BENCHMARKING SEISMIC PERFORMANCE OF NEW REINFORCED CONCRETE FRAME BUILDINGS

Curt B. Haselton and Gregory G. Deierlein

Current building code provisions and seismic design methodologies have the expressed goal of providing life safety for the building occupants. However, existing seismic design methods do not provide the means to quantify the risks to life safety or economic losses. As a result, the implied risks of buildings designed according to current buildings codes are not known, except insofar as the provisions have evolved over time to provide reasonably good performance. The performance based earthquake engineering (PBEE) methodology, currently under development by the Pacific Earthquake Engineering Research (PEER) Center, provides the means to rigorously assess risks to life safety and economic losses for buildings and bridges. Combining and improving upon aspects of prior developments in regional earthquake loss modeling (e.g., ATC-13, HAZUS, etc.) and methodologies to evaluate existing structures (e.g., FEMA 273 and FEMA 356), the PEER PBEE approach seeks to quantify performance in terms of mean annual probabilities of casualties, direct dollar losses, and loss of functionality. Casualty risks are primarily associated with the risk of structural collapse under high intensity and infrequent ground motions, whereas the probabilities of dollar losses and downtime are more associated with repair of structural and non-structural damage under smaller and more frequent earthquakes. The performance metrics are all quantified probabilistically, taking into account the uncertainties in (a) definition of the seismic hazard (ground shaking), (b) simulating nonlinear structural response to the ground motions, (c) evaluating the resulting damage to structural and non-structural components, and (d) evaluating the losses associated with the damage.

This research project, which is supported by the PEER Center, has the goal to apply the PEER PBEE assessment method to benchmark the performance of reinforced concrete moment frame buildings designed according to current (2004) building code provisions. Thus, the research will help establish a more direct linkage to the risk levels (primarily, probabilities of collapse, dollar losses, and repair times) implied by current code provisions. In addition to evaluating risk and performance data in an absolute sense, results of the study are intended to gauge the relative performance between different building designs that meet the intent of current building codes, e.g., variations in performance depending on variations in strength, the strong-column weak-beam ratio provided in design, or variations in the height of the structure. In this sense, the benchmarking exercise will extend the PEER PBEE methodology to consider uncertainties in “design parameters”, which add a new dimension to the problem. Data from the benchmark exercise will provide a framework to evaluate minimum performance requirements and potential benefits of newly proposed innovative seismic force resisting systems, which are not covered by current building codes. The benchmark exercise will also be a mechanism to begin packaging the PEER performance assessment methods into a coherent methodology for seismic performance assessment. The results of this study, and future research in performance-based design, are envisioned to contribute to the development of performance-based design standards (e.g. ATC 58).