EFFECTIVENESS OF CONFINING REINFORCEMENT ON STRENGTH AND DUCTILITY OF REINFORCED CONCRETE HIGHWAY BRIDGE PIERS

INTRODUCTION

General Introduction

Concrete bridges are important structures to serve public transportation. Frequently, earthquakes cause damage to building and bridges in many countries. Structures must be designed to withstand earthquakes without collapse. The strength and ductility of the structures are required to dissipate the seismic energy through inelastic deformation. The ductility is the lateral deformation ability while the structures still maintain their gravity load carrying capacities.

There have been extensive studies of structural behavior under earthquake in North America, Europe, Japan and other countries. Recently, various researchers have been investigating the seismic activities in South-Eastern Asia region and it is indicated that Thailand is located in a moderate seismic zone. In the past, buildings and structures in Thailand have been designed and constructed without any consideration of seismic loadings. Recently seismic hazards have occurred especially in northern and western parts of the country with earthquake intensity of 5 to 6 Richter scale (Warnitchai and Lisantono, 1996). The new findings about the present active faults lead to potential to cause the seismic hazards for Thailand.

Since the western and northern parts of Thailand are located in moderate seismicity with peak ground acceleration between 0.15g and 0.225g. , in 1997, the ministerial regulation (Ministry of Interior, 1997) stated the seismic design provision enforcing the design of structures in nine northern provinces such as Chiang Rai, Mae Hong Son, Phayao, Nan, Lumpang, Phrae, Chiang Mai, Tak, and in a western province, Kanchanaburi. Furthermore, the national earthquake committee suggested that Bangkok should be enforced for structural design against seismic activity. For the concrete bridge structures built in the ten provinces of moderate seismicity, the structures can be considered to be subjected to seismic lateral forces conforming to zone 2 of AASHTO code (Warnitchai and Lisantono, 1996). The behavior of bridge pier subjected to earthquake can be explanted in Fig. 1.

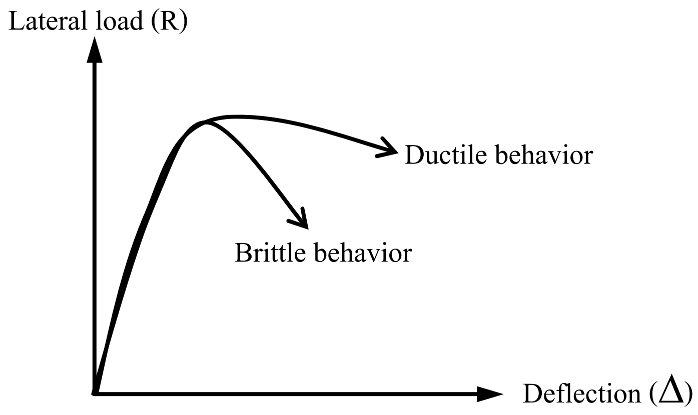

Figure 1 Lateral load vs. lateral displacement

At ultimate state, the bridge columns will undergo inelastic response and plastic hinging at particular locations of the structure such as the connections of column and footing in Fig. 2 To maintain integrity of the structure, it is necessary that the structure has relatively large ductility so that shear failure or significant strength degradation do not occur.

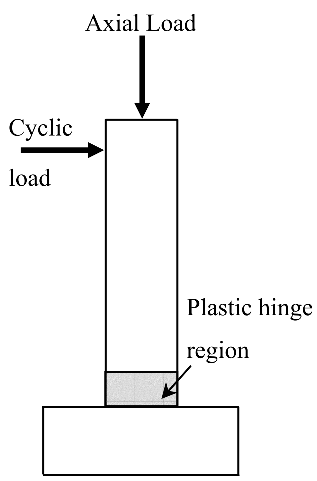

Figure 2 Structural model of column and footing

Fig. 3 shows the seismic hazard map of Thailand (Warnitchai and Lisantono, 1996). Seismic Hazard Map of Thailand was proposed. It was found that the western and northern region are located in seismicity with peak ground acceleration between 0.15g and 0.225g. It present the peak ground acceleration with a 10% chance of being exceeded in a 50-year exposure time based on Uniform Building Code (UBC 1994).

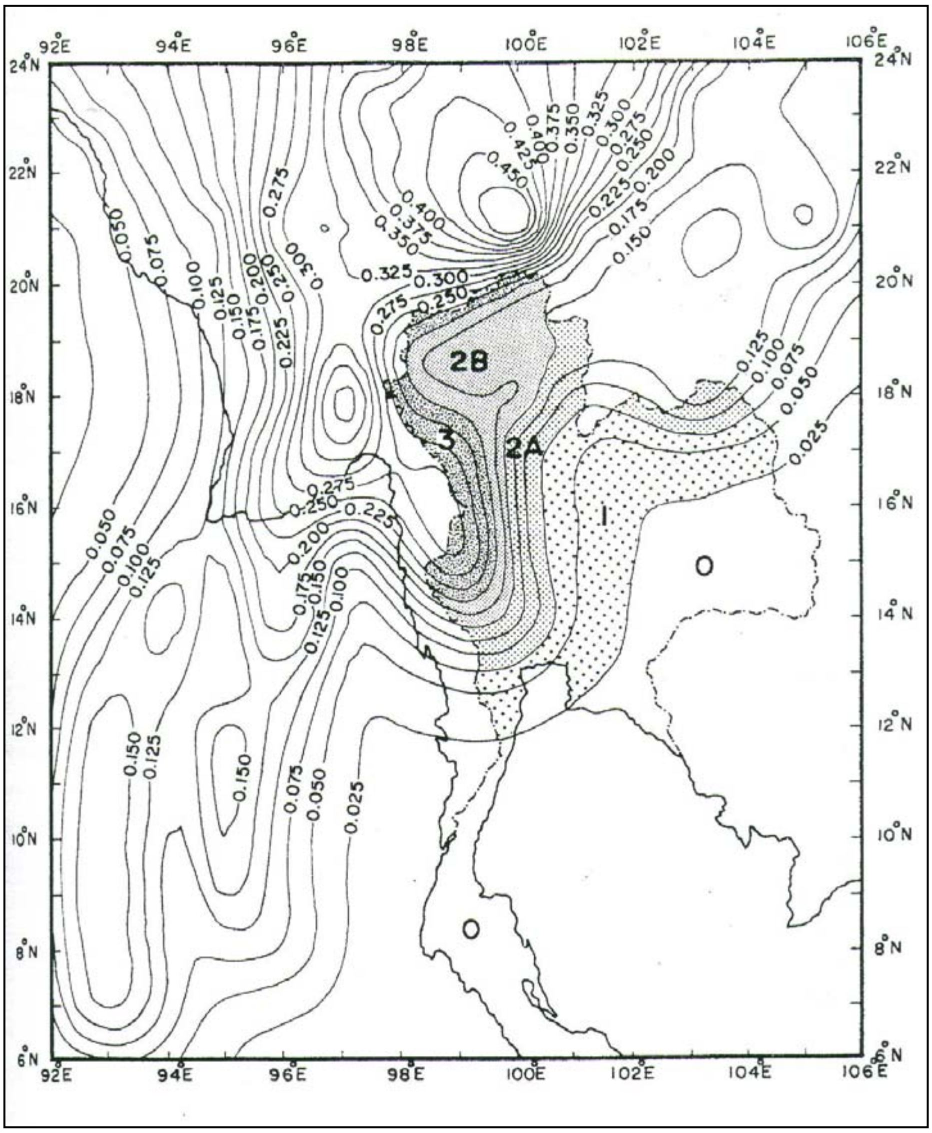

Figure 3 Seismic hazard map of Thailand

Source: Warnitchai and Lisantono (1996)

It is well established that the adequate confinement of bridge columns achieve high ductility and dissipate energy capacity of reinforced concrete bridge piers. However, the behavior of reinforced concrete bridge piers subjected to axial load and modulate cyclic lateral loads for load practice in Thailand need be investigated. Moreover, various parameters affecting the seismic performance of bridge structures such as shear span ratio, confinement ratio, axial reinforcement ratio, axial load intensity and eccentricity loading need be studied so that design recommendation for confinement of the bridge pier can be suggested.

Purpose and Scope of Research

The objective of this research was to investigate the strength and ductility of reinforced concrete bridge piers subjected to moderate cyclic loads experimentally and analytically. For the experimental study, six specimens have prototypes of reinforced concrete columns the same cross section dimension of 400 mm × 400 mm and have the total height of 2050 mm while the effective height is 1550 mm. The longitudinal reinforcement consists of 13 mm diameter deform bars with yield strength of 395 MPa (SD345). Tie reinforcement is 6 mm diameter round bars with yield strength of 245 MPa (RB245). The test specimens were subjected to constant axial load and cyclic load applied by displacement control with one cycle of the number of unloading and reloading in each step.

To study the physical parameters affecting the strength and ductility of reinforced concrete bridge piers extensively, forty-two specimens were analyzed to determine the behavior of the specimens when subjected to constant axial load and lateral cyclic loads with three cycles of numbers of loading, unloading and reloading in each step of displacement increment. The column cross section was 400 mm × 400 mm and the shear span ratio was varied between 2.5 and 4.5 and axial load was varied between $0.075f'_cA_g$ and $0.2f'_cA_g$. The calculated tie reinforcement ratios are varied between the minimum ratio required by AASHTO with non seismic performance and 66 percent of the amount required with seismic performance. The main steel reinforcement and confinement reinforcement were deform-bars with the yield strength of

395 MPa (SD345). The concrete strength is 28 MPa. The fiber element method was used for analyzing inelastic behavior of the specimens.

The analytical behavior of the columns and the recommendation for reinforce concrete bridge columns design for moderate ductility level within the scope of studies will be reported.