

System Fragility Analysis Of A Geometrically Complex Bridge For Seismic Risk Evaluation Of Existing Highway Bridge Network

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Bridge infrastructure plays a key role in the serviceability evaluation of the transportation network. Seismic risk assessment of these infrastructure is a crucial step in seismic disaster planning and response of transportation network. It provides valuable understanding of the direct and indirect effects of seismic events on traffic disruption of the network, regional economic stress, and resilience quantification. The past seismic events have demonstrated the higher degree of vulnerability of these structures. The fragility functions are usually employed for the vulnerability assessment of critical structures, which represents the conditional probability of reaching or exceedance of seismic demand for a specific damage level. It helps the decision makers with the basic understanding of planning the emergency response, de-routing, retrofit and safety prioritization. Usually, for the simplest type of system, the system fragility is described based on the single-most vulnerable component. When the most fragile component reaches its capacity level, there is a probability that rest of the components will be at some fraction of the damage state for the same input seismic demand. This provides enough support to the consideration of multiple components and their correlation for the derivation of the system fragility. Moreover, response in complex bridge systems is affected by the change in input loading direction in conjunction with the change in the direction of the bridge system. To develop a representative system's fragility functions, all these complexities and the individual component response should be considered. This study focuses on seismic vulnerability assessment of a testbed composite type, curved highway bridge structure by developing seismic fragility functions. For this purpose, a high-fidelity 3D non-linear analytical modeling was carried out based on the recommended design guidelines. A suite of compatible ground motions, including low probability and high intensity waveforms, were extracted from the strong ground motion database, and used as input excitation. The selected waveforms were applied in different directions in the horizontal plane to look for the response of the most critical components in each direction. Dynamic response of structural components is evaluated, both in the longitudinal and transverse direction with laminated rubber bearings as isolation devices. The displacement response histories of the pier and bearings are compared for evaluation purposes. The bearing hysteresis response history shows the effectiveness of the bearings by reducing the displacement demand on the pier while remaining within the safe limit of the ultimate capacity. For different damage state levels, the fragility functions were derived for the major contributing components (columns and bearings) by convolving the component's capacity and demand models. The bridge system fragility was derived by using the joint probabilistic distribution demand functions, which consider the combination of all the critical components response and the inherent demand correlation. Since the target structure is designed seismically isolated, therefore the system's fragility shows to be mostly influenced by the response of the bearing. It was observed that change in loading direction directly affect the fragility profile due to the change in effective stiffness of the system.