Development of Optical Fiber Cable and Connector for Home Wiring in FTTH

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Abstract

With the development of FTTH optical network, the demand of the optical fiber cable more suitable for home wiring is increasing. As an example of the advanced home wiring formula to facilitate FTTH optical network construction, a connectorized optical fiber cable is wired from an optical outlet to ONU in the house. When we consider a general use in a house, an optical fiber cable needs to be tough and flexible.

We have developed a new optical fiber cable which has a high strength property, flexibility and high reliability. And we’ve also developed a field assembly connector which can be installed to the cable directly. So we can wire the new cable in the most suitable way for an each home arrangement. Using these products combination, we can propose an advanced solution of home wiring.

In this paper, we describe the structure and property of our new optical fiber cable and new field assembly connector.

Keywords: optical fiber cable, field assembly connector; optical outlet, ONU; FTTH

1. Introduction

Recently, the number of FTTH subscribers in Japan has been rapidly increasing, and this trend will be accelerated after this. To meet this growing demand, it is important to make the optical fiber wiring construction easy. And now a day, considering the practical use of optical home wiring, the flexible wiring fitted with each home arrangement, prevention from accident of the optical fiber cable, and security become important issues.

Figure 1 shows the example of the home wiring system. In the conventional home wiring system (Fig.1(a)), the optical fiber was drawn into ONU with a drop cable from a closure directly. And a mechanical splice or a fusion splice is used to connect with SC connector pigtail in ONU. However, the worker needs to handle a thin optical fiber, for fear the fiber is bent too small or pulled by strong force. As a result, it was required to be done by skillful workers and it took a long time to construct.

Therefore, as shown in Fig.1(b), a new optical home wiring system becomes to be introduced recently. An optical outlet is set in the room, and an optical fiber cable with connectors is wiring between the outlet and ONU. In the outlet, field assembly connectors which can be attached to a drop cable directly is used[1].

In this system, worker does not need to handle a thin optical fiber directly during the construction, so the construction becomes so easy and the time is reduced as much as compared with conventional system.

A present situation, an indoor cable or an optical fiber cord are used between optical outlet and ONU. However, in the indoor cable, two steel wires exist both side of a cable (Fig.2(a)), and bending direction is restricted, so the flexible wiring was very difficult. On the other hand, an optical fiber cord which uses high tensile yarn in place of steel wires is good for the flexible wiring, but because the outer sheath is thin, the optical fiber breakage and the trouble of loss increase are likely to happen due to burdening the external force to the cord in the practical use.

From these reasons, the demand of optical fiber cable with connectors which has flexibility and high strength property is strongly demanded.

2. Development of a new optical fiber cable

2.1 Development concept

Firstly, we described the new developed optical fiber cable suitable for home wiring. Our development concepts are;

1. Stronger than conventional indoor cable, so as not to be broken even if an accident occurs.
2. Easier Handling than an optical fiber code
3. Smaller diameter so that almost of existing ONU are applicable
4. To adjust for length in the field is possible

2.2 Structure of a new optical fiber cable

Figure 2(b) shows the structure of the developed cable. We arranged the optical fiber in the center, and enclosed with high tensile yarn, and covered with flame retardant outer sheath.

We have realized both property of toughness and flexibility by using high tensile yarn in the cable, selecting a sheath with moderate elasticity material, and designing the most suitable...
Moreover, using a bending insensitive optical fiber, we can bend the cable to the radius which is regulated by the minimum permitted bending radius of the fiber. And Considering to install to an existing ONU, the cable outer diameter must not be exceed Φ3mm.

Table 1 Property of a new optical fiber cable

<table>
<thead>
<tr>
<th>Test item</th>
<th>Condition</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>Initial loss</td>
<td>OTDR &lt;0.25dB/km</td>
</tr>
<tr>
<td>property</td>
<td>Tension</td>
<td>150N</td>
</tr>
<tr>
<td></td>
<td>Crush</td>
<td>1200N/25mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R5mm</td>
</tr>
<tr>
<td></td>
<td>Impact</td>
<td>3N·m</td>
</tr>
<tr>
<td></td>
<td>Torsion</td>
<td>±180deg/20N</td>
</tr>
<tr>
<td></td>
<td>Bending</td>
<td>±180deg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R15mm, 10times</td>
</tr>
<tr>
<td></td>
<td>Cable</td>
<td>Φ30mm ×6turns,</td>
</tr>
<tr>
<td></td>
<td>bend</td>
<td>10turns</td>
</tr>
<tr>
<td></td>
<td>Winding</td>
<td>±90deg/20N</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R25mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1000cycles</td>
</tr>
</tbody>
</table>

| Environmental      | Temperature  | -10 ~ +40°C    |
|                    | Cycle        | 3cycles        |
| property           |              | ΔIL< 0.1dB/km  |

| Frame retardant    | Flame        | IEC 60332-1    |
| property           | retardant    | Pass           |

