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Soil-Structure Interaction in a Case Study Bridge: Seismic Response under Moderate and Strong Near-Fault Earthquakes

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Abstract : Seismic isolation proves to be a powerful technology in reducing seismic hazards and enhancing overall structural resilience. However, the performance of the technology can be influenced by various factors, including seismic inputs and soil conditions. This research aims to investigate the effects of moderate and strong earthquakes associated with different distances of the source on the seismic responses of conventional and isolated bridges, considering the soil-structure interaction effects. Two groups of moderate and strong near-fault records are applied to the conventional and isolated bridges, with and without considering the underlying soil. For this purpose, using the direct method, three soil properties representing rock, dense, and stiff soils are modeled in Abaqus software. Nonlinear time history analysis is carried out, and structural responses in terms of maximum deck acceleration, deck displacement, and isolation system displacement are studied. The comparison of dynamic responses between both earthquake groups demonstrates a consistent pattern, indicating that the bridge performance and the effects of soil-structure interaction are primarily influenced by the ground motions and their frequency contents. Low ratios of PGA/PGV are found to significantly impact all dynamic responses, resulting in higher force and displacement responses, regardless of the distance associated with the ruptured fault. In addition, displacement responses increase drastically on softer soils. Thus, meticulous consideration is crucial in designing isolation systems to avoid underestimating displacement demands and to ensure sufficient displacement capacity. Despite a lower PGA value in high seismicity areas in this study, the acceleration demand during strong earthquakes is up to 1.3 times higher in conventional bridges and up to 3 times higher in isolated bridges than in moderate earthquakes. Additionally, the displacement demand in strong earthquakes is up to 2 times higher in conventional bridges and up to 5 times higher in isolated bridges compared to moderate earthquakes, highlighting the increased force and displacement demand in strong earthquakes.

Keywords : bridges, seismic isolation, near-fault, earthquake characteristics, soil-structure interaction
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