Evaluation of Seismic Performance of Bridges in Thailand

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Summary

In this research, the effects of moderate earthquakes on bridges of Department of Rural Roads which were not specifically designed to withstand earthquakes are investigated. Components in the study includes seismic hazard analysis, classifications of bridges of Department of Rural Roads, cyclic loading tests of 0.40 m x 0.40 m RC columns, cyclic loading tests of bearings, seismic downhole tests to measure shear wave velocity for site classification, and seismic response analysis of bridges. From cyclic loading tests of columns, the ductility capacity of the RC bridge column detailed according to the current practice is found to be 4.0. A series of analysis are conducted on 16 bridge models. Piers with 0.35 m x 0.35 m and 0.40 m x 0.40 m sections in bridges with a span length of 10m or less are found to be vulnerable to earthquakes because of a high ductility demand.

Keywords: Moderate earthquakes; bridges; bridge pier; seismic response analysis; cyclic loading.

1. Introduction

Thailand is prone to moderate earthquakes originated in the Western and Northern parts of Thailand, and in the neighboring countries like Laos and Myanmar. Like many old buildings constructed before the new regulation came into force, a number of existing bridges constructed by Thailand Department of Rural Roads were not originally designed to withstand earthquakes. Therefore, it was necessary to investigate the seismic performance of these bridges.

2. Seismic Hazard Map

The seismic hazard maps of Thailand showing horizontal ground acceleration were developed. The hazard map with 10% probability of exceedance in 50 years shows that the peak horizontal accelerations on rock outcrop in the Northern part (Maehongsorn and Chiangmai provinces) can be as high as 0.25g, whereas in the Western part of Thailand (Karnchanaburi and Tak provinces), up to and 0.15g. In Bangkok, the peak horizontal ground acceleration falls between 0.02g to 0.03g.

3. Site Classifications

Shear wave velocity is one of the key components to classify the soil condition. Using the concept of wave propagation, seismic downhole test was performed to obtain shear wave velocity at eight sites in the northern, western and central parts of Thailand. Soils in Chiangmai, Chiangrai and Karnchanaburi are of stiff soil while ground conditions in Bangkok falls in soft soil conditions.

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4. Cyclic Loading of Bridge Columns

Seismic performance of RC bridge columns was evaluated. 0.40 m x 0.40 m columns are widely used with minimal confining steels. Hence, three 0.40 m x 0.40 m RC columns with different lateral reinforcement details were tested in this study. The column size was chosen based on the typical column used in a 10 m span bridge. The columns were subjected to cyclic loadings under displacement control. The column which represents a typical column design of Department of Rural Roads bridges has a ductility capacity of 4.0. It is found that the amount of confinement does not significantly affect the ductility of columns.

5. Cyclic Loading of Elastomeric Bearings

To better model the bridge structure, the stiffness and other mechanical properties of elastomeric bearings were obtained experimentally. The bearing is subjected to lateral displacement on the top by a hydraulic actuator. The hysteretic behaviors indicate that substantial energy is dissipated during the cyclic loading. The elliptical shape loop is typical of a viscoelastic material. The shear modulus of the bearing used for the present study was estimated to be 1 MPa.

6. Seismic Response Analysis

There are 16 bridge configurations with various foundation types, and span lengths. A series of finite element analyses were performed on bridge models using SAP2000. The response spectrum method is used to obtain the maximum elastic force demands. The design peak rock accelerations used in this study are 0.15g and 0.25g which are the peak horizontal accelerations obtained from the Western and Northern parts of Thailand, respectively. From the seismic response analysis, it is found that bridge piers with the column sections of 0.35 m x 0.35 m and 0.40 m x 0.40 m appear to be most vulnerable because ductility demand is larger than or close to the ductility capacity.

7. Conclusions

The present study is aimed at investigating the performance of RC bridges of Thailand Department of Rural Roads subjected to moderate earthquakes. The following conclusions can be made:

1) The hazard map with 10% probability of exceedance in 50 years shows that the peak horizontal ground accelerations on rock outcrop in the Northern part (Maehongsorn and Chiangmai provinces) can be as high as 0.25g, whereas in the Western part of Thailand (Karnchanaburi and Tak provinces), up to and 0.15g. In Bangkok, the peak horizontal ground acceleration falls between 0.02g to 0.03g.

2) The ductility capacity of the 0.4m x 0.4m bridge column detailed according to the Department of Rural Roads' current code of practice was found to be 4.0. The ductility is slightly affected by an increase in confining steels.

3) From a series of analyses, bridge piers with the column sections of 0.35 m x 0.35 m and 0.40 m x 0.40 m appear to be most vulnerable because ductility demand is larger than or close to the ductility capacity.

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