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Entitled

Performance Assessment of Existing RC Bridges Equipped with Seismic Risk Mitigation Systems

by

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Abstract

Many bridges built before adopting current design standards may be at risk as they do not meet the latest seismic performance objectives. Bridges are vital infrastructure components required to be serviceable after earthquakes to avoid negative consequences on daily traffic. Previous seismic hazard studies considered the United Arab Emirates an earthquake-prone region subjected to two scenarios: (i) near-field events, and (ii) far-field earthquakes. Therefore, the vulnerability of pre-seismic code bridges in the UAE should be carefully assessed, and retrofit techniques should be proposed to mitigate possible earthquake losses. This study is thus devoted to assessing the seismic vulnerability of a benchmark structure representing pre-seismic code multi-span bridges before and after the retrofit with different mitigation techniques. A brief survey of the most common reinforced concrete bridges in Al-Ain City, UAE, is conducted to select the benchmark structure. The numerical modeling approaches of the selected bridge and retrofit systems are verified using the results of previous experimental studies. Detailed three-dimensional fiber-based simulation models are then developed to assess the seismic response of the benchmark bridge under the effect of diverse earthquake records representing far-field and near-source seismic scenarios in both longitudinal and transverse directions. The obtained results from several inelastic pushover analyses (IPAs) and incremental dynamic analyses (IDAs) are employed to provide insights into the local and global seismic response of the investigated multi-span bridge and develop a range of fragility functions with and without the retrofit techniques. The inelastic analyses under the effect of two earthquake scenarios confirmed that the seismic response and probability of damage of the investigated bridge are controlled by the bents curvature ductility (CD). Higher damage probabilities are observed in the pre-code bridge under the effect of far-source events and at lower intensities than their near-field counterparts. The longitudinal direction of the as-built bridge is more vulnerable than the transverse direction. Several retrofit techniques are investigated to improve the seismic performance of the bridge in the two orthogonal directions and under the two considered seismic scenarios. The mitigation techniques increased the lateral strength and provided comparable overstrength factors to previous research studies. The inelastic analysis results in the longitudinal direction of the bridge confirmed that utilizing SMA bearings reduces CD and bearing displacement (BD) demands. Although the comprehensive probabilistic assessment study in the transverse direction indicated that SMA bearings reduce BD demands, the bridge should mainly be retrofitted with BRBs to overcome the high CD demands in bents, particularly under the most critical seismic scenario. Thus, the most effective retrofit technique in the transverse direction is achieved using both SMA bearings with BRBs. The study provided insights into the impact of different retrofit techniques on improving the seismic performance of substandard bridges and presented a range of fragility functions for assessing and mitigating the infrastructure seismic risk.

Keywords: Multi-span bridges, seismic retrofit, incremental dynamic analysis, pushover analysis, fragility functions, BRBs, SMA bearings