Experimental Study of Model Cable Inter-supported by a Shape Memory Alloy Wire

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Summary

This study proposed and tested a system of a stay cable transversely attached with a tensioned Shape Memory Alloy (SMA) wire. Cyclic tension loading test of pre-tensioned 0.5mm diameter SMA wire was firstly conducted. The effective modulus and energy dissipation per unit volume were derived from the tested hysteretic loops of pre-tensioned SMA wire. The pre-strain effects on the effective modulus and energy dissipation of SMA wire was discussed based on the test results. Then vibration mitigation experiment of a model stay cable transversely attached with a tensioned SMA wire was conducted. The strain level of SMA wire was calculated from the stay cable force increment. Both the 1st and the 2nd in-plane vibration mode were tested in the experiment. The effects of the SMA wire installation location and pre-strain on frequency and damping ratio of the model-cable-SMA-wire system were discussed. The test results confirmed there was an optimal pre-strain of SMA wire for the maximum mode damping larger than 0.50%. The study confirmed great potential application of pre-strained SMA wire as cross-ties for stay cable vibration mitigation.

Keywords: stay cable; SMA; pre-strain; damping; frequency

1. Introduction

Large-amplitude vibrations of stay cables in cable-stayed bridge have attracted many researcher's attention. Installing damper near cable anchorage and connecting adjacent cables by cross-ties are two major counter-measures for these harmful vibrations. The method to optimize the damper attached to a stay cable has been extensively studied [1-3]. Cross-ties could enhance the in-plane stiffness of cable system, which in turn increases the critical wind speeds for triggering aerodynamic instabilities. Experimental studies have shown that although vibration frequency of cross-ties connected cable system was obviously increased, the damping contribution from traditional steel wire were found to be small [4]. And the use of too much cross-ties to inter-connect a set of cables can lead to other concerns from an aesthetic point of view. As stay cable becomes longer and longer, individually applied dampers or high strength steel cross-ties might not be so effective due to the practical limitations, and one way to integrate the advantages of the two methods was to hybrid employment of dampers and cross-ties[4-6], with the inevitable increasing of system complexity and cost.

SMA is a type of smart material with high damping and re-centering capability. Earlier studies have shown that SMA also has high fatigue resistance and high corrosion durability. Therefore, Efforts have been undertaken to develop various types of dampers, actuators and other devices to mitigate engineering structures vibration in the past few decades [7-10]. A few literatures are also already available to apply SMA dampers for cable vibration mitigation. Zuo and Li developed a SMA damper and verified the mitigation effects by both numerical simulation and experimental results [11]. Li, Liu and Ou conducted theoretical and numerical studies to explore the damping effects of cable with attached SMA damper [12]. Liu, Li, Song and Ou further conducted model cable

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