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Aerodynamic and Structural Dynamic Control System of Cable-stayed Bridge for Wind Induced Vibration

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Abstract

1. Introduction

This is a continuous three-span steel cable-stayed bridge with a central span of 175 m and a side span of 75 m. Since the location is a scenic spot in Seto National Park, attentive consideration was given from the viewpoint of landscape. And finally a cable-stayed bridge based on the image of a bow was adopted. The towers and side spans were constructed in large blocks by the use of a floating crane while the center span was installed by the cantilever method.

2. Wind-proof Design

Based on the results of wind tunnel testing, measures were taken against suspected instability. Tuned mass dampers (TMD) were installed for the girder and tower during construction. Since horizontal members were omitted from the tower due to design requirements, generation of galloping was suspected in relatively low wind speed due to reduced in-plane stability against winds. To deal with this situation, we decided to install deflectors at four corners of the tower out of consideration for landscape design, influence on the substructure, and ease of maintenance. Their shape and dimensions were determined by wind tunnel testing.

Aerodynamic behavior of the cables under wind action was investigated in the wind tunnel. And vibration control measures were tested. According to the wind tunnel results, the aerodynamic force is 2% at the most in terms of logarithmic damping where rain vibration occurs.
As countermeasures against vibration of cables, U-stripes were cut in the surfaces of large-diameter cables and rubber with high damping capacity was installed in anchor tubes of the girder. The performance of the damping equipment was checked by measuring damping factors in each mode of vibration both before and after installation.

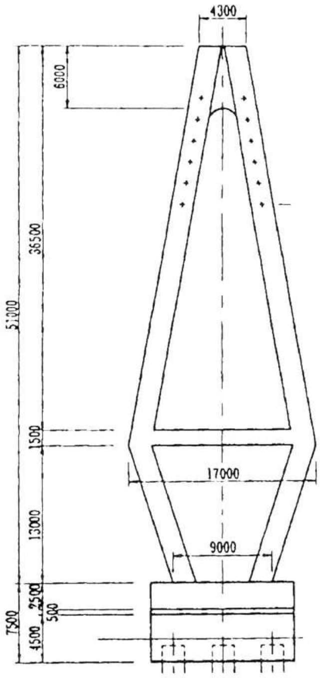


Figure 1 Shape of Tower

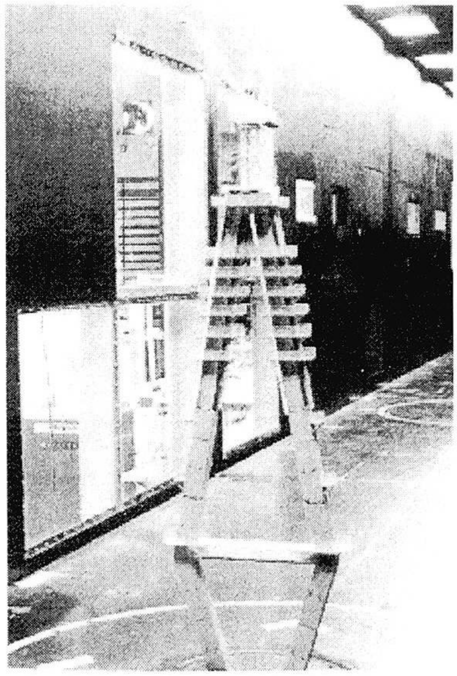
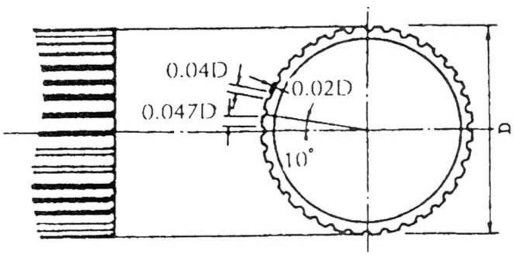


Figure 2 Wind Tunnel Test of Tower during Construction



Cable Section

Figure 3 U-Stripe Cable

3. Conclusion

This paper reported on the stability of the bridge against winds. The vibration control measures designed for the bridge based on the results of wind tunnel testing are summarized as follows.

(1) For the tower, deflectors were installed to protect the completed bridge against galloping and tuned mass dampers (TMD) were used to prevent vortex-induced vibration during construction.

(2) For the cables, U-stripes were provided in the surfaces of the polyethylene tubes on the top-layer cables as countermeasures against rain vibration while rubber with high damping capacity was installed on the middle-layer cables.

No vibration was observed on the bridge under construction or the completed bridge.