Seismic Pounding Mitigation of an Existing Cable-Stayed Bridge Using Metallic Dampers

Ahad Javanmardi, Khaled Ghaedi, Zainah Ibrahim

Civil Engineering Department, Faculty of Engineering, University of Malaya, Kuala Lumpur 50603, Malaysia

Karuppiah Udayar Muthu

Brindavan College of Engineering, Dwarakanagar, Yelahanka, Bangalore 560064, Karnataka, India

Contact: Ahadjavanmardi@gmail.com

Abstract

This paper aims to mitigate the seismic pounding effects on an existing steel cable-stayed bridge through the implementation of metallic dampers. The earthquake-induced pounding phenomena were reported on the bridge in 1988. To aid the aim, a finite element model of the bridge is created and the nonlinear time-history is performed to assess the impact of the proposed control system on the bridge seismic performance. Results of the comparative study showed that the seismic pounding significantly mitigated by metallic dampers and the global seismic responses of the bridge enhanced, relatively.

Keywords: Cable-stayed Bridge; Vertical pipe damper; Metallic damper; Pounding mitigation; seismic performance; nonlinear dynamic analysis.

1 Introduction

Over the last four decades, the application of cable-stayed bridges has gain popularity among long spans bridges due to their structure and economic advantages. On the other hand, these types of bridges are characterized by low damping and high flexibility, which make them vulnerable to large amplitude oscillation during earthquakes as unpredictable events [1–3]. The dynamic and seismic responses of cable-stayed bridges have been investigated by many researchers [4–6]. The source of geometric nonlinearities such as cable-sag effect, beam-column effect, and large displacement effect (p-delta), were identified by Nazmy and Abdel-Ghaffar [7]. The cable-sag effect causes excessive nonlinearity in cable-stayed bridges. In addition, the dynamic behavior of cable-stayed bridges is significantly affected by the identified nonlinearities.

The deck-tower connection and bridge support at abutments are also greatly dominated the dynamic response of the cable-stayed bridges. The rigidity of deck-tower connection limits the horizontal displacement of the deck and increases base shear of the tower. On the other hand, the hinge connection enlarged the flexibility and horizontal displacement of the deck. Furthermore, the geometry of towers such as shape and height also reflects on the dynamic response of the cable-stayed bridges [8].

The reports on the major earthquakes revealed that, one of the major causes of the damage or failure during earthquake events, is earthquake-induced pounding phenomena. This phenomenon happens when the separation gap between adjacent structure is smaller than the elastic deformation of the structures [9]. In addition, structures with low lateral strength may need special attention to prevent the pounding with adjacent structures [10,11]. The earthquake-induced pounding may also occur in bridges if the seismic displacement of the bridge exceeds the opening of expansion joints at adjacent spans or

https://doi.org/10.2749/kualalumpur.2018.0617
Distributed by structurae