The Calculation Method of Wind Pressure Load for a Bundle of Aerial Cables
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Abstract
When designing outside aerial plant, it is important to calculate the wind pressure load so that the appropriate telecommunication pole or messenger wire can be selected. The wind pressure load is calculated by simply adding together the diameters of each cable and using the existing method. When several optical fiber cables are bundled with a spiral hanger, it is unclear how they will behave under windy conditions as a result of bundling and not fixed in the hanger. This means it impossible to calculate the appropriate wind pressure load.

To resolve these problems, we observed the behavior of the spiral hanger and bundled cables in a wind tunnel experiment, and undertook an investigation to determine whether the theoretical value calculated by our proposed wind pressure load method was correct by comparison with experimental values.

Keywords
Cable bundling, Spiral hanger, Wind pressure load, Summation of diameter, Cross-section for wind pressure load.

1. Introduction
The increase in the provision of optical access services has led to the installation of aerial optical fiber cable. The number of cables that can be fixed on a telecommunication pole is limited because NTT and another company use poles in common. This also means that aerial facilities can be something of an eyesore. So a method is needed by which several cables can be bundled thus resolving the above problems. A spiral hanger is one possible solution. The use of cable bundling has some merits. One is that an additional new optical cable can be easily installed, and the other is that existing bundled cable can be simply removed. When cable is bundled, however, it is impossible to calculate the appropriate wind pressure load under windy conditions because several cables are installed within the space enclosed by the spiral hanger. (Henceforth we refer to this as “hanger space”). This means we need an appropriate method for calculating the wind pressure load for bundled cables so that we can design efficient outside plant. In this paper, we describe a method for calculating the wind pressure load for aerial cables bundled in a spiral hanger.

2. Cable bundling
With the existing cable installation method only one cable is installed and it corresponds to one supporting object (messenger wire). With the cable installation method using the spiral hanger (as shown in cross-section in Fig.1) several cables are installed in the hanger space and correspond to only one supporting object.

3. Wind pressure load
The load acting on aerial cables is shown in Fig.2.

Figure 1. A bundle of aerial cables

Figure 2. Load acting on aerial cable
The wind pressure load is equal to the horizontal component of the load acting on the cables. The value depends on the wind speed and the aerial cables’ cross-section. In outside aerial plant, two types of wind pressure load are applied corresponding to each area. They are;

[Type A] Wind pressure load per unit area: 100 [kgf/m$^2$]
  (Equal to wind speed of 40 [m/s])

[Type B] Wind pressure load per unit area: 50 [kgf/m$^2$]
  (Equal to wind speed of 28 [m/s])

Wind pressure load is calculated by timing it and from the cross-section of the aerial cables. The cross-section of each cable is different, and the cross-section of bundled cables is particularly unclear. This makes it necessary to determine the behavior of each cable at different wind speeds by wind tunnel experiments.

4. Experiment and analysis method

4.1 Experiment systems

As shown Fig.3, we constructed a simulated outside plant in a wind tunnel, and measured the tension that acts on a supporting object under wind speeds of 0 to 50 [m/s]. We also recorded the behavior of aerial cables using a video camera.

4.2 Analysis method

We converted the measured tension to wind pressure load by using following equation

\[
\left( \frac{W_1S_1}{8T_1} \right) + \left[ \frac{3}{8} \left( \frac{T_1}{EA} - \alpha(\theta_1 - \theta) \right) \left( \frac{W_1S_1}{8T_1} \right) \right] + \left( \frac{W_1S_1}{8T_1} \right) \times \left( \frac{3W_1S_1}{64EA} \right) = \frac{3W_1S_1}{64EA} \tag{1}
\]

\(W_1\): Initial Load [kg/m]

\(T_1\): Initial Tension [kN/m]

\(\theta_1\): Initial Temperature [°C]

We then compared it with the theoretical equation (2)

\[p = \frac{1}{2} \rho v^2 d \tag{2}\]

\(p\): pressure load per meter [kgf/m$^2$]

\(\rho\): density of air [kg • s$^{-2}$/m$^4$]

\(c\): constant for object shape (c=1)

\(v\): wind speed [m/s]

\(d\): cross-section for wind pressure load [m]

5. Experimental result and discussion

5.1 Relation between cross-section and wind pressure

We converted the experimental tension data to wind pressure load by using equations (1) and (2), and plotted it in Fig.4.

