Analysis and Experiments on the Secondary Stresses of the Parallel Wire Cable in Suspension Bridge

Minjae LEE
Manager
Daelim Industrial Co.
Seoul, Korea
leemj@daelim.co.kr

Jonghoon MOON
Senior Manager
Daelim Industrial Co.
Seoul, Korea
triton@daelim.co.kr

Jahgeol YOON
General Manager
Daelim Industrial Co.
Seoul, Korea
yoonjg@daelim.co.kr

Ho-Kyung KIM
Professor
Seoul Nat'l University
Seoul, Korea
hokyungk@snu.ac.kr

Summary

Flexural behaviours of tensioned parallel wire cable are suggested intuitively in three different ways, no slip, friction slip, and free slip. Indoor experiments for verification of suggested equations are carried out with tensioned parallel wire strand. Test results show that this simplified approach can describe well the flexural behaviour of parallel wire cable. The secondary stress in main cable of suspension bridge can be estimated in a way that is easier and more accurate.

Keywords: secondary stress; parallel wire cable; suspension bridge; no slip; friction slip; free slip

1. Introduction

The secondary stress of parallel wire cable in suspension bridges had been studied intensively decades ago. However, from that date up to the present, the theoretical approach is difficult for engineers to estimate the exact secondary stress of parallel wire cable.

Slip between wires is influenced by external pressure produced by cable wrapping, and the cable band spaced apart at regular distance restricts the slip of wires. In this study, the deflection curves of wrapped and unwrapped parallel wire cable clamped by cable bands are suggested. Scaled pushing and bending tests of both the wrapped and unwrapped parallel wire cables are carried out to verify the analytical approach.

2. Deflection of parallel wire cable subjected to bending moment

The bending behaviour of parallel wire cable varies according the slip between the wires. In this paper, three deflection shapes, "no slip", "friction slip" and "free slip", are suggested.

It is well known by the work of T.A.Wyatt[1] that the deflection curve of tensioned cable subjected to bending moment is exponential function assuming that there is no slip between the wires.

The inner pressure produced by the cable wrapping makes a small frictional resistance between the wires. If the bending moment is small as much as the shear force between wires doesn't exceed the frictional resistance, the cable behaves as like as no-slip cable. On the other hand, if the shear force between the wires exceeds the frictional resistance, the slip between the wires is started. In this paper, the deformed shape of slipped wires is assumed intuitively as a straight line that is to say the shear force in the slip range is constant and equal to the frictional resistance.

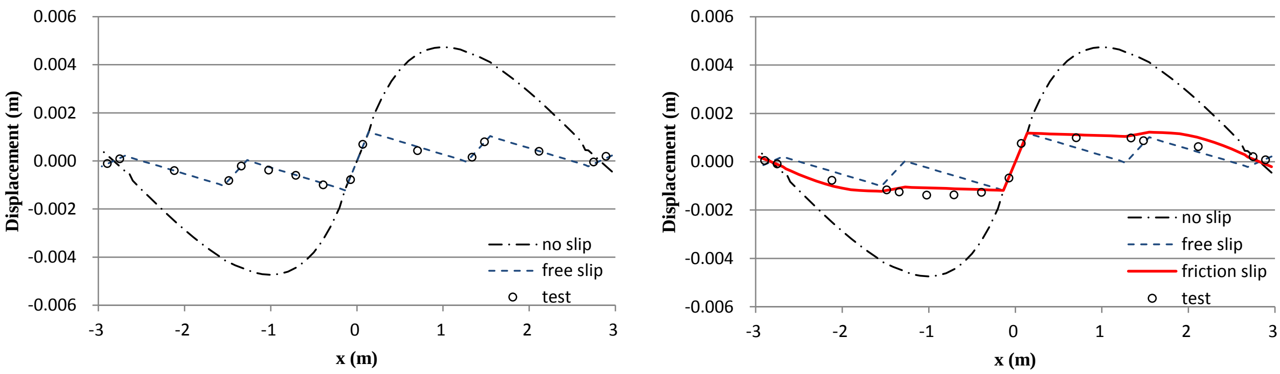
If cable band or cable wrapping is not installed outside the parallel wire cable, it can be easily assumed that there is no contact pressure and no friction resistance between wires. Because the wires in tensioned cable subjected to bending moment can slip freely, the inclined angle in free slip range is zero.

https://doi.org/10.2749/222137813808626894
Distributed by structurae

3. Experiments for verification

The purpose of this research is to clarify the structural behaviour of the individual wires in parallel wire cable in suspension bridge. Simplified equations are suggested intuitively to understand the secondary stress of cable easily. The experiments to verify them are carried out using parallel wire strand. A small number of indoor experiments to investigate the flexural behaviour of parallel wire cable were conducted in the past. Among them, Nakamura's test [2] in 1974 is selected for experimental verification of the present suggestion as shown in Fig. 1.

Fig. 1: Deflection measurement test of PWS



(a) T=50tf, p=0.00MPa, φ_0=0.01rad

(b) T=50tf, p=1.75MPa, φ_0=0.01rad

Fig. 2: Rotational loading test

Fig. 2 show that the suggested deflection curves agree fairly well with test result. As the wrapping pressure is increased on the PWS, the deflection curve takes after the no slip case.

4. Conclusions

Although the importance of the secondary stress of parallel wire cable in suspension bridge has long been raised steadily, there are only a few studies available due to the complexity and uncertainty of the behaviour of the individual wires. So far, engineers are not easy to deal with those existing theories on the secondary stress of parallel wire cable. In this paper, simplified equations which can describe the flexural behaviour of parallel wire cable are suggested and verified by indoor experiment. By combination of three kinds of curve, free slip, friction slip, and no slip, the flexural behaviour and the secondary stress of parallel wire cable can be estimated easily.

5. References

[1] WYATT T.A., "Secondary Stresses in Parallel Wire Suspension Cables", *J. Struct. Div., ASCE*, 86(ST7), 1960, pp37–60.

[2] NAKAMURA K., SHINKE T., NISHIMURA A., "Secondary Stress Analysis on Wire-Wrapped Parallel Wire Cables in Suspension Bridges", Transaction of JSCE, Vol.11, 1979, pp76-79.