EVALUATION OF SEISMIC RESPONSE FOR RC BRIDGE PIERS IN VIETNAM A LOW-MODERATE SEISMIC ZONE

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1. INTRODUCTION

The recent earthquakes as the Northridge Earthquake of 1994, the Hyogoken-Nanbu Earthquake of 1995, the Taiwan Chi-Chi Earthquake of 1999, the Iran Earthquake of 2001, the Chuetsu Earthquake of 2004, and the Wengchuan Earthquake of 2008), caused serious damage to many lifeline facilities, many reinforced concrete bridge piers suffered severe diagonal shear failure as well as flexural failure. Therefore, shear representation including axial force variation is of utmost significance, taking into account that vertical components in recent earthquakes are high relative to horizontal components. The proposed plastic hinge detail incorporating new materials could potentially make bridges serviceable even after they undergo large deformations and dissipate energy. According to the analyses of the earthquake records obtained by the seismometers, Vietnam is located at a moderated seismic activity area. Reinforced concrete bridge piers dissipate earthquake energy through substantial inelastic deformation. The objective of this study is to determine response seismic at the plastic zone of the bridge pier (determine a hysteretic curvature at the plastic hinge of a pier) in low moderate seismic zone (i.e. acceleration coefficient, A = 0.09 – 0.29 g with g being the gravity acceleration).

2. ANALYSIS OF BRIDGE PIER

2.1. Overview

When seismic forces are estimated from an elastic analysis, Vietnam Specification was established based on AASHTO LRFD 1998 (referred to as 22TCN 272-05) allow these forces to be reduced by appropriate response modification factors. These reduced forces can be used for design, but only if the substructure units are made ductile enough to undergo plastic hinge with out suffering catastrophic failure. The philosophy is that seismic induced forces can only become large enough to produce plastic hinges. Once plastic hinges form, force can no longer be absorbed, but deflections will be large. The response modification factors are applied to forces and not displacements. Since the codes require the seismic analysis and ductile details and allow the use of response modification factors for typical bridge structures with seismicity higher than seismic zone 2 (i.e. acceleration coefficient A > 0.09 g), it is apparent that plastic behavior would be a real possibility in these regions.

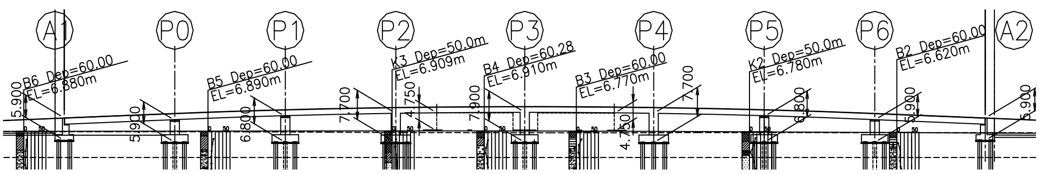

Fig. 1 The continuous bridge in Vietnam

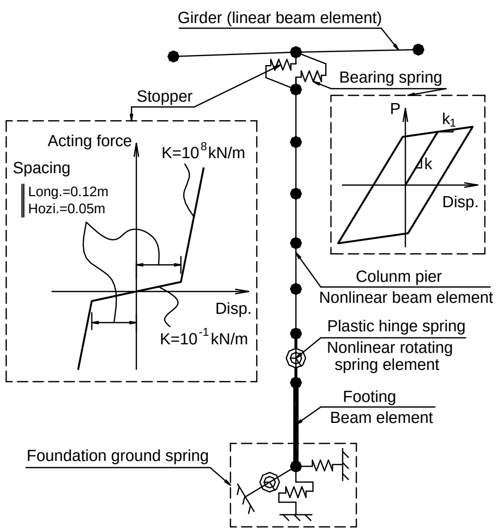

Fig. 2 Modelling of the bridge pier

Keywords: Seismic design, seismic zone, plastic hinge, pier, response analysis

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2.2. Analytical model

This study describes a multi-span continuous bridge representative of a typical bridge in Vietnam (shown in **Fig. 1**). The compressive strength of the concrete of the pier is 30 MPa; the diameter of the spiral reinforcement is 16 mm; the diameter of the longitudinal reinforcement is 25 and 29 mm, spacing of the spiral is 300 and 125 mm corresponding to the bent piers and the rigid piers. The rubber bearing supports and stopper are installed at the top of the piers. An analytical model of the bridge pier as shown in **Fig. 2** is made to estimate seismic performance of the bridge.

