Experimental Investigation on Transverse Steel Damper Seismic System for Cable-stayed Bridges

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Abstract

To investigate the seismic performance of transverse steel damper seismic system (TSDSS), a shake table test is conducted on a 1/35-scale model of Sutong Bridge, a long span cable-stayed bridge with a main span of 1088 m. During the test, two types of transverse structural systems are considered, one is the TSDSS, an energy dissipation system with the transverse steel dampers (TSDs) placed at deck-tower/bent connections, and the other is a fixed system with transversally fixed bearings. Two ground motions for different site types (i.e., hard and soft) are selected as inputs. Results show that (1) the TSDSS significantly reduces lateral horizontal forces at the deck-tower/bent connections, and reduces displacement and curvature demands along tower and bent shafts, meanwhile limiting the deck-bent and -tower relative displacements at an acceptable level for practice. (2) the isolation efficiency of TSDSS are robust regardless under soft- or hard-site ground motions; for both waves, the percentages of the reduction of curvature demands at bottoms of the bent and tower are averagely around 36%.

Keywords: Shake table test; Cable-stayed bridges; Lateral isolation; Transverse steel damper

1 Introduction

Since 1980s, a large number of cable-stayed bridges have been constructed in China. Due to the crucial role as key joints in the transportation networks and the difficulty of seismic-induced damage repair, main components of structure including foundations and towers are required to remain elastic under design-level earthquakes in Chinese engineering practice [1, 2]. Unfortunately, however, strong earthquakes have occurred occasionally around the world over the past decades, and some cause severe damages in bridges. For example, during the 1999 Chi-Chi earthquake in Taiwan, Chi-Lu Bridge, a single tower cable-stayed bridge, suffered severe damages [3]. Therefore, how to improve the seismic performance of cable-stayed bridges has drawn increasing attentions from the engineering community.

In the longitudinal direction, a full- or semi-floating system is often applied in practice. In such a system, Fluid Viscous Dampers (FVDs) are often installed at deck-tower connections to limit displacement demands at the deck [4, 5]. Therefore, the longitudinal seismic performance of cable-stayed bridges is generally acceptable for practice. In the transverse direction, on the other hand, fixed constraints are often used at deck-bents/towers connections for providing enough stiffness to carry traffic and wind loads. This is the so-called conventional Transverse Fixed System (TFS), which, as a result, will inevitably increase seismic demands at substructures. In this regard, bents (or piers), towers and foundations are always designed extraordinarily strong to resist large seismic events.

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