RH 30 days	<0.02 dB/km	<0.02 dB/km
	Temperature aging	120°C 30 days	<0.02 dB/km	<0.02 dB/km
	Water soak	23°C 30 days	<0.02 dB/km	<0.02 dB/km
	Low temperature aging	0°C 90 days	<0.02 dB/km	<0.02 dB/km

λ=1.55μm

Table 3. Mechanical characteristics of trial 100-fiber and 640-fiber SZ-slotted core cable.

Item	Test condition	Results	
		100-fiber SZ cable	640-fiber SZ cable
Tensile performance	Permissible tension applied	<0.01 dB	<0.01 dB
Squeezing	Permissible tension applied Bending radius = 300 mm Squeezing angle = 90°	<0.01 dB	<0.01 dB
Bending	Bending radius = Cable OD × 10 ± 90° 10 cycles	<0.01 dB	<0.01 dB
Crush	1,960 N/100 mm	<0.01 dB	<0.01dB
Impact	1 kg, 1 m	<0.01 dB	<0.01dB

λ=1.55μm

five slots in which five 4-fiber ribbons are stacked on top of each other, and the 640-fiber cable has a slotted rod structure with 8 slots in which ten eight-fiber ribbons are stacked on top of each other. In order to ensure water-blocking performance, a water-blocking tape is wrapped around the slotted core and the outer layer is sheathed with polyethylene. The cross-sectional view of these cables is shown in Fig. 3. The 100-fiber cable is about 12.5 mm in outer diameter and 110 kg/km in designed weight. The 640-fiber cable is about 28 mm in outer diameter and 520 kg/km in designed weight. Therefore, the cables are equivalent to those cables that use conventional fiber ribbons.

4. Cable performance

The properties of the trial cables were evaluated and the results are given below.

4.1. Temperature cycling

The cables wound each on a drum were given temperature cycling of –30 to +70 °C to investigate attenuation changes. The results are given in Figs. 4 and 5. With either cable, transmission loss at room temperature was 0.25 dB/km or less (at 1.55 μm), and attenuation changes in temperature cycles were 0.1 dB/km or less (at 1.55 μm). Thus, both cables were confirmed to have good performance.

4.2. Mechanical properties

The cables were evaluated for tensile, squeezing, bending, crush and impact characteristics. The test items, conditions, and results are summarized in Table 3. Both cables were confirmed to show good results in various mechanical tests. As a result of inspecting the ribbons after the cables were tested, no such defects as split ribbons were noticed.

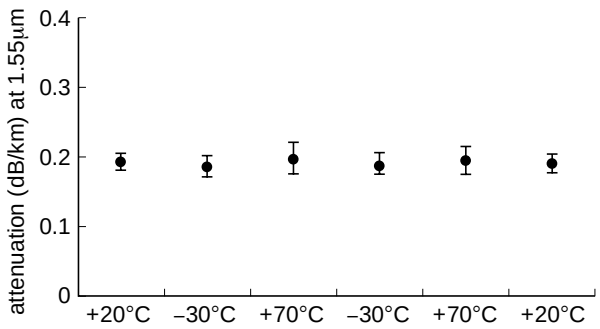

Fig. 4. Transmission attenuation of 100-fiber SZ-slotted core cable under temperature cycling.

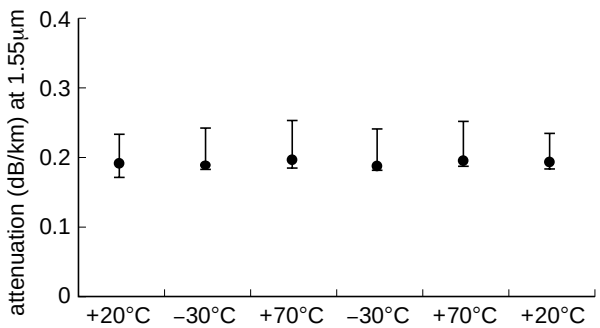

Fig. 5. Transmission attenuation of 640-fiber SZ-slotted core cable under temperature cycling.

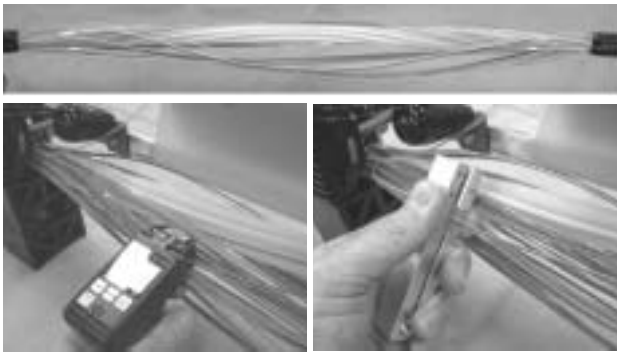

Fig. 6. The ribbon slack and the mid-span access verification (640-fiber SZ-slotted core cable).

4.3. Slack of fiber

The ribbons were investigated for slacking when the sheath was removed at an arbitrary location on 500 mm and 700 mm for the 100-fiber cable and 640-fiber cable, respectively. The obtained degrees of slacking were 20 mm or more, so it was confirmed that fiber identification within the closure and mid-span splitting of ribbons could be performed. Figure 6 shows the fiber identification and mid-span branching operations for the 640-fiber cable.

5. Conclusion

We have developed the two-step splittable ribbon, which can be divided into sub-unit ribbons at first, and eventually separated into individual fibers, as a result of implementing the sub-unit structure and optimizing the properties of the ribbon material. This ribbon can be applied to an SZ-slotted core cable that provides easy mid-span access. A 100-fiber SZ-slotted core cable with 4-fiber ribbons splittable each into two 2-fiber ribbons and a 640-fiber SZ-slotted core cable with 8-fiber ribbons splittable each into four 2-fiber ribbons were fabricated as trial cables. As a result of evaluation, we confirmed that the newly designed SZ-slotted core cable shows good performance.

Since the SZ-slotted core cable, which used the developed two-step splittable ribbon combines the high-density package and the flexible mid-span access, it can provide the benefit in FTTH network construction.

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