Research Project Highlight

Inclusion of Modeling Uncertainty, Parameter Uncertainty and Parameter Estimation Uncertainty in PBSD of Ordinary Standard RC Bridges

TSRP Topic M3 - Inverse PBEE analysis
Project # 1147-NCTRTE

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Abstract

The current research is intended to complement and extend the PI's recent work on the development of a simplified, yet rigorous, framework for risk-targeted performance-based seismic design (PBSD) of Ordinary Standard Bridges (OSBs) in California. The design framework developed based on the PEER probabilistic performance-based earthquake engineering (PBEE) assessment methodology considers explicitly the following basic sources of uncertainty in its formulation: (1) the seismic hazard associated with the seismic intensity measure and ground motion record-to-record variability; and (2) the uncertainty in the structural capacity against various damage/limit-states. At the heart of the PBEE methodology is the explicit quantification of pertinent sources of uncertainties and their propagation through the various steps of the analysis methodology. The project aims at significantly enhancing the previous work by the inclusion, quantification and propagation of the following additional sources of uncertainty in the PBSD framework developed: (i) the aleatory uncertainty associated with finite element (FE) model parameters (e.g., constitutive material model parameters, damping model parameters); (ii) the epistemic parameter estimation uncertainty associated with using finite datasets to estimate the parameters of the aleatory probability distributions characterizing the FE model parameters and especially the fragility functions for the various limit-states considered; and (iii) the epistemic modeling uncertainty characterizing the overall numerical modeling of the bridges considered and resulting from the inability of idealized (due to numerous simplifying assumptions) numerical models of bridge systems to predict exactly their actual seismic response. The analytical and computational frameworks previously assembled will be extended via a modular incorporation of these additional sources of uncertainty. Bridge testbeds and their risk-targeted redesigned versions will be analyzed with and without these additional sources of uncertainty to

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evaluate their significance. Their contributions to the seismic performance of OSBs will be accounted for in the PBSD framework and the resulting simplified PBSD procedure developed.

Deliverables

Extended version of the analytical and computational PBSD framework and the resulting calibrated and validated simplified PBSD procedure for OSBs to account for the three additional sources of uncertainty along with the developed software (workflow, modules, algorithms); PEER technical report and papers in conference proceedings and refereed journals.

Research Impact

The targeted additional sources of uncertainty considered are commonly omitted or neglected in PBEE by invoking that the earthquake ground motion uncertainty is the predominant source of uncertainty. However, recent studies have shown that these sources of uncertainty can or are likely to be significant and must be included for a comprehensive seismic performance assessment of structures. Modeling uncertainty is expected to have highly significant effects on PBSD in light of the results of recent blind studies. To our knowledge, a comprehensive PBSD analytical and computational framework accounting explicitly for all pertinent sources of uncertainty is not currently available for bridge structures. Only components and portions of such an integrated framework that includes the targeted three sources of uncertainty in addition to the uncertainties in the seismic input and limit-state capacities (i.e., fragility functions) are available for building structures. Although some analytical treatment of the aleatory uncertainty of FE model parameters already exists as part of the PEER PBEE methodology, the proposed research will focus on the investigation and quantification of the effects of this source and other two sources of uncertainty on the PBSD of OSBs. The proposed research will contribute to the extension and further development of the PEER PBEE framework and resulting PBSD methodology for OSBs by providing a more comprehensive account and treatment of the pertinent sources of uncertainty contributing to the quantification of structural seismic performance.

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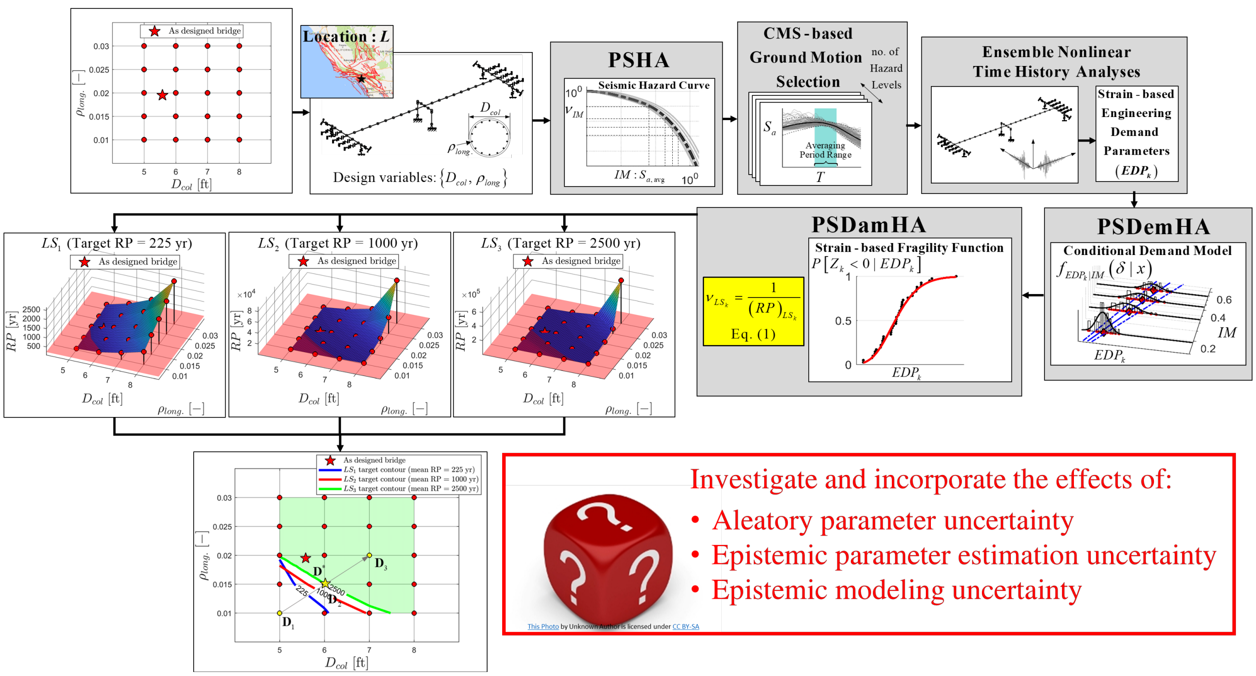
Project Image



Overall workflow for risk-targeted PBSD of OSBs

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