Optimum Deck and Tower Configurations for the Transverse Seismic Response of Cable-stayed Bridges

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Abstract

Cable-stayed bridges represent key points in the infrastructure networks and their seismic response needs to be understood and optimised from the early stages of the design process. The configuration of the towers and the deck, as well as the articulation between them, play an important role in the seismic performance. This work is focused on the dynamic interaction between the deck and the towers in the transverse direction (perpendicular to traffic) during the earthquake. An extensive parametric analysis based on the modal response spectrum analysis of a large number of cable-stayed bridge finite element models is performed. The analyses are repeated considering the contribution of different vibration modes and it is found that the governing ones are strongly influenced by the flexibility of the deck and the towers. The results demonstrate that when the vibration frequencies of the towers and the deck coincide, the transverse seismic response of the whole bridge is significantly amplified. Based on this observation, this work proposes simple analytical expressions to obtain the critical tower frequencies that should be avoided in the conceptual design of the bridge in order to prevent potentially catastrophic seismic effects. Finally, these expressions are applied in the conceptual design of a 500-m span cable-stayed bridge.

Keywords: cable-stayed bridges; seismic response; deck-towers interaction; spectrum analysis; modal contribution; design recommendations.

1 Introduction

Cable-stayed bridges represent key points in the infrastructure networks and their seismic response should be optimised. These structures present low damping values and complex dynamic interactions between their different members that need to be carefully considered in their design [1]. Previous research works and reports on damage observed in cable-stayed bridges after past earthquakes suggest that the seismic interaction between the deck and the tower in the transverse direction is very important [2,3].

An extensive numerical study on the modal contribution to the peak deck-tower reaction under different types of earthquakes was recently presented in [4]. This paper is conceived as an extension of that work, which aims to demonstrate the use of a simplified formulation proposed therein to avoid potentially catastrophic deck-tower interactions in the conceptual design of the bridge towers.

2 Parametric analysis

The bridges considered in this work have a conventional symmetric configuration with a

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