New Wiring Technology for Cost-effective Construction of FTTH Networks Using Free Branch Cable

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For the purpose of constructing more economical FTTH networks, the authors have developed a new aerial fiber distribution cable named "Free Branch Cable (FBC)" and a pre-connectorized elastic spiral drop cable. In this paper, the authors introduce the configurations of these new cables and propose a new wiring concept with these new cables that can reduce total cost of FTTH deployment.

1. Introduction

In Japan, the number of FTTH subscribers has already reached 10 millions and it is forecasted to increase at an accelerated pace. To meet the rapid increase of subscribers, it is necessary to make FTTH installation faster. The newly developed cables and accessories for FTTH applications can be installed easily in a short time, and are expected to contribute to the future progress of the information society.

2. Comparison between typical and newly developed FTTH network construction models

2-1 Typical model of FTTH networks

A typical FTTH network in Japan is shown in **Fig. 1(a)**. Distribution closures are installed on to the distribution cable network in a FTTH service area. Each closure connects the distribution cable with the drop cables that run into subscriber premises. In the cases where there is no closure installed near subscriber premises, drop cables tend to be strung over long distances and sometimes two or more drop cables run through the same area, causing increases in FTTH installation time and cost.

2-2 New model of FTTH networks

To resolve the above mentioned problem in the typical FTTH network model, the authors devised a new model shown in **Fig. 1(b)**. To evade the overlapping of drop cables, the drop cable runs from the drop point to each subscriber premises by the shortest possible route. The authors also developed a simple connector case that can be used in place of drop closures for connecting single-fiber drop cables to the distribution cable. The newly developed connector case is more suitable than conventional drop closures in terms operatability and cost. For constructing the new FTTH network model, a distribution cable that allows easy mid-span access at an arbitrary point is needed.

3. Free Branch Cable (FBC)

3-1 Cable construction

The cross-sectional view of the newly developed distribution cable "Free Branch Cable (FBC)" is shown in **Fig. 2.** This cable is a maximum of 32 optical elements

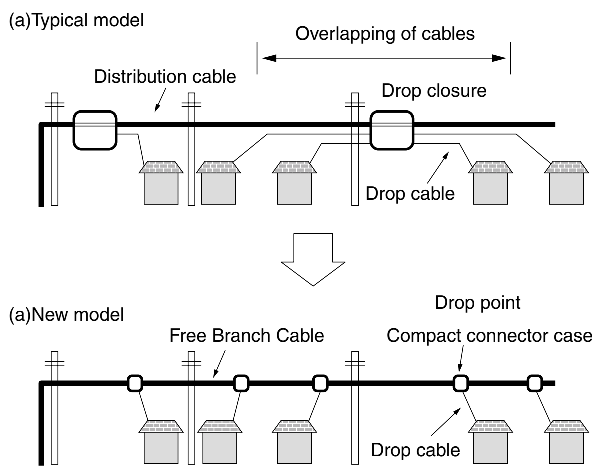

Fig. 1. Typical FTTH network model in Japan and new model

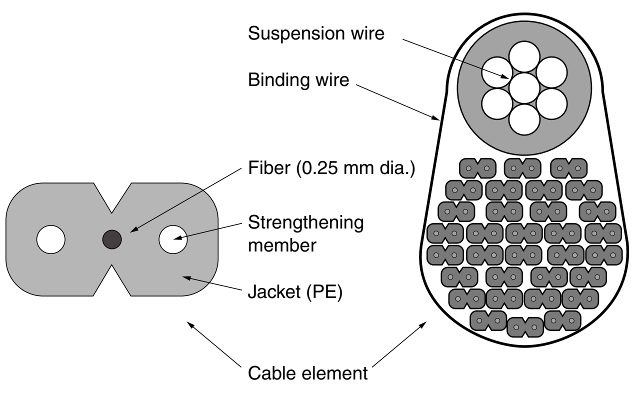

Fig. 2. Cross-section of FBC

stranded into a unit and bounded to a suspension wire with a binding wire. Each optical element contains a single fiber and two strengthening members arranged on both sides of the fiber, jacketed with linear low-density polyethylene (LLDPE).

3-2 Configuration of drop point

As is shown in **Fig. 3**, the drop cable is drawn out through a clamp that is mounted on the suspension wire of FBC. The procedure for connecting FBC and the drop cable is as follows:

(a) The optical element to be dropped is drawn out from FBC at a point nearest to the subscriber. (An optical element can be drawn out easily without interrupting the FTTH services delivered over other optical elements.)

(b) A connector of the cable-jacket grasping type is assembled to the optical element.

(c) The optical element is connected to the pre-connectorized drop cable.

(d) The connection is stored in a compact connector case instead of a drop closures.

