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The Effect of Direction of Orthogonal Horizontal Components of Earthquake on the Nonlinear Response of Skewed Bridges

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Abstract

The effects due to the combination of bilateral skewed horizontal components of earthquakes on the nonlinear responses of the skewed bridge piers are investigated using a time domain nonlinear finite element program. Seismic responses of bridge piers are evaluated realistically by simultaneously applying the both horizontal components of earthquake strong ground motions. Analyzes have been done with varying angle of horizontal components of the ground motion from 0^0 to 90^0 relative to the bridge deck to find out the effect of direction of components of earthquake on nonlinear response of a bridge piers. A 3D nonlinear model of Foothill Bridge in California was constructed. The plastic hinge formation trends, hysteresis cycles and base shear values of piers have been investigated. Numerical results show that the response of skewed bridge piers are affected by varying the direction of horizontal components of earthquake.

Keywords: skewed bridges, direction of earthquake, nonlinear response.

1. INTRODUCTION

Bridges as one of the elements of transportation systems, depending on the road and site conditions as well as aesthetics considerations, have different geometries. Unlike the normal bridges the special bridges such as c-bent bridges, curved bridges or skewed bridges face with various problems during seismic excitations. Furthermore, due to less specific studies on such structures, only a few special criteria and regulations may have been provided in design codes and guidelines.

Among these, skewed bridges may find hazardous condition during an earthquake due to the collision of the deck and abutments that may consequently cause torsion in the piers. It has been shown that the bridge piers are subjected to the combination of torsion and bending moments, significant seismic capacity reduction may be observed in them. [1- Hsu, H.-L and Wang, 2- Hsu, H.-L and Liang]

Extensive researches have been conducted on the dynamic behavior of skewed bridges. Khaloo and Mirzabozorg (2003) studied about the load distribution factors in simply supported skew bridges. They conducted finite element analysis on five simply supported bridges with i-section concrete girders. The nonlinear dynamic response of columns was not focused in the study.

Tirasit and Kawashima (2005) reported that the seismic torsions in skewed bridge pries are larger than those of straight bridge piers. Moreover, skewed bridge piers have higher ductility demands. They also studied the effect of pounding and failure of the bearings on the piers.

Malaki (2005) performed a parametric study to investigate the pounding effect of the superstructure on the bearing retainers when a gap is present. He concluded that ignoring the gap in the analysis could cause erroneous non-conservative results. Due to yielding of retainers, the use of nonlinear material modeling for the retainer was also recommended. Here again the ductility of the piers and their nonlinear behavior was not included in the study.