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Extending Probabilistic Seismic Hazard Analysis to Portfolio and Regional Loss Estimation: A San Francisco Bay Area Example

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For single-family woodframe dwellings in the nine-county San Francisco Bay Area, we demonstrate a new method for computing a portfolio or regional loss exceedance probability curve (or "loss curve" for short) as an extension of conventional Probabilistic Seismic Hazard Analysis (PSHA). The method makes use of probabilistic loss-given-ground-shaking relations ("damage functions" or "fragilities") that are available from various sources, including the CUREE-Caltech Woodframe Project, HAZUS, and our own relations. Of note, our method can accommodate loss-given-ground-shaking relations that require multiple measures of ground shaking intensity (i.e., vector hazard), such as the HAZUS relations that use 0.3- and 1.0-second spectral acceleration.

Whereas PSHA calculates the ground shaking hazard at a site independently of that at any other site, the method we demonstrate takes into account the correlation in ground shaking across sites that can be affected by a common earthquake event. This is done by separating the inter-event and intra-event variabilities in ground shaking for a given earthquake magnitude, source-to-site distance, etc. Not including the correlation in ground shaking underestimates the probabilities of observing extreme (large or small) aggregate losses.

Just as the ground shaking hazard curves computed via PSHA are uncertain due to various modeling assumptions, so are the corresponding loss curves. Using Monte Carlo simulation, we quantify the epistemic uncertainty in the loss curves that is induced by uncertainties in the seismicity and ground shaking models – i.e., the characteristic earthquake magnitude, the fault slip rate, and the appropriate ground shaking attenuation relation. In addition, we include the epistemic uncertainty brought about by different loss-given-ground-shaking relations.

While the method we demonstrate can be computationally demanding, particularly if the uncertainty in a loss curve is to be quantified, we show that it is amenable to parallel computation.