Vibration Behaviour and Seismic Performance of a Steel Cable-Stayed Bridge with Low-Rise Pylons

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Summary

In this study, the vibration behaviour and seismic performance of a cable-stayed bridge with a centre span of 575 m in length and pylons of 95.5 m in height were verified. The height of the pylon and the connection condition between the stiffness girder and pylons were assumed to be parameters. As a result, the parameters studied in this work greatly affected the vibration behaviour and seismic performance of the bridge.

Keywords: cable-stayed bridge; low-rise pylon; connect condition between girder and pylons; vibration behaviour; seismic performance.

1. Introduction

Given the excellent spanning capacity, cable-stayed bridges are often constructed to span big obstacles such as large rivers, gulfs and valleys. In case that cable-stayed bridge was damaged due to earthquake, huge negative impact on rescue and relief might be caused because of its high importance. In general, cable-stayed bridges are of large-scales, their restoration from earthquake damage might take a long period and high budget, which must greatly affect the reconstruction of the disaster area. On the other hand, the seismic vulnerability of cable-stayed bridges has been demonstrated by recent earthquakes. One anchorage plate connecting the steel box girders to one abutment of the cable-stayed Shipshaw bridge was damaged by the1988 Saguenay Earthquake in Canada [1]. During the 1995 Hyogoken-Nabu Earthquake, the Higashi-Kobe Bridge, a cable-stayed bridge with a centre span of 485 m suffered a big blow. The pins of pendulum shoes that support vertical forces on both sides of the end pier were taken off and the bridge end was lifted up about 0.4 m [2]. The Chi-Lu Cable-Stayed Bridge was under the final construction stage when the 1999 Chi-chi earthquake happens in Taiwan, besides severe damage occurred in the deck on the southern side of the bridge, damage occurred in the pylon as well [3]. In evidence, it is significant to ensure the seismic performance of the cable-stayed bridges which are located in seismically active region.

For a cable-stayed bridge, the stiffness girder is elastically supported by multiple cables that are strung to the pylons, and piers in the side span. Because of the high statically indeterminate degrees, the vibration behaviour of cable-stayed bridges is very complex. Furthermore, there are several choices for the structural configuration of cable-stayed bridges and the dynamic response of a cable-stayed bridge greatly depends on its structural configuration. Up to now, there have been numerous research works on the seismic performance of cable-stayed bridges, the representative studies can be found in [4] - [10]. However, there has not been a complete seismic design system for cable-stayed bridges in Japan and the cable-stayed bridges are generally aseismic designed by special specifications. In this work, the vibration behaviour and seismic performance of a 5-span steel cable-stayed bridge with low pylons were investigated by nonlinear dynamic analysis method. The bridge with a centre span of 575 m is planned to span a bay. The total height of the pylons is restricted by 105 m since its location is near an airport. It is only 51.5 m high from the stiffness girder centroid at the pylon position to the outermost stay cable position at the pylon (hereafter referred to as effective height of pylon and denoted by H_e). The ratio of the effective pylon height to the length of centre span is about 1/11 which is greatly smaller than the average ratio 1/7 - 1/5.

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