Experimental study on vibration mitigation of long stay cables using cross ties

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Summary

Stay cables in cable-stayed bridges are susceptible to large-amplitude vibration caused by wind, rain and support motion due to their large flexibility, small mass and low inherent damping. Using cross ties is one of the considerable countermeasures for vibration mitigation of stay cables, especially longer ones. In this study, free vibration tests were conducted using a scaled cable system model which consists of three stayed cables connected by a cross tie. The effects of tensioning method, initial tension and stiffness of cross ties on in-plane and out-of-plane vibration mitigation of the cable system were investigated. The test results were explained based on the theoretical analyses by the finite element method and the energy based method. The measured frequencies of cable system are approximately the same as the theoretical ones and the measured damping has the same tendency as that from the theoretical studies.

Keywords: stay cable; vibration mitigation; cross ties; experiment; damping.

1. Introduction

Cable-stayed bridges have become very popular over the last forty years because of their economy, structural efficiency and aesthetics. Stay cables are critical structural components in cable-stayed bridges. Owing to their large flexibility, small mass and low inherent damping, stay cables are susceptible to large-amplitude vibration caused by wind, rain and support motion. Continued oscillations may result in fatigue and corrosion of strands, reducing the life of cables [1]. Using cross ties is one of the considerable countermeasures for vibration mitigation of long stay cables; however, the analysis method for design of cross ties has not been established yet.

One mechanism of the cross ties is to increase the frequencies of stay cables, another mechanism is to increase the damping. Ehsan and Scanlan [2] dealt with the redistribution of oscillation energy in the cable system, which consists of stay cables connected by cross ties, with the component mode synthesis approach and showed the efficiency of cross ties for the vibration mitigation of stay cables. Caracoglia and Jones [3] simulated the frequencies characteristics of the cable system by a general analytical procedure. However, the above investigations did not consider the damping of the cable system. Sun [4] conducted a full-scale experiment on vibration mitigation of stay cable and showed that the damping of stay cable is very low. Yamaguchi [5] investigated the structural damping of cable system applying the energy method based on the measured damping in a test of single cable and showed that there is more or less a damping-increase when using cross ties. Bosch and Park [6] simulated the performance of stay cables with cross ties and cable dampers and found that the benefits of a combined use of cable dampers and cross ties are not necessarily the sum of benefits from the dampers and the cross ties separately. Zhou and Sun [7] presented a three-element Maxwell model for the analysis of concentrated damping in cable system, the model also can be utilized for analyzing the cable system.

In the present study, free vibration tests were conducted using a scaled cable system model that consists of three stayed cables with one cross tie connected. The effects of type of cross tie,

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