| Special property   | Corner        | 1200N/25mm     |
|                    | crush        | R0.5mm         |
|                    | Right angle  | 90deg/5N       |
|                    | Bending      | R5mm, 0.5mm    |

|                |               | ΔIL< 0.1dB      |

In case of the indoor cable, transmission loss increases more than 1dB at load 30N. On the other hand, it found that transmission loss increases only 0.37dB in a new optical fiber cable. From these results, the new optical fiber cable has a high strength property rather than the conventional indoor cable. And as well as an optical fiber code, Φ3mm round shape structure used high tensile yarn in place of steel wires improved the handling property much better than indoor cable. Moreover, if we use the bend insensitive fiber which can be bent to Φ15mm[2] handling property can be much improved. We can realize the flexible wiring shown in Figure 8.

![Diagram](image.png)
2.4 Property of a new optical fiber connector

Table 2 shows the comprehensive reliability results of SC connector which is assembled to new optical fiber cable in factory. Tested cable is installed with a bend insensitive fiber which can be bent to Φ30mm and the all tests have been measured in 1550nm. It was confirmed to be equal to the SC connector property which is assembled to an optical fiber cord.

<table>
<thead>
<tr>
<th>Test item</th>
<th>Condition</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical property</td>
<td>Insertion Loss</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Reflection Loss</td>
<td>-</td>
</tr>
<tr>
<td>Mechanical property</td>
<td>Straight Pull</td>
<td>98N</td>
</tr>
<tr>
<td></td>
<td>Flex</td>
<td>90deg/9.8N/100times</td>
</tr>
<tr>
<td></td>
<td>Vibration</td>
<td>1.5mmmp-p/10-55kHz</td>
</tr>
<tr>
<td></td>
<td>Shock</td>
<td>100G 6ms/3-direction</td>
</tr>
<tr>
<td></td>
<td>Durability</td>
<td>500cycles</td>
</tr>
<tr>
<td>Environmental property</td>
<td>Temperature Cycling</td>
<td>-25 ~ +70°C</td>
</tr>
<tr>
<td></td>
<td>Humidity Temperature Cycling</td>
<td>-10 ~ +65°C, 85%RH</td>
</tr>
</tbody>
</table>

2.5 SC connector with a shutter

The new optical fiber cable can also be attached with the SC connector with a shutter. A combination of shutter SC and the new cable can make home wiring more reliable.

Figure 9 shows an outline of the SC connector with a shutter. When the SC plug was released from SC adaptor, a shutter covers the ferrule end face. Due to this mechanism, shutter prevents connector end face from the dust which is getting optical property worse, and also interrupts the light leaking out of connector.
When released from SC adaptor, because of shutter mechanism, the SC housing length is longer than conventional SC connector, but when inserted to SC adaptor, the shutter housing moves backward, and the connector shape and length are same as conventional SC connector. It means shutter SC has full compatibility to conventional SC connector.

2.6 Install to existing ONU

Figure 10 shows our new optical fiber cable and SC connector with a shutter is installed to existing ONU. Since the diameter of the cable is $\Phi 3\text{mm}$, it can be installed in almost of the existing ONU. Due to the cable toughness and flexibility and shutter SC safety, the optical cable home wiring can have a very high performance.

3. Development of field assembly connector

In order to realize the most fitted wiring which corresponded to each home room arrangement, we developed the new field-assembly SC connector which can be attached to our new optical fiber cable.

Of course, this connector is assembled without adhesive and electric power, and assembled directly to our new cable, same as our conventional one which is assembled to drop or indoor cable[1].

3.1 Structure of new field assembly connector

Figure 11 shows a shape of the new field assembly SC connector. And Figure 12 shows the internal structure of the connector.

This connector has the same internal structure as our conventional field-assembly SC connector which is assembled to drop or indoor cable directly[1]. And this connector has a full compatibility with a conventional SC connector.

3.2 Assembly method

Regarding to connector assembly method, after setting cable grip parts, it is same as our conventional field assembly connector[1]. Figure 13 shows fiber insertion work in connector.

After cleaving fiber to a proper length, the fiber with handling cable is inserted along the cable insertion guide of the attached jig until the cable grip is locked to the housing. It takes about 2 minutes to assemble the connector.
3.3 Property of new field assembly connector

Table 3 shows the comprehensive results of new field assembly connector to our new cable.

- Tested cable is a bend insensitive fiber which can be bent to Ø30mm and the tested wavelength is 1550nm. We were able to confirm that optical property equal to those of conventional field-assembly SC connector.

The test result of continuous temperature cycling is shown in Figure 14, we confirmed a good result which the fluctuation of insertion loss was lower than 0.2dB during the temperature cycle test of – 40 to +70 °C that was assumed for using in the outdoors.

4. Conclusion

We developed not only the new optical fiber cable which had both flexibility and high strength property but also the field assembly connector which make use of the cable property.

It is expected as technology to contribute to FTTH service expansion in the future.

5. References


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