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Title

Probabilistic Performance-based Seismic Risk Assessment of Bridge Inventories with Loss and Impact Estimates

Abstract

Among the evolving challenges in earthquake engineering practices, accurate seismic risk assessment of bridges in developed countries, like Canada, has significant impact on public safety and maintaining socioeconomic development of the society. There are various approaches developed for seismic vulnerability and risk assessment of bridges in recent years. However, these existing seismic risk assessment methodologies cannot be easily applied to all the bridges in large transportation networks because that would require exceedingly vast amount of resources and time. This thesis presents a new approach for seismic risk assessment of large bridge inventories in a city or region or national bridge network based on the framework of probabilistic performance based seismic risk assessment. Sample concrete bridges from the City of Ottawa transportation network are used in a pilot study to demonstrate the validity of the approach. From the concrete bridge samples, five bridges are selected as representatives of the inventory group in the Ottawa region for detailed investigation and calibration of the damage fragility relationships. Three dimensional nonlinear time history analysis of the representative bridges have been carried out. To account for the influences of local site effects, microzonation information are used to generate site-specific seismic hazard curves for the representative bridges. Simulated ground motions compatible with the site specific seismic hazard and scaled recorded ground motions near Ottawa are used as input excitations in nonlinear time history analysis of the representative bridges. From responses predicted by the nonlinear time history analysis, seismic demand models are developed. Damage fragility relationships are derived for the damage states of concrete cover spalling, longitudinal bar buckling and unseating or loss of span failure modes. The probability of bridge damage corresponding to the calculated bridge responses is estimated. Using data from HAZUS models, loss models and decision fragility curves are developed for downtime and repair cost. A normalizing procedure to obtain generalized fragility relationships in terms of structural characteristic parameters related to bridge span and size and longitudinal and transverse reinforcement ratios is presented. The overriding advantage of the proposed probabilistic seismic risk assessment methodology is that quantitative information on the probability of failure of all the bridges in the entire inventory can be easily evaluated by using the developed normalized fragility relationships without the need of carrying out detailed nonlinear time history analysis of each bridge. From the quantitative assessment results, priority lists of the bridge inventory for seismic decision making on safety and risk mitigation can be established.

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