

PERFORMANCE-BASED AFTERSHOCK ENGINEERING

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My research focuses on the integration of the performance of (possibly) damaged buildings in the aftershock scenario into current building design procedures. Current building design procedures take into consideration only mainshocks. After a mainshock, the reduced capacity of damaged buildings to resist future aftershock ground motions is generally not considered in existing procedures. Also, immediately following a mainshock, the likelihood of aftershocks is significantly increased. The rate of aftershocks is time-decaying in nature such that it is at its maximum immediately after the mainshock and decreases with increasing elapsed time from the mainshock. Such nonhomogeneity of the aftershock occurrence rates is also not considered in current building design procedures.

As a first step towards quantifying the effects of aftershocks, we have developed a methodology to quantify the time-varying aftershock hazard at a site after a mainshock in terms of possible future aftershock ground motions. We refer to this procedure as Aftershock Probabilistic Seismic Hazard Analysis, or APSHA for short. APSHA allows us to quantify the life-safety threat to a building occupant if we can also quantify the degree of mainshock-induced damage sustained by the building. Such information allows us to make informed evacuation and re-occupancy decisions in damaged buildings by considering the probability of building collapse in the post-mainshock situation which is assumed to be proportional to fatality risk.

We have also developed a methodology to quantify the expected losses in a damaged building due to future aftershocks given a mainshock of known magnitude. This is the first step towards the development of a theoretical framework similar to the current Pacific Earthquake Engineering Research Center (PEER) framework which aims to provide the annual rates of exceeding a given level of losses for a particular decision variable. We model the changes in damage states of a (possibly) mainshock-damaged building due to aftershock occurrences as a nonhomogeneous continuous-time markov process. In our model, we take into consideration the effects of downtime for a damaged building and its resulting contribution to financial losses.

We also aim to incorporate aftershock analysis into the formulation of a theoretical framework for the pre-mainshock design problem so that the mainshock analysis can take into consideration future random aftershock sequences as well. We also hope to formulate a decision-theoretic framework which provides a normative approach to seismic risk-management decision making based on such a probabilistic, PEER-like format. A particular challenge in the formulation of such a framework is that a decision process (or a series of decision processes) is usually embedded in the formulation in the post-mainshock scenario. Such decisions include when to start repair and when to permit re-occupancy of a mainshock-damaged building. We seek to evaluate the optimal decision sequences in the post-mainshock environment by using stochastic dynamic programming based on the markov description of the damage states of the building in the aftershock scenario. The optimal decisions in the post-mainshock situation can then be considered in the formulation of the pre-mainshock design problem as well.