Aerodynamic Stability of Large Suspension Bridge using Cable Frames

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Summary

A new method for improving the structural rigidity of a suspension bridge without dramatically increasing the weight of the structure is presented. The design introduces cable frames that are arranged in way to keep the distances of the cables. The frame provides an increase in the torsional stiffness. The aim of the frame is to maintain the position of the cables in such a way that they act together to provide the diaphragm effect. The new method is called a “2x4 Cables System”. It was first theoretically proven here that such a system improves the stiffness against torsional flutter. Then, vibration analysis for the torsional stiffness of the frame with four cables are shown and discussed. Vibration analyses were performed using SAP90 to check the structure’s aerodynamic rigidity and stability. Numerical results for the 2x4 models and basic model (model without the frame) were analyzed here. The natural frequencies of the different models were also discussed. Using the index created by Selberg that shows the stability of suspension bridges, the limiting wind velocity of flutter is shown to be controlled by both the bending and torsional vibration frequencies of the structure.

In conclusion, the 2x4 system is able to ensure about twice the torsional rigidity of suspended girder by the numbers of cable frames. And thus it will respond to the challenges in structural engineering to ensure more aerodynamic stability of the system and further examinations are being designed with the wind-tunnel test in mind. With the new method, it will become possible to control the stability and the weight of large suspension bridges and thus make these aesthetically pleasing structures feasible and economically viable.

Keyword; Aerodynamic stability, large suspension bridge, torsional flutter, torsional rigidity, 2x4 cables system, natural frequency, torsional vibration, wind-tunnel test.

1. Introduction

Wind is the invisible enemy of large bridges. A collapse of Tacoma Narrows Bridge in 1940 was very famous. Therefore we have examined the aerodynamic stability of the suspension bridge from various viewpoints for a long time. Heretofore increasing the torsional rigidity of girder was a main current of the improvement of the aerodynamic stability. The streamlined box girder appeared at the old Severn Bridge in the late 1950s informed that the aerodynamic problems were a key factor. Then, in 1990s, the team of Dr. Brown [5] developed a multi-box girder for the aerodynamic stability at Messina crossing. However, the self-weight becomes heavier with span; it is not suitable for the larger suspension bridges. Therefore, it is extremely important aspect to minimize the girder weight.

In a conventional method, the weights become heavier with length and this increases the total cost of construction of suspension bridge. Therefore, the method by which aerodynamic stability can be secured without increasing the weight of the girder is necessary.

2x4 model forms the two features of the structures: a means of vertical interval and a means of

https://doi.org/10.2749/222137810796024006