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Geostatistical approach for multi-scale seismic liquefaction risk assessment

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The Seismic Microzonation studies (SMs), promoted all over the Italian territory by the Department of Civil Protection, provide fundamental knowledge of the subsoil response in seismic conditions at the urban scale. Amplification phenomena related to lithostratigraphic and morphological characteristics, instabilities and permanent deformations activated by the earthquake, are highlighted in hazard maps produced at increasing reliability levels (level 1 to 3 of SM). In particular, zones prone to liquefaction instability are firstly identified following the predisposing factors, such as geological and geotechnical characteristics and seismicity. The robustness of the definition of these areas is strongly correlated to the availability and the spatial distribution of surveys. Moreover, the typology and quality of the investigations considerably influence the method of analysis and the degree of uncertainty of the results.

This work aims to establish an updated procedure of the actual SM guidelines and integrates recent research activities at different levels of SMs, to improve the hazard maps accuracy in terms of liquefaction susceptibility. For the scope, the case of the Calabria region in the south of Italy, well known for the high level of seismicity, was studied. At a regional scale, the base-level analysis was implemented for a preliminary assessment of the Attention Zones (AZ), potentially susceptible to liquefaction. The predisposing factors were implemented at a large scale, taking advantage of geostatistical tools to quantify uncertainties and filter inconsistent data. The regional-scale analysis allowed to highlight areas prone to liquefaction and effectively addressed the subsequent level of analysis. At a local scale, the quantitative evaluation of the liquefaction potential was assessed using simplified methods, integrating data from different survey types (CPT, SPT, Down-Hole, Cross-Hole, MASW) available in SM database. The definition of Susceptibility Zones (SZ) was provided considering additional indexes, combining the results obtained from different surveys typologies and quantifying the uncertainty due to the limited data availability with geostatistical methods. The analyses at the regional and municipality scale were matched with seismic liquefaction evidence, well documented in past seismic events. This multi-scale process optimises resource allocation to reduce the level of uncertainty for subsequent levels of analysis, providing useful information for land management and emergency planning.