The following are obtained from figure 4.

i) In range A(0 [m/s] < wind speed < 10 [m/s])

The cross-section is small; therefore wind pressure load is also small. Then cables remain at the bottom of the hanger space. (Video evidence).

ii) In range B(10 [m/s] < wind speed < 30 [m/s])

The higher wind speed is, the higher wind pressure load becomes. Then cables begin to be pushed toward the hanger wire and stacked vertically along it. Therefore cross-section increase and pressure load become higher.

iii) In range C(wind speed > 30 [m/s])

The cables are almost completely vertically stacked along the hanger wire as a result of the wind pressure load, which becomes higher than the summation of the cables’ diameters. From this point on, the cross-section reaches an almost constant value.
Table 1. Effect of wind speed on cables

<table>
<thead>
<tr>
<th>Wind Speed</th>
<th>Behavior</th>
<th>(A)</th>
<th>(B)</th>
<th>(C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0~10 [m/s]</td>
<td>Wind direction</td>
<td>0~10 [m/s]</td>
<td>Wind direction</td>
<td>30~ [m/s]</td>
</tr>
</tbody>
</table>

The behavior of the cables in range C is important because the wind pressure load for Type A (40 [m/s] wind speed) or Type B (28 [m/s] wind speed) is calculated when aerial outside plant is designed as described above. Table 1 shows that light optical cables are stacked vertically along the hanger wire in the hanger space.

The cross-section converted from the experimental value is greater than the summation of the aerial cables’ diameters, so we must consider the cross-section of the hanger as regards wind pressure load.

5.2 Cross-section considering hanger of spiral shape

The cross-section for the wind pressure load of the hanger is assumed to be the thickness of the hanger wire, and we investigated thus as follows using three samples in a wind tunnel experiment.

i) Sample 1.
Here the sample consisted of a messenger wire and a spiral hanger.

Figure 5. Cross-section for wind pressure load (Sample1)

As shown Fig.5, the cross-section for the wind pressure load is regarded as being
①: only the diameter of messenger wire
②: a summation of the thickness of hanger and ①

ii) Sample 2.
Here optical aerial cables are installed into a hanger space and the diameter summation of the cables is smaller than the inside diameter of the hanger.
As shown in Fig. 6, the cross-section for wind pressure load is regarded as being
①: diameter of messenger wire and cables
②: a summation of the thickness of hanger and ①

iii) Sample 3.
In this case the optical aerial cables are installed in the hanger space and summation of cable diameters is larger than the inside diameter of the hanger.

Figure 6. Cross-section for wind pressure load (Sample2)

Figure 7. Cross-section for wind pressure load (Sample3)

As shown in Fig. 7, the cross-section for wind pressure load is regarded as being
①: the outside diameter of the hanger
②: the inside diameter of the hanger

The wind pressure load is calculated using equation (2) based on above assumed cross-section for wind pressure load. We obtained the following three graphs as shown Fig. 8 to 10.

Figure 8. Wind pressure load

Figure 9. Wind pressure load

Figure 10. Wind pressure load
According to Fig. 8 to 10, the value obtained in experiment ③ is higher than that obtained when the messenger wire diameter is considered the cross-section for the wind pressure load ①. Moreover, the value obtained in experiment ③ is smaller than that obtained when we consider the diameter summation of the hanger thickness to be the cross-section for the wind pressure load. Therefore, in terms of the easy design of safe aerial outside plant, it is necessary to calculate the wind pressure load on the basis of the thickness of the hanger wire being added to the messenger wire diameter.

According to figure 8 to 10, The value of experiment ③ is higher than that of messenger wire diameter treated as cross-section for wind pressure load ①. And, the value of experiment ③ is smaller than that of considering diameter summation of hanger thickness as cross-section for wind pressure load. Therefore at the point of easy and safe design of aerial outside plant, it is necessary to calculate wind pressure load which thickness of hanger wire is added to messenger wire diameter.

### 6. Conclusion

We undertook an experiment in a wind tunnel to confirm the behavior of optical cables under windy conditions and to calculate the appropriate wind pressure load.

We proved that the cables stay at the bottom of the hanger space at low wind speed but that they stack vertically in the hanger space as the wind speed increases. This shows that the wind pressure load increases as the cross-section increases.

With a bundle of cables, and taking the cables’ behavior in the hanger space into consideration, we can decide the cross-section for the wind pressure load by appropriately following the flow shown in Fig. 11.

**Figure 11. Flow of cross-section conduction**

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**Reference**


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