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AREAL EXCEEDANCE OF GROUND MOTION AS A CHARACTERISTIC OF MULTIPLE SITE SEISMIC HAZARD: SENSITIVITY ANALYSIS

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Probabilistic seismic hazard assessment (PSHA) is widely used in earthquake engineering practice and seismic risk management. However, the results of classical point-wise PSHA contain no information about simultaneous ground motions during one earthquake at different sites located within a defined area. Such multiple-site estimations are very useful for assessment of damage and corresponding losses in densely populated areas and for analysis of lifeline performance. Recently the standard metric for hazard – exceedance rate of a given ground motion level at a particular site – is appropriate and widely used for specifications in building codes. However, this metric provides no information about simultaneous ground motions at different sites located within a defined area. The Design Ground Motion (DGM) value may be exceeded within certain fraction of the reference area during particular earthquake. To describe how large may be the exceedance fraction and how frequently the DGM value (or any other ground motion level) may be exceeded within the reference area, Wenzel and Sokolov (2018) introduced a parameter called Fraction of Areal Exceedance (FAE). The parameter specifies the probability that a particular ground motion level will be exceeded at least once in at least the fraction (e.g. percentage from 0% to 100%) of the reference area during considered time period (e.g. 50 years). The estimations of FAE may be used both for the risk management decisions and for selection of appropriate design ground motion. This paper describes the sensitivity analysis of FAE for the case of a 15 × 10 km area in Western Saudi Arabia.

Figure 1 shows examples of the FAE hazard curves constructed assuming different models of within-earthquake spatial correlation. The estimations of FAE depend on the level of specified ground motion to be exceeded, or on the reference probability of at least one exceedance of ground motion amplitude during the specified time period. Figure 4 shows examples of the FAE hazard curves constructed for two DGM levels, namely: reference probabilities 10% and 2% in 50 years that correspond to return period 475 years (DGM_{475}) and 2475 years (DGM_{2475}), respectively. The FAE hazard curves show that, depending on the ground-motion correlation model, there is 10% probability for the DGM_{475} level and 2% probability for the DGM_{2475} level that the DGM level will be exceeded at least once in 50 years in 20% to 40% of the area. Thus, it is no surprise to find quite significant exceedance of design ground motion in earthquake observations.

Hazard metrics, whether they describe location-specific hazard or area-related hazard, as the approach presented here cannot quantify risk. The latter always includes exposure and vulnerability of the exposure. However, our new metric (FAE) can be understood as a hint as to whether a fixed return period ground motion level is associated with similar risk, if risk is understood as losses within an area in one event. Imagine a low and high seismicity area, both built up with code-compliant buildings designed for a fixed return period ground motion (for instance 475-year). The FAE-curve, however, may show higher values for the high-seismicity area as compared to the low seismicity area at the same return period. Thus, at this return period earthquakes in the high seismicity area may result in a larger area where the design ground motion is exceeded and thus will presumably cause higher losses. As a consequence, the design ground motion – or the associated return period – may be adjusted. Indeed, this could lead to more risk-related building codes, but it remains an issue to be discussed in future studies. Such application requires comparative analysis between the areal characteristics of seismic hazard and loss and establishing of relationship between FAE and loss characteristics.

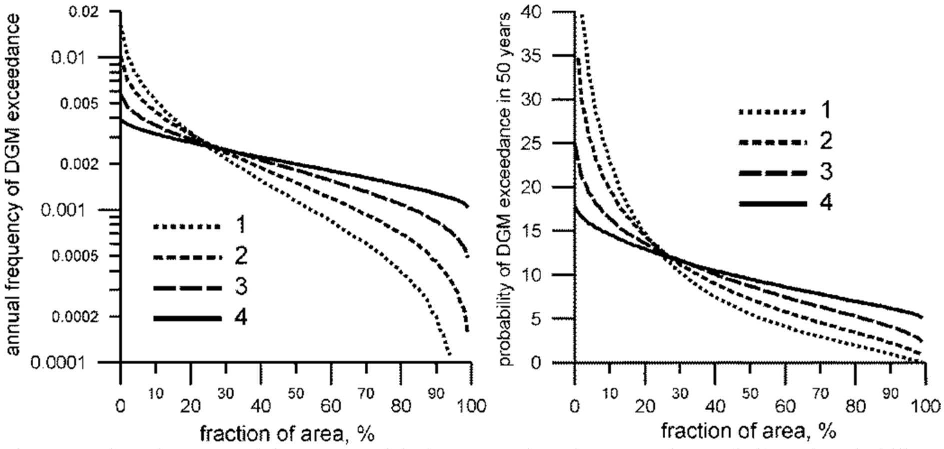

Figure 1. The FAE hazard curves plotted as annual frequency of design ground motion exceedance (left) and probability of at least one exceedance during 50 years (right). PGA, 475-yr return period design ground motion averaged for the area ($DGM_{475,A}$) 95 cm/s^2. Results obtained using different models of within-earthquake site-to-site correlation are shown by different line styles: 1 – spatially uncorrelated ground motions; 2 and 3 – correlated distances 5 km and 40 km, respectively; 4 – perfect site-to-site correlation.

REFERENCES

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