Uncertainty Treatment in Performance Based Seismic Assessment of Typical Bridge Classes in United States

Bridge networks are expensive and complex infrastructures and are essential components of today's transportation systems. Advancement of computer-aided modeling and computational power have made development of bridge fragility curves more accessible. However, the complexity of the problem and uncertainties involved in fragility analysis of structures in addition to difficulties in validating the results require precaution in utilization of the results as a decision making tool.

The main focus of this research is to study the treatment and quantification of uncertainties incorporated in various steps of bridge seismic performance based assessment (PBA). The uncertainties are divided into three main categories. First, the uncertainties that arise from ground motion time and frequency content alteration because of scarcity of the recorded ground motions available. Second, uncertainties associated in the modeling and simulation procedure of PBA. Third, uncertainties that originate from assumptions made in simplified probabilistic frameworks conventionally used for seismic PBA of bridges.

Legitimacy of the scaling of ground motions is studied using the response of several simple nonlinear systems to amplitude-scaled ground motions suites. Biases in the response are obtained compared to unscaled records for both as-recorded and synthetic ground motions. Results demonstrate the amount of the bias is considerable and can significantly affect the outcome of PBA. The origin of the bias is investigated and consequently a new metric is proposed to predict the bias induced by ground motion scaling without nonlinear analysis. Results demonstrate that utilizing the predictor as a scaling parameter can significantly reduce the bias for various nonlinear structures.

To address the uncertainties associated in the modeling and simulation, multi-span simply supported concrete girder bridge class were selected due to the frequency of the construction in central and southern United States region and lack of seismic detailing. A large-scale parameter screening study is performed using Plackett-Burman experimental design that considers a more complete group of parameters. Ordering of the parameters was performed and their influence on resulting fragility curves was investigated. Parameters with lesser importance were removed to decrease the computational expense of probabilistic study of the structure's seismic response. The results from this section provide more direct information on parameter reduction for PBA as well as provide insight into where future investments into higher fidelity finite element and constitutive models should be targeted.

Conventional simplistic PBA approaches do not account for the fundamental correlation between demand and capacity models. A more comprehensive PBA approach is presented and fragility analysis is performed with implementation of a new formulation in the component fragility analysis for MSSS bridge class. The outcome is compared with the one from the conventional procedure. The results show the correlation between demand and capacity affects the outcome of PBA and the fragility functions variation is not negligible. Therefore using the presented approach is necessary when accuracy is needed.

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The public is welcome to attend.