EVALUATION OF SEISMIC RESISTANCE OF EXISTING BRIDGE IN VIETNAM BY DYNAMIC RESPONSE ANALYSIS

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1. INTRODUCTION

Due to the elastic deformation of rubber, the bridge support used rubber bearing support and undergoes relatively displacement between girders and bearing, bearing and pier can reduce the internal force of their structure during an earthquake. Rubbers bearing support was also arranged in bridge structure by Vietnamese engineers. It is only arranged in order to transfer load from superstructure to substructure. It wasn't designed for earthquake resistance. In seismic area, the bearing of bridge has large influence to structure. Elastic deformations of rubber bearing can be decreased unsafely for bridge structure. In this paper, friction coefficient is used as parameters to discuss safety limit of existing bridge in Vietnam when earthquake occurs.

Fig 1: This is one of bridges which was designed and constructed by Vietnamese.

2. DYNAMIC RESPONSE ANALYSES

2.1. Analysis outline

In this analysis, one of the existing bridges in delta plain South Vietnam is adopted. The bridge consists of 5 simple spans with PC slab girder. Width of carriageway is 11m; arrangement of 12 PC slab girders, the distance between girders is 1m. The deck is supported by rubber bearing. Dimension of rubber bearing is 150x200x35mm. The foundation of pier is composed of six cast-in-place piles with a diameter of 1m. Footing is bored cast in place pile system. D=1m, L=51m (for P1, P4) and L=62m (for P2, P3). Modeling of pier foundation is a linear springs (K_X, K_Y, K_θ). The wall pier with a plastic hinge at the bottom is connected with a non-linear springs. Plastic hinge length is $L_p = 0.6$ m ($0.1D \leqq L_p \leqq 0.5D$, D=1.2 m), the hysteresis property is the Takeda model. The rubber bearing is modeled into a nonlinear spring bilinear in horizontal direction; the girder and footing was a linear beam element. The friction coefficient between bearing and girder is assumed to be 0.15, 0.3, 0.5 and ∞ (1.0). The friction coefficient such as 0.15, 0.3 to 0.5 and ∞ (1.0) can be obtained by Teflon, steel plate and rigid displacement between girder and bearing.

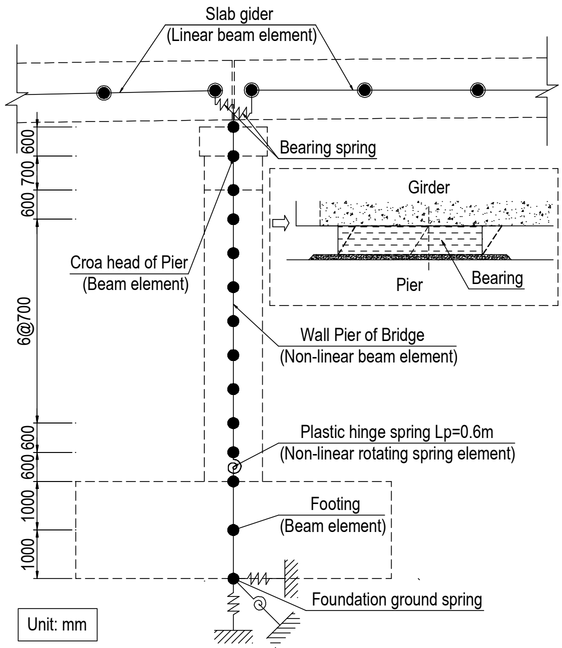

Fig 2: Analytical model of bridge (Pier P2)

The input level 2 earthquake ground motion is provided in Specifications for Highway Bridges. The dynamic analysis is performed using the New-mark β method and time interval is 0.01s. Rayleigh damping model is used.

In the analysis, the effects of each parameter are simulated using the horizontal earthquake inputs. The calculation cases are changed on friction coefficient of bearing (μ) and spring stiffness (K).

2.2. Analysis results

a) Response horizontal displacement of bearing

In order to restrain the lateral displacement of elastomeric bearings in slab-girder bridge must be fixed a bottom of the bearing on the top pier and allow for longitudinal movement of the elastomer. The elastomer's stiffness in the transverse direction contributes to the overall stiffness of the system.

Key words: Dynamic response analysis, seismic resistance, existing bridge in Vietnam.

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Fig 4 and **Fig 5** show displacement of bearing. The displacement is large when $\mu < 0.3$ and displacement is almost constant when $\mu > 0.3$.

Table 1: Characteristics of bearing

Friction coefficient, μ	Beginning sliding displacement , δ (m)	
	$K = 8.15x10^4$ kN/m	$K = 1.63x10^5$ kN/m
0.15	0.008172	0.004086
0.30	0.016344	0.008172
0.50	0.027239	0.013619
∞ (1.0)	0.054479	0.027239

Table 2: M - θ response of plastic hinge (pier P2)

μ	$K = 8.15x10^4$ kN/m		$K = 1.63x10^5$ kN/m	
	Moment (KN.m)	θ (rad)	Moment (KN.m)	θ (rad)
0.15	12170	0.0020	11950	0.0015
0.3	12420	0.0063	12170	0.0021
0.5	12390	0.0057	12150	0.0017
∞ (1.0)	12480	0.0073	12160	0.0019

Table 3 shows horizontal displacement of left bearing and right bearing on pier P2 in some of calculation cases. The maximum displacement of bearing in the analysis is 0.13m when spring stiffness and friction coefficient is small ($K = 8.15x10^4$ kN/m, $\mu = 0.15$, respectively) and the slip phenomenon is shown between girder and bearing. The bearing is almost elastic deformation when $\mu > 0.15$ ($\mu = 0.3, 0.5, 1.0$).

b) Effects of the friction coefficient to pier

Fig 6 and **Fig 7** show response of plastic hinge by M - θ relation, the rotation angle increases with the increasing of the friction coefficient. The hysteretic curve of the rotation moment-angle shows a non-linear property. The maximum displacement of top pier is δ = 5.33 cm ($K = 8.15x10^4$ kN/m, θ = 0.0073 rad < 1/100, high of pier is H=7.3m, respectively). In this analysis, pier isn't damage when rotation angle smaller than 0.0073 rad.

3. CONCLUSION

The influence of friction coefficient and spring stiffness to displacement of pier and bearing is discussed. Through the study of the pier model, it was possible to approximately estimate the maximum response of bearing and a plastic hinge location. By analytical model, a single bridge pier based on Japanese seismic design isn't collapse, especially with friction coefficient μ is small.

4. REFERENCES

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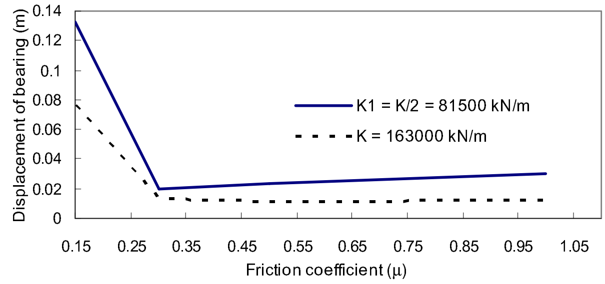

Fig 4: Horizontal displacement of right bearing (pier P2)

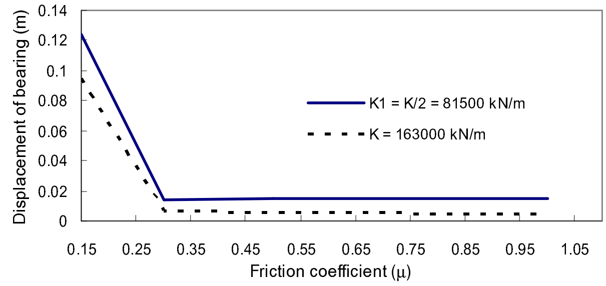

Fig 5: Horizontal displacement of left bearing (pier P2)

Table 3: Horizontal displacement of bearing

μ	$K = 8.15x10^4$ kN/m		$K = 1.63x10^5$ kN/m	
	Displ. of left bearing P2 (m)	Displ of right bearing P2 (m)	Displ. of left bearing P2 (m)	Displ. of right bearing P2 (m)
0.15	0.1243	0.1326	0.0945	0.0765
0.3	0.0137	0.0193	0.0070	0.0131
0.5	0.0145	0.0236	0.0055	0.0116
∞ (1.0)	0.0153	0.0296	0.0050	0.0119

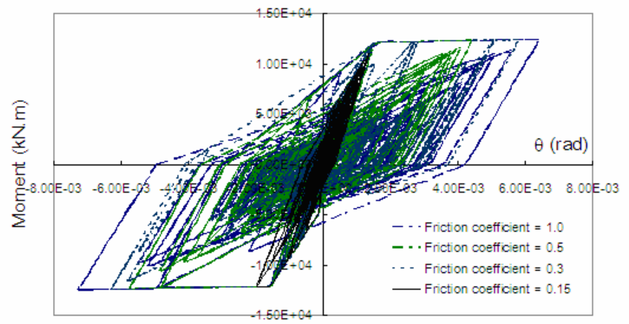

Fig 6: M - θ response of plastic hinge ($K=8.15x10^4$kN/m)

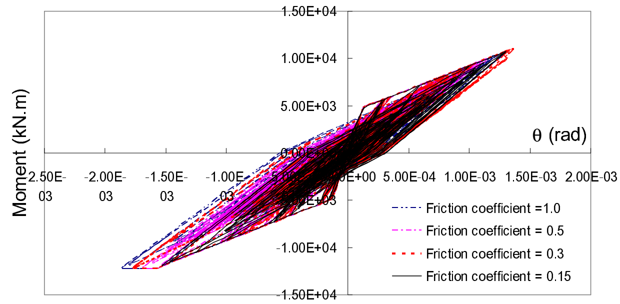

Fig 7: M - θ response of plastic hinge ($K=1.62x10^5$kN/m)

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