3-3 Characteristics of FBC

The results of FBC tested in accordance with the IEC standards are shown in **Table 1**

4. Accessories

4-1 Closure

In Japan, aerial closures are installed in various points on the FTTH network, and they have many functions (e.g. storage of fusion splicer, mechanical splicer, connector, and fiber splitter). Therefore, the interior of these closures has become extremely complicated, and FTTH installation workers are required to do their work faster and more skillfully.

The authors have developed a new closure having splitter modules and/or FO modules. **Figure 4** shows the internal structure of the closure. These modules are prefabricated and have connector interfaces at input/output sides, so workers do not need to handle bare fibers or splice fibers using fusion splicers or mechanical splicers. The splitter modules and FO modules are of the same size, so network designers can flexibly combine these two kinds of modules to realize necessary functions at various points within a network. The splitter module is composed of four 1×8 splitters, and has a 4MT connector interface. Because eight splitter modules can be installed in the closure, a maximum of 32 fibers can be distributed to 256 fibers. On the other hand, the FO module is capable of dividing a 4-fiber rib-

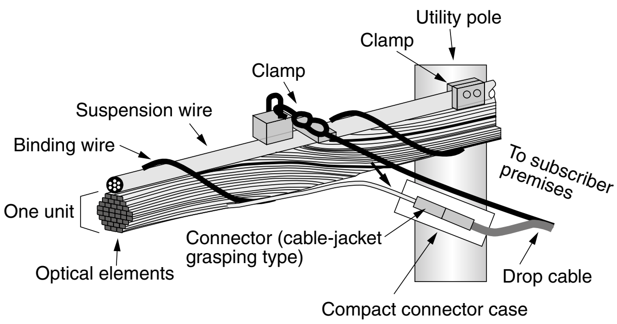

Fig. 3. Configuration of cable drop point

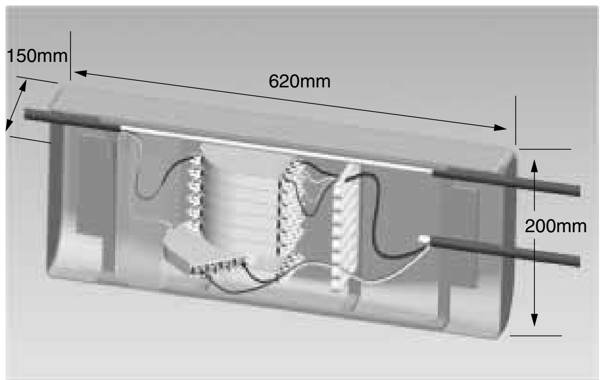

Fig. 4. Closure configuration

Table 1. Test results for FBC

Items	Conditions	Results
Attenuation coefficient	1550 nm	<0.25 dB/km
Temperature cycling	3 cycles at -30 to 70 deg. C	<0.25 dB/km
Tensile property	9600 N	<0.05 dB
Bending property	Bending radius: 10D 5 cycles of 180 deg. bending	<0.05 dB
Squeezing property	Squeezing angle:90 deg.	<0.05 dB
Crushing property	1960 N on 100 mm-width	<0.05 dB
Impact property	1 m with 1 kg	<0.05 dB
Torsion property	10 cycles at +/-180 deg./m	<0.05 dB

Attenuation measured at 1550 nm

Table 2. Structural specifications of closure

Items		Specifications
Closure	Number of cables	3 cables (each side) 6 drop cables (each side)
	Waterproof property	IPX4
	Number of modules	8
Splitter module	Input side	One 4-fiber MT connector
	Output side	Eight 4-fiber MT connectors
FO module	Input side	One 4-fiber MT connector
	Output side	Four SC connectors (field assembled or prefabricated cable-jacket grasping type connector)

bon to four single fibers, and has a 4MT connector interface at the input side and an SC connector interface at the output side. Because eight FO modules can be installed in the closure, a maximum of eight 4-fiber ribbons can be fanned out into 32 or less number of single SC connectors. The inner structure of the closure is simple, including only the module storage section and the cable clamping section. Each module can be removed without interrupting data transmission other fibers, simply by sliding it outward. **Table 2** shows the specifications of the closure.

4-2 Compact connector case

Figure 5 shows the outward appearance of the compact connector case that can be used at FBC drop points. This product has a compact, simple structure and can store one set of connectors. The dimensions of the case are 140 mm in length by 15 mm in height by 25 mm in width. The soft rubber lining installed inside prevents rainwater from entering the case. A field-assembled or prefabricated cable-jacket grasping type connector can be stored in the connector case. The connector case is fixed to the suspension wire of the drop cable. The tension on the drop cable does not affect the connectors because both the optical element and drop cable are introduced into the case in slackened condition.

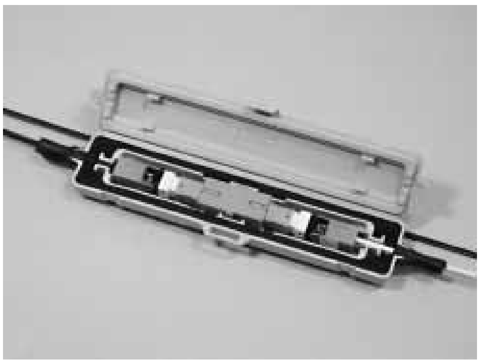

Fig. 5. Connector case

4-3 Spiral Drop Cable

The cross-section of the spiral drop cable that can be used in the new FTTH model is shown in **Fig. 6**. This cable is composed of a suspension wire, two strengthening members, and a single fiber, jacketed with flame-retardant PE. The suspension wire part and the drop cable part can be separated by cutting the bridge.

The structure of the spiral drop cable is shown in **Fig. 7**. This cable has the straight section at one side and the variable-length spiral section at the other side, with a SC connector at both ends. The spiral section is hung from the suspension wire. The straight section and the spiral section form a single continuous cable, not two sections spliced together. Because the spiral drop cable is a length-adjustable cable, it is suitable for use in connecting FBC and subscriber premises. The spiral section is stored in a protective cover, and the end of the cover facing the straight section is tapered. By pulling the protective cover toward the direction of subscriber premises, the spiral section of the cable can be drawn out from the cover's tapered end without being uncoiled.

The method for installing the spiral drop cable is as follows (**Fig. 8**):

(1) The spiral drop cable is connected between FBC and the subscriber premises.

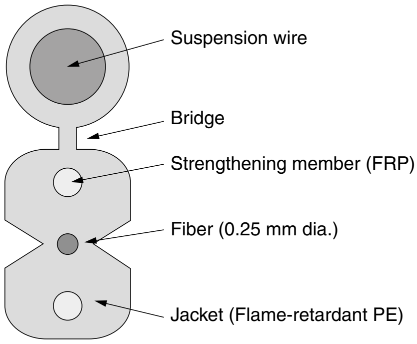

Fig. 6. Cross-section of spiral drop cable

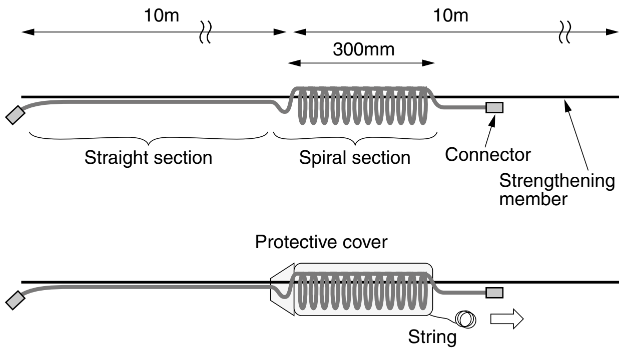

Fig. 7. Structure of spiral drop cable

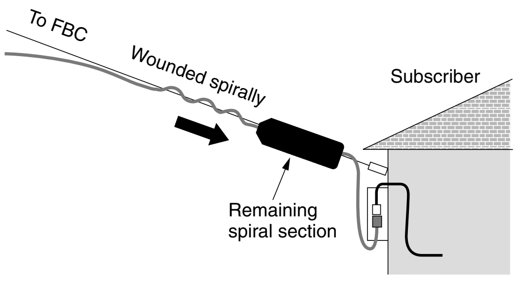

Fig. 8. Installation method for spiral drop cable

(2) The string is pulled in the direction of the subscriber premises. The desired length of the spiral section is drawn out without being uncoiled.

(3) The remaining spiral section in the protective cover is fixed under the roof eaves in the subscriber premises.

Table 3 shows the evaluation test results for the spiral drop cable.

Table 3. Test results for spiral drop cable

Items	Conditions	Results
Attenuation coefficient	1550 nm	<0.25 dB/km
Temperature cycling	-30 to 70 deg. C	<0.05 dB
Bending property	Bending radius:15D 100 turn	<0.05 dB
Squeezing property	Squeezing angle: 90 deg.	<0.05 dB
Crush property	1960 N on 100 mm-width	<0.1 dB
Impact property	1 m with 0.3 kg	<0.1 dB
Torsion property	10 cycles at +/-180 deg./m	<0.05 dB

4-4 Cable-Jacket Grasping Type Slim Connector

The structure of the newly developed slim connector is shown in **Fig. 9**. The connector with a pulling eye is slim enough to pass through the telephone line pipe in the subscriber premises when pulling the drop cable.

