Seismic Performance of Curved Bridges on Soft Soils Retrofitted with Buckling Restrained Braces

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Damage to bridges has been evident during many earthquakes, even when the structure was designed according to model codes. Abutments act like a retaining wall during a seismic event. Past studies show that there have been several incidents of damage to abutments and shear keys due to pounding. This research attempts to study the performance of an existing multi-span curved bridge supported on rigidly capped vertical pile groups which pass through a deep layer of soft clay. The soil-structure interaction (SSI) between the pile group and soil is idealized as linear springs in two perpendicular horizontal directions. At the expansion joints and abutments, steel shear walls are provided to improve the performance and concrete shear keys are utilized to restrain the lateral movement of the girders and deck during seismic events. A seismic retrofit scheme using Buckling Restrained Braces (BRB) is implemented at the abutments to prevent pounding damage. The earthquake response of the bridge with SSI is obtained under bidirectional earthquake excitations.

Buckling Restrained Braces (BRB) at each girder, parallel to the deck length, are implemented to prevent pounding damage. BRBs are idealized using bilinear plastic link elements with a backbone curve adopted from experimental data. Time history analyses are performed for historical earthquakes. It is observed that the soft soil surrounding the piles has a significant effect on the dynamic response of the bridge; in addition, the bearing displacements are underestimated if SSI is ignored. Non-linear analysis shows that pounding damage to the abutments and the deck can be prevented by using a combination of properly designed BRBs. Incremental Dynamic Analysis with scaled ground motions shows that the relative displacement between the deck and the abutment is reduced up to 50% after implementing a retrofit with BRBs. Concrete shear keys are also protected against damage due to the reduced lateral displacement of the deck.

Keywords: Earthquakes; Bridge; Soil-structure interaction; BRB; Pounding