Seismic Performance of Single-Column RC Bridges with Shear Failure

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Summary

This study chooses the typical configuration of the single-column RC bridge in Bangkok with three different column heights such as 4,5 meter, 6,3 meter, and 15 meter to be the case studies for bridge with short, medium, and tall column height, respectively. The damage states of the studied bridges were evaluated which considered shear failure. Three artificial ground motions generated corresponding to the design spectrum for the inner area of Bangkok were applied to the analytical model of the studied bridges to perform the IDA. The results were found that, when the shear failure was considered together with the flexural failure, the studied bridges collapse as brittle, semi-ductile, and ductile for the bridge with short, medium, and tall column height, respectively. In other words, without consideration of shear failure lead to over capacity of the bridge with short and medium column height.

Keywords: RC bridges; seismic performance; shear failure; incremental dynamic analysis.

1. Introduction

Seismic responses of the structures can be directly evaluated by the mean of Nonlinear Time History Analysis (NTHA). To evaluate the seismic performance of the structures, there are several techniques have been proposed. The recent popular method is Incremental Dynamic Analysis (IDA) which has been compiled and proposed by Vamvatsikos and Cornell. The monotonic scalable ground motion intensity measure (IM) was plotted together with a damage measure (DM) called incremental dynamic analysis curve (IDA curve). The IDA curve contains the necessary information to assess the performance levels or limit-states of the structures which are important ingredients of Performance Based Earthquake Engineering (PBEE). The IDA attracts researchers and engineers to use as the tool for evaluating the seismic behaviour of the structures.

The single-column bridges are generally weak under earthquake because the massive mass of the superstructure was supported by the single column as seen from the damage of this bridge type in the Kobe earthquake. This kind of bridge was widely used in Bangkok, the capital city of Thailand. The oldest one is the part of the expressway, the main line of transportation. It was constructed in 1979 without the requirement of seismic induced consideration. Department of Public Work and Town & Country Planning of Thailand has announced the seismic design standard for the seismic risk regions in Thailand in 2009. Bangkok is classified to the low to moderate seismic risk region.

Mander et al. uses IDA to evaluate seismic performance of bridges which considers only failure from the flexure. Therefore, This study chooses the typical configuration of the single-column RC bridge in Bangkok with three different column heights such as 4,5 meter, 6,3 meter, and 15 meter to be the case studies to investigate the seismic performance by IDA of the single-column reinforced concrete bridges with shear failure consideration.

2. Damage states of three studied bridges

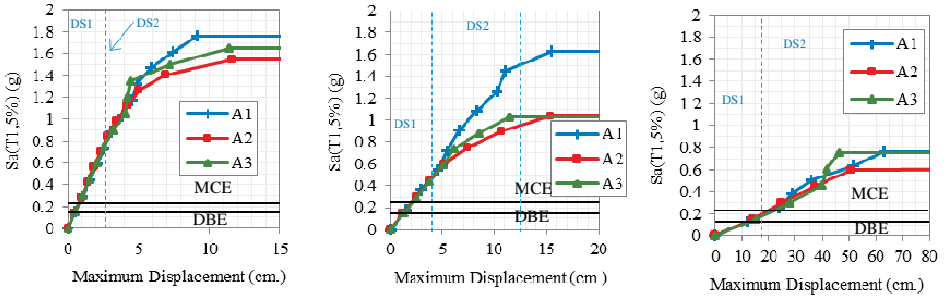
To evaluate the limit of each damage state with shear failure of the studied bridges, the initial and the final shear capacity of the bridge column of all studied bridges was evaluated.

The DM of this study is the maximum lateral displacement of the top of the middle column of the bridge because it can be used to evaluate the damage of the bridge directly. Therefore, the damage limit states extracted from the moment-curvature of the cross-section of the bridge column which considered shear failure were transformed to the lateral displacement limits.

As described previously that the bridge column was designed without consideration of the seismic induced force, this study assumes that the bridge collapse when it DM beyond the DS2 limits.

3. Seismic performance of three studied bridges

Three artificial ground motions were generated corresponding with design spectrum for Bangkok by SeismoArif and referred as A1, A2, and A3. All generated ground motions were applied to the analytical model of all studied bridges to perform IDA and evaluate IDA curves. To evaluate the seismic performance of the studied bridges, the damage limit-states were defined to the IDA curves obtained from IDA of MDOF of the bridges as shown in Fig. 1.



(a) 4,5 m. column height *(b) 6,3 m. column height* *(c) 15 m. column height*

Fig. 1: IDA curves of three studied bridges under three artificial ground motions generated by NTHA of MDOF

Because Bangkok situates in low to moderate seismic zone, the results show that even if the bridges were designed without the consideration of seismic induced load, they are strong enough to resist the ground motion level for the inner area of Bangkok without any damages. Except for the studied bridge with 15 meters column height, the bridge yield under MCE level.

4. Conclusions

This study aims to investigate the seismic performance of single-column RC bridges with three various column heights when included shear failure consideration. The IDA were performed. The defined DS of studied bridges were applied to the results of IDA to evaluate the seismic performance.

The results of IDA show obviously that the seismic performance of the single-column bridges strongly relates to the bridge column height. Performance of the studied bridges decrease when the bridge column increase.

This study also found that, when the shear failure was considered together with the flexural failure, the studied bridges collapse as brittle, semi-ductile, and ductile for the bridge with short, medium, and tall column height, respectively. In other words, without consideration of shear failure lead to over capacity of the bridge with short and medium column height.