第 I 部門　　Pounding Effect of Skew Bridge and Method of Mitigation

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1. INTRODUCTION

Nowadays due to the complexity of interchanges shape and the lack of space in the urban areas, the skewed highway bridges are frequently employed in the urban transportation systems. The research and the investigation of this type of bridge reveals that it is more susceptible to the seismic damage compared with the straight type bridges with regular geometry due to the in-plane rotation of the deck. In this study, the mainly object is to measure the behavior pounding between the seat type abutment and its adjacent deck and its pounding towards to the shear key using Incremental Dynamic Analysis(IDA) method. Ertugrul Taciroglu et al. (2014) has already proven that deck rotation, abutment unseating, and column drift ratio are generally higher than those for straight bridges [1]. Therefore, the further research is to investigate the method of mitigating the effects of pounding which mostly caused by the rotation of deck.

2. METHODOLOGY

(1) Incremental Dynamic Analysis (IDA)

IDA is the dynamic extension of static pushover analysis which can estimate the structural performance thoroughly and exactly, especially for the structural state, which is the dynamic instability problem. This method involves subjecting a structural model to one or several ground motions, which in this research several ground motion sets from PEER, each scaled to multiple levels of intensity, thus generating several curves of response in terms of scaled intensity levels. After pinpointing at those series of dynamic seismic records towards time analysis, the relationship of intensity level and damage measure, defined formally as failure criteria of structures, can be obtained, thus the characteristics of structure under different seismic intensity level can be observed to determine the limit state of structure.

(2) Finite element model

The used bridge is a three-span prestressed concrete bridge with box-girder decks that are supported by column-bents and seat-type abutments. And the FEM model will be created by using OpenSees. Here my research opted to use three-dimensional spine-line models for the bridge superstructures, with line elements located at the centroids of the cross-sections following the bridge alignment. This kind of FEM bridge model assumption serves a good balance between computational efficiency and accuracy as shown in Figure 1. Important assumptions and main aspects of

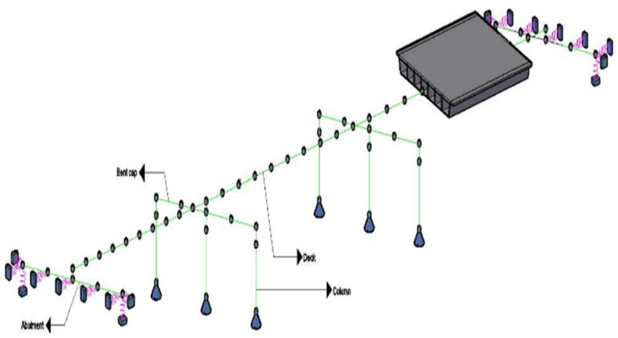

Fig.1 FEM model of skew bridge

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this model will be introduced in the following part of this chapter.

First the deck as mentioned above are modelled as "spine-lines" using elastic beam-column elements which means the yielding of deck is not expected during the seismic.

Then for cap-beam is rigidly connected with the superstructure since usually both components are casted monolithically without any joints. There for the flexural stiffness of superstructure greatly enhances the torsional stiffness of the cap-beam which means it torsional constant **J** is artificially magnified.

The column are categorized into core section (confined concrete) and cover concrete (unconfined concrete) being applied with different constitutive relation. The upper connection with superstructure are rigidly embedded and the soil-pile interaction are simply modelled as fixed relation.

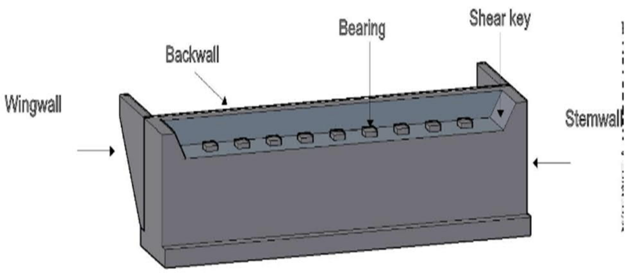

Fig.2 Configuration of seat-type abutment

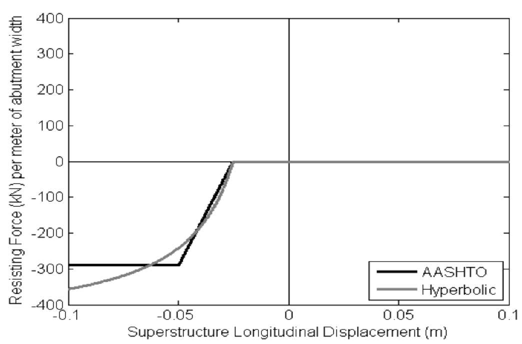

Fig.3 Abutment longitudinal reaction

Figure 3 includes basic components of abutment. The simulation of the pounding element between deck and abutment will be represented by five non-linear spring with gap to simulate the situation of pounding under seismic wave before contact and after contact. The properties are shown below. The abutment stiffness models are based on large-scale abutment tests performed on the outdoor shaking table at UCSD matching very well with test data.

3. COLLAPSE CRITERIA

Here two non-simulated collapse criteria will be defined:

(1) Column-bent maximum drift ratio is greater than 8%.

(2) Deck displacement relative to the abutment in the longitudinal unseating direction is greater than the seat length.

4. CONCLUSION

Several results were obtained based on the time analysis.

(1) Trends in deck rotation

Shear key strength has a large influence on bridge deck rotation. Especially for larger skew angles which has comparably more probability of shear key failure, thus the probability of a large deck rotation meanwhile increases.

(2) Trends in column-bent drift ratio

Here the rotational angle of column is not that sensitive to the skew angle, which probably due to the overly stiffness supplied by multi-column of each bent.

REFERENCE

[1] Peyman Kaviani, Farzin Zareian, and Ertugrul Taciroglu: Performance-Based Seismic Assessment of Skewed Bridges PEER 2014.1.