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Assessment of earthquake-induced- risk of soil liquefaction using CPT-based methods: application to the case study of Cavezzo municipality (Italy)

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Soil liquefaction susceptibility of a given area is the subdivision of the territory in areas characterized by the same probability of liquefaction manifestation given an earthquake over a specified severity (Lai et al. 2017). This division depends mainly on the expected ground shaking, the local stratigraphy, and the groundwater table. Other factors such as geomorphology and the distances towards main rivers are also relevant.

Soil liquefaction susceptibility maps assessing the liquefaction susceptibility in Cavezzo, (Emilia-Romagna region, Italy) have been generated comparing two Italian seismic events, the 20 and 29 May 2012 Emilia Earthquakes, making use on the geotechnical data of 286 cone penetration tests (CPT) and 48 cone penetration tests with piezocone (CPTU). This field- information was mainly obtained by the Regione Emilia Romagna authorities, as well as new explorations were carried out during the European LIQUEFACT project. The maps were generated through three different representations: (1) Simple cross- sections (3D maps) of the factor of safety against liquefaction triggering and the probability of liquefaction; (2) 2D maps representing computed spatially correlated liquefaction risk indexes; and (3) Punctual estimations of lateral displacements, LD.

For the first approach, numerical simulations were performed to obtain the CRR (Cyclic resistance ratio) following three independent approaches: Moss et al. (2006); Robertson (2009) and Boulanger and Idriss (2015) which were further integrated through a logic tree. The CSR (Cyclic stress ratio), using the peak ground acceleration (PGA) value for every seismic event was obtained through a chosen ground motion prediction equation (GMPE): Bindi et al. (2014) assuming those values as representative for the municipality during every seismic event. Moreover, two groundwater table scenarios were considered: (1) the reported ones from every field test, and (2) assuming it on surface, checking its great impact. Furthermore, an analysis of the continuity of clearly identified susceptible soil layers (in depth and on the surface) was done grouping the results using geomorphological criteria.

For the second approach, point-wise assessment of liquefaction risk indexes were computed, namely, the Liquefaction Potential Index, LPI (Iwasaki et al. (1978) and the Liquefaction Severity Number, LSN (Tonkin and Taylor, 2013). The LPI and LSN outcomes' consistency was checked following the Papathanassiou et al. (2015) approach. 24 maps have been constructed by following two geostatistical methods: Ordinary Kriging and Inverse Distance Weighting (Isaaks and Srivastava, 1989). Moreover, one index and one interpolation geostatistical method (represented by their cartographic errors) are proposed to better represent the actual liquefaction field manifestations after the 29 May 2012 Emilia Earthquake.

Lastly, for the third approach, for a selected smaller area, the lateral displacements, LD were estimated by first obtaining the Lateral Displacement Index, LDI (Zhang et al., 2004) and geometric features (Russel et al., 2017) describing the topographic inclination and the closest distance of every chosen location respect to the Secchia river-base.

This example shows how simulations for selected seismic scenarios, groundwater levels, geomorphