Ground Motion Record Selection as a Multi-objective Optimization Problem

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ABSTRACT

Nonlinear response history analysis (NRHA) is the most realistic seismic performance assessment method. NRHA requires the selection of acceleration time-histories, which appears to be a major issue for the successful application of the method. The acceleration time-histories should be consistent with the seismicity of the building's site and representative of the expected (or the design) earthquake, i.e. representing all possible future events at the site. Typically, the problem of record selection is tackled either through scaling natural (or recorded) ground motion, or generating them artificially. Existing heuristic methods select and/or scale ground motion records so that their mean spectrum is close to a target/design design spectrum. The records obtained following this practice offer good estimates of the mean response but considerably underestimate the inherent response variability and thus provide no insight regarding the dispersion around the mean.

We propose a novel and computationally efficient method for selecting and scaling ground motions records aiming to minimize the error between a target spectrum and the average spectrum of a subset of records through an optimization process. The proposed method selects and scales the ground motion records so that their mean spectrum and the (period-depended) dispersion fit best a target spectrum and the associated dispersion. The problem is formulated as a two-criteria optimization problem, where the record selection considers both the mean spectrum and its dispersion at the range of periods of interest. The proposed procedure is efficient, easy to implement and able to quickly search a pool of ground motion records identifying record subsets that provide estimates of the response quantities of interest. With a minimum number of ground motions we are able to ensure sufficient dispersion estimates for the response quantities. A three-storey moment frame building is considered as a benchmark problem in order to demonstrate the efficiency of the proposed scheme.