Probabilistic Evaluation of Retrofit Effect on Seismic Performance of Vincent Thomas Bridge under Spatially Variable Ground Motions

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ABSTRACT

The Vincent Thomas Bridge (VTB), a long span suspension bridge, connects the city of San Pedro and Terminal Island of Los Angeles Port. As a part of one of the busiest ports in the west coast of USA, the bridge carries an overwhelming number of port traffic. Although for any suspension bridge, wind-induced vibrations are mostly studied due to historical failure events, concerns regarding seismic safety of suspension bridges have gained significant attention after the damage occurred to the under-construction Akashi Kaikyo Bridge during the 1995 Hyogo-ken Nanbu earthquake. It has been found out that the main span of the Vincent Thomas Bridge lies directly over the Palos Verdes Fault, which has the capacity to produce an earthquake with a magnitude (M_w) of 7.25 considering a return period of 1000 years. The bridge was retrofitted in spring 2000. Before retrofit performance study of the bridge highlighted that the collapse of tower-shaft is one of the major concerns.

In this study, a panel based simplified model as well as a member based detailed before and after retrofit three dimensional finite element (FE) models of VTB are developed using a widely used commercial software. In order to show the appropriateness of these models, eigenproperties of the bridge models are evaluated and compared with results including those from system identification from ambient vibration and 2008 Chino Hills earthquake response data. In this paper, the spatial variability effect of ground motions on the seismic performance of VTB in terms of fragility curves is investigated by both random vibration based spectral analysis and response spectrum approach. As performance level for suspension bridge is not defined in the literature, for fragility curves, this study proposes performance levels considering rotational ductility at critical tower locations. The spatial variability of ground motions between the supports is taken into account in terms of coherency function, which comes from loss of coherency, wave-passage and site-response effects. The site-response effect originates from the difference in soil conditions at different supports of the bridge. A statistical approach is adopted in obtaining the coherency function which represents uncertainties in the ground motion variability. The response of VTB under spatially varying ground motion is evaluated by non-linear inelastic time history analysis. It is found out that spatially varying ground motion has important effects on the dynamic behavior of the long span suspension bridge. Therefore, to be more realistic in assessing the seismic performance of long span suspension bridge the spatial variability of the ground motions should be considered in the analysis.