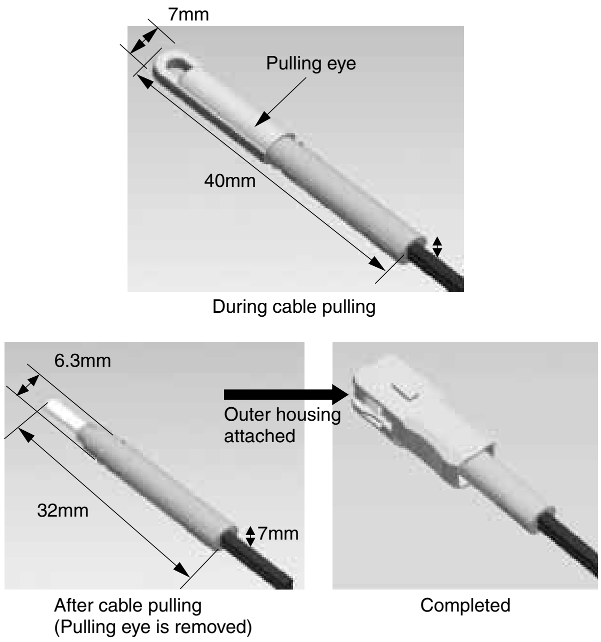

Fig. 9. Structure of slim connector

By assembling this connector to the spiral drop cable, the cable can be connected directly between FBC and the terminal in the subscriber premises instead of being connected to a cable joint under the roof eaves. The connector's diameter is 7 mm, which is almost the same as the spiral drop cable diameter, and the length is about 40 mm. After the pulling of the spiral drop cable is completed, the pulling eye is removed from the connector and the outer housing can be attached in its place. The overall size of the connector is the same as that of the SC connector, and therefore can be connected to each other.

Table 4 shows the results of the test conducted for evaluating the connection and mechanical properties of the connector assembled at the spiral drop cable. The test results indicate that the connector has excellent properties equivalent to those of the conventional SC connector.

Table 4. Test results for slim connector

Items	Conditions	Results
Insertion loss	–	Avg. 0.12 dB
Return loss	–	>50 dB
Tensile strength	150 N × 1 min	<0.1 dB
Bending proof	90 deg / 4.9 N 10 times	<0.1 dB
Vibration	1.5 mmp-p, 10-55 kHz	<0.1 dB
Impact	100G 6ms, 3-direction	<0.1 dB
Durability	500 cycles	<0.15 dB
Temperature cycling	-25 to 70 deg. C 6 hrs × 10 cycles	<0.10 dB

Attenuation measured at 1550 nm

5. Comparison of working time

Table 5 shows the FTTH installation process for the new FTTH installation model and the conventional model.

(a) Conventional model

The total work time is estimated as 234 minutes at 6 subscriber premises. The procedures in the process that require most time were removal of cable jacket from the distribution cable and installation of the first closure (19 minutes) and stringing of the drop cable from sparsely installed closures (10 minutes).

(b) New model

The total work time is estimated as 168 minutes at 6 subscriber premises. The work time is reduced by 28% compared with the conventional installation model. The optical elements in FPC are individually stranded, so one element can be separated from the cable in only one minute. The new compact connector case contributes to reducing the closure installation time by 16 minutes.

Table 5. Comparison of work procedures in conventional and new FTTH network models

Conventional model (Slotted-core cable & drop cable)	Work time (min.) 1st subscriber premises	Work time (min.) 2nd to 6th subscriber premises	New model (FB cable & spiral drop cable)	Work time (min.) 1st subscriber premises	Work time (min.) 2nd to 6th subscriber premises
Raising and lowering of aerial work platform	5	5	Raising and lowering of aerial work platform	5	5
Removal of cable jacket & Installation of closure Assembly of connector to branch cable	19	1	Disengagement of optical element from FBC cable	1	1
Assembly of connector to branch cable	3	3	Assembly of connector to FBC cable element	3	3
Assembly of connector to drop cable	3	3	Storage of connection into compact connector case	2	2
Clamping of drop cable at access point	4	4	Clamping of optical element at access point	5	5
Raising and lowering of aerial work platform	5	5	–	–	–
Stringing of drop cable	10	10	Stringing of drop cable	5	5
Clamping of drop cable at subscriber premises	5	5	Clamping of drop cable at subscriber premises	5	5
	–	–	Drawing out of spiral section	2	2
Total work time at one subscriber premises	54	36	Total work time at one subscriber premises	28	28
Total work time at 6 subscriber premises	234		Total work time at 6 subscriber premises	168(reduced by 28%)	

6. Conclusions

The authors have developed a new 32-fiber aerial distribution cable named "Free Branch Cable (FBC)," a pre-connectorized elastic spiral drop cable, and the accessories. The cable and accessories were verified as having high reliability. It was also confirmed that the drop cable installation time in the newly devised FTTH network model is reduced by about 30% compared with the conventional model.

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