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APPLICATION OF STOCHASTIC SHAKEMAPS BASED ON RANDOM FIELD OF GROUNDSHAKING

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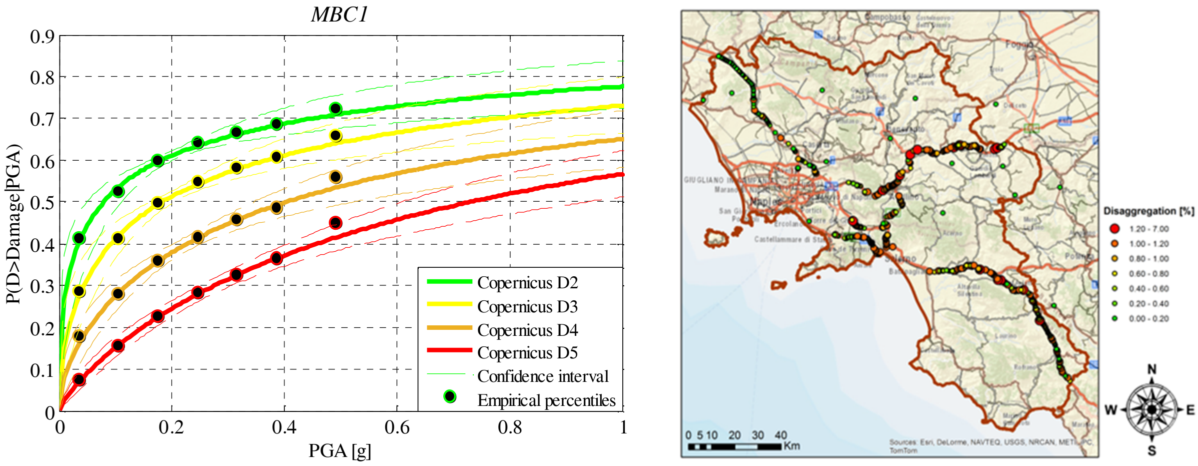
Recent earthquakes have exposed the vulnerability of existing buildings, demonstrated by damage incurred after moderate-to-high magnitude earthquakes. This stresses the need to exploit available data from different sources to develop reliable seismic risk components. With respect to loss assessment analysis, empirical fragility assessment, connectivity analysis etc., accurate estimation of ground-shaking at the location of the infrastructures of interest is as crucial as the accurate evaluation of observed damage for these infrastructures. This implies that explicit consideration of the uncertainties in the prediction of ground shaking leads to more robust results. Instead, neglecting the spatial correlation in the ground motion prediction residuals may lead to results that underestimate the actual dispersion expressed by the data. Several ground-shaking fields can be generated according to the joint probability distribution of ground-shaking at the location of the infrastructures of interest considering the spatial correlation structure in the ground motion prediction residuals and updated based on the registered ground shaking data. As an alternative to the embedded coefficients in the ground motion prediction equations accounting for subsoil categories, site-specific stratigraphic and topographic coefficients can be applied directly to the ground motion fields at the engineering bed rock level.

The basic underlying idea (like the method described in Miano et al. (2016) for portfolio loss assessment) consists of the following considerations:

- The ground shaking levels recorded at adjacent buildings are going to reveal significant spatial correlation. This calls for adopting a full probabilistic model based on the ground motion prediction equation (GMPE), where the inter-event and intra-event correlations between the GMPE residuals are characterized (e.g., Park et al., 2007; Goda & Atkinson, 2010; Goda, 2011). The GMPE's considering a spatial correlation structure are usually expressed in terms of multivariate Lognormal joint probability distributions;
- The ground shaking propagated to the bed rock level using the GMPE can be modified (or propagated to the surface) based on site-specific stratigraphic and topographic considerations. Alternatively, the ground-shaking can be estimated directly at the surface by employing the coefficients embedded in the GMPE to take into account the site conditions;
- A "complete" GMPE representation through the joint Lognormal probability distribution can be updated both based on the recorded registrations of the earthquake event of interest at the surrounding stations (e.g., Park et al., 2007; Crowley et al., 2008; Miano et al., 2016) and the observed damage pattern;
- An alternative shake map can be generated as stochastic realizations of the ground shaking field according to the updated GMPE description at the ground surface.

This paper shows this procedure and its application to different fields: a) Empirical fragility curves generation, obtained using as case study the observed damage in the aftermath of Amatrice Earthquake for residential masonry buildings. Figure 1-a shows an example of empirical fragility curves and their plus/minus one standard deviation confidence intervals for masonry buildings without tie rods or tie beams with number of stories ≤2 (Masonry Buildings Class 1, MBC1) and damage levels D2-D5 (European Macroseismic Scale EMS, 1998 (Grünthal, 1998) damage grades); b) Estimates of total direct economic losses for a portfolio of bridges from Campania region for the given earthquake scenario of Irpinia 1980. Figure 1-b shows the total direct loss deaggregation for this portfolio of bridges in order to quantify the contribution of each bridge to the total direct losses incurred; c) Connectivity analysis related to a road network in Campania region (Italy) considering the same seismic scenario of Irpinia 1980.



(a) (b)

Figure 1. a) Empirical fragility curves and their plus/minus one standard deviation confidence intervals for Masonry buildings without tie rods or tie beams with number of stories ≤2 (Masonry Buildings Class 1, MBC1) and damage levels D2-D5 (EMS 98 damage grades); b) Total direct loss deaggregation for the portfolio of the RC bridges in Campania region (Italy).

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