2.3. Ground motion

The ground acceleration record in the Tsugaru Ohhashi (1983) with the maximum acceleration is 1.41 m/s^2 correspond to Level 1 ground motion in Japan Specification adopted as input data at the ground level in this study. According to others research on earthquake activities, this record can corresponds with a low moderate seismic zone in Vietnam.

3. ANALYTICAL RESULT

The results show the maximum rotation angles of the plastic hinges at the bottom of the columns, shear forces and moments obtained from analysis are smaller than there resistance as shown in **Table 1**. **Fig. 3** shows the hysteretic responses at the plastic hinges of the piers including which the pier P0, P1 are installed by the rubber bearing at the top and the pier P2 is rigidly jointed between the pier and the girder. In addition, the analysis shows that all piers are still in elastic state, no serious damage is evaluated for Level 1 earthquake motion. The bridge is secure from the current earthquake occurring in Vietnam.

Table 1 Moment and shear force at the plastic hinge

Pier	Shear (kN)		Moment
	Response	Resistance	(kN·m)
P0	502.4	3854	1738
P1	1588	3854	6914
P2	4605	5229	6977
P3	4621	5229	7099
P4	3986	5229	8210
P5	1597	3854	6953
P6	505.9	3854	1751

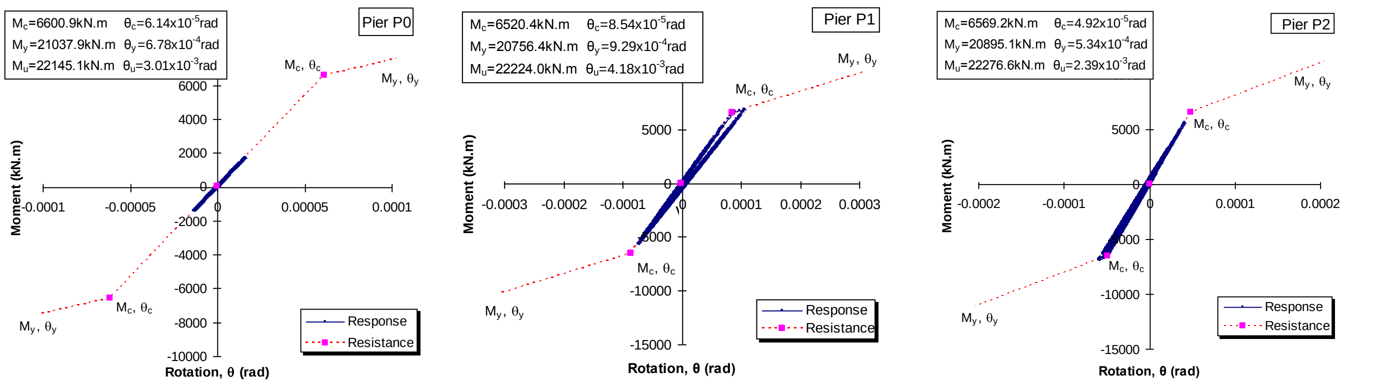

Fig. 3 Hysteretic response of the pier P0, P1, P2 at the plastic hinge

4. CONCLUSISONS

The seismic design for bridge in Vietnam is brief review in this paper. Current Vietnam seismic design requires that an elastic analysis is performed to estimate design forces. For the typical bridge structure modeled, this study indicates that plastic hinge at the column base may occur in a low to moderate seismic zone such as Vietnam.

For Level 1 earthquake motion according to Japan code, no serious damage is evaluated. The bearing capacity of the pier is still within elastic state. The bridge is also secured from the current earthquake occurring in Vietnam.

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