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Engineering Validation of Simulated Ground Motions for Building Damage Assessment

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Synthetic ground motion signals (hereinafter, "ground motions" or "GMs"), simulated at fine grid spacing, represent an attractive option for loss estimation purposes. Among stakeholders the general concern is that simulated GMs may not be equivalent to real (e.g., recorded during past earthquakes) records in estimating seismic structural demand, and hence, in estimating the induced damages to structures and losses. To overcome this, several recent studies and research efforts are developing and implementing testing/rating methodologies for simulated GMs via collaboration between GM modellers and engineering users.

This study addresses, on a statistical basis, whether simulated GMs for four historical earthquakes lead to biased estimates of the seismic structural demands and expected damage levels for relevant building types in comparison with real records. In particular, the study considers the Graves and Pitarka's (2010) hybrid broadband ground motion simulation methodology for the following historical events: 1979 M 6.5 Imperial Valley, 1989 M 6.8 Loma Prieta, 1992 M 7.2 Landers, and 1994 M 6.7 Northridge. The considered building types are selected based on the predominant structural systems encountered in the regions of the historical events (i.e. California). The seismic structural demand is assessed using the recently developed FRACAS (Fragility from Capacity Spectrum Assessment) methodology, recommended in the guidelines for Analytical Vulnerability developed within the Global Earthquake Model (GEM) Project. The capacity curves for the studied building types and the damage states definitions are derived from the HAZUS package developed by the Federal Emergency Management Agency (FEMA). For each earthquake and building type, a color-coded map representation of the analysis results is developed to also allow verification of whether or not there is a systematic directionality in the over- or underprediction trends of the simulations relative to recorded data.

The results from this study highlight the similarities and differences between synthetic and real records. These similarities should provide confidence in using the simulation methodology for engineering application, while the discrepancies, if statistically significant, should help in improving the generation of synthetic records.