Experimental study of potential bearing uplift of cable-stayed bridges under earthquakes

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Abstract

To investigate the potential bearing uplift of long-span cable-stayed bridges, a 1/35 scaled double-tower bridge model was tested on four shake tables at Tongji University, China. A longitudinal floating system was first applied to the test model, *i.e.,* the unlimited longitudinal but restrained transverse movements. Then, viscous fluid dampers (VFDs) were installed as the tower-deck connections to study their effects on alleviating the issue of bearing uplift at auxiliary piers. Test results showed that: (1) though ground motions were merely longitudinally input, there was a possibility of bearing uplift due to the longitudinal vibration of the towers combined with the vertical vibration of the deck; (2) the effectiveness of the VFDs on reducing the bearing force at the auxiliary pier was related to the characteristics of earthquakes; (3) compared with the deck longitudinal displacement, the effectiveness of VFDs on controlling its vertical displacement was insignificant.

Keywords: long-span cable-stayed bridge; earthquake; shake table tests; bearing uplifting; viscous fluid damper.

1 Introduction

Cable-stayed bridges become the preferred bridge scheme for the newly built bridges with a span length from 400 m to 1200 m own to the aesthetical appearance, high structural efficiency, and good economy. In practice, floating or semi-floating systems are often adopted in the longitudinal direction for a long-span cable-stayed bridge due to the consideration of thermal movement. These systems also have the inherent seismic isolation characteristic which elongates the natural periods. Therefore, this kind of long-span cable-stayed bridge is characterized by large flexibility and low structural damping [1][2], resulting in large longitudinal seismic deck displacement. Various dampers, such as the viscous fluid damper (VFD), have been proposed to reduce seismic displacement. Martínez-Rodrigo and Filiatrault [3] analyzed and compared the effects of several kinds of seismic devices (i.e., metallic dampers, VFDs, tuned mass dampers, and friction pendulum bearings) on the seismic responses of a single-tower cable-stayed bridge with a span of 137.4 m, and the results revealed that the VFDs could balance the seismic displacement and force responses well of the cable-stayed bridge. Jia et al. [4] further investigated the effect of VFDs on a long-span cable-stayed double-tower bridge with a span of 680 m. The results showed that the VFDs can significantly reduce the longitudinal and vertical seismic deck displacement by around 50% and 30%, respectively.