

Site specific probabilistic long-period ground motions evaluated by FDM reciprocity method

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We studied long-period (LP, $T > 3s$) ground motions in the Osaka sedimentary basin, Japan, using probabilistic approach. In order to account for various uncertainties, probabilistic approach requires simulations of many cases, and GMPEs are commonly used for estimation of the probabilistic seismic hazard. However, some phenomena, e.g. directivity or details of basin wave generation, may be poorly described by GMPEs. Deterministic simulation is necessary to reduce estimation uncertainties. From another side, basins frequently host megacities, which require detailed analysis of the seismic hazard. Due to large cost such analysis is limited to a single preselected Maximum Credible Earthquake. Here we consider one very common case in earthquake engineering practice, when there is only one target site hosting important structure: skyscraper or long-span suspension bridge. In this case we can use reciprocity approach and greatly reduce computation cost. Reciprocity approach allows us to combine deterministic waveform simulation and probabilistic seismic hazard estimation in a systematic way, i.e. by considering all possible earthquakes.

In order to account for uncertainties within one earthquake model we used heterogeneous source modeling. This modelling approach is a result of compilation of many source observations (inversions) of strong earthquakes and allow easily generate possible variations of the slip and the rupture velocity distributions (aleatory uncertainties). As a result, by simulating a set of heterogeneous source models we can calculate hazard curve and then estimate level of strong ground motions (e.g. response spectrum amplitude at natural periods of the target structure) at target probability of exceedance. Many models have to be calculated in this case. For deterministic simulation of LP motions, we can use detailed 3-D crust and basin velocity structure models and the 3D-FDM method.

In (Petukhin et al., 2017, 16WCEE) we already tested this approach in case of one target earthquake: M9 megathrust earthquake in Nankai trough. Target site is Konohana in Osaka Bay area, which is hosting many important structures and the deepest land part of Osaka basin at the same time (depth of sediments is 1500m). In this work we continue the study and applied it to smaller but nearby crustal earthquakes, surrounding target site. From J-SHIS database we selected 10 scenario earthquake models within radius 70km (Figure 1). Reciprocity method was used to calculate GFs at target site from all source's planes at the same FDM run. Then, waveforms (and then response spectra) of many heterogeneous source models were calculated simply by summation of GFs. Considering annual probabilities of earthquake occurrence (NIED, 2009) we calculated hazard curve at Konohana site for all scenario earthquakes (Figure 2). For validation, we also calculated hazard curve using GMPE for response spectra of Japanese eqs. (Uchiyama and Midorikawa, 2004, AIJ) and compared both hazard curves for Konohana site.

キーワード : Long-period ground motion、probabilistic seismic hazard、reciprocity method、Osaka basin
 Keywords: Long-period ground motion, probabilistic seismic hazard, reciprocity method, Osaka basin

