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Evaluation of peak values and spatial variability of earthquake ground motion for design engineering applications

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Several important applications of earthquake engineering require the determination of peak values of ground motion, such as peak ground velocity (*PGV*) and displacement (*PGD*), and the evaluation of the spatial variability of ground motion, commonly referred to as spatial coherence. *PGV* is used in a variety of engineering applications, ranging from the assessment of seismic actions on buried pipelines, because of its direct relationship with transient ground strains, and its use as an indirect estimator of macroseismic intensity and structural damage, to methods for the assessment of liquefaction potential. *PGD* is a critical parameter to assess the seismic response of bridges, which is generally assumed to depend on the relative displacements between piers (D_{ij}), the latter being proportional to *PGD*, as well as for the dimensioning of seismic isolation devices. Issues related to the spatial variability of ground motion are of primary relevance to accurately estimate the seismic behavior of spatially extended structures, such as bridges, viaducts and pipelines. In these cases, ground motions arriving at different points of the structure may vary significantly both in amplitude and phase and, therefore, the hypothesis of synchronous seismic input at each point of the construction cannot be accepted.

In seismic norms, such as Eurocode 8 (EC8) and the 2008 Italian Building Code (NTC08), peak values of ground motion are usually computed based on empirical correlations with design spectral values of accelerations and, referring to the design of bridges, relative displacement between adjacent points is determined from empirical relationships as a function of *PGD*.

In this contribution we present the studies performed in the framework of the 2014 Reluis Special Project S2 ("Numerical simulations of earthquakes and near-source effects") with the objective of evaluating the peak values and spatial variability of earthquake ground motion, in relation with the empirical relationships proposed by the seismic norms, with emphasis on near-source effects. Namely, the following topics are addressed:

1. review of the empirical correlations for *PGV*, *PGD* and D_{ij} provided by EC8/NTC08 and proposal of new relationships to better explain recorded data especially in near-field conditions;
2. analysis of the spatial coherence function as a function of both separation distance and frequency for different seismic sources, source-to-site configurations and geologic conditions.

To achieve the above objectives, both recorded data, included in the SIMBAD strong motion database (Smerzini et al., 2014), and results of physics-based numerical simulations carried out by a high-performance spectral element code (SPEED: http://speed.mox.polimi.it/) have been used. The latter is, in fact, a powerful method to simulate spatially variable ground motion when recorded data are scarce, especially in the near-field of large earthquakes, and has the great advantage of allowing one to investigate the dependence of ground motion on physical factors, such as magnitude, near-source effects, local site conditions, for a variety of realistic, albeit "virtual", conditions.

References

Smerzini C., Galasso C., Iervolino I. and Paolucci R. (2014). Ground Motion Record Selection Based on Broadband Spectral Compatibility, Earthquake Spectra, 30 (4): 1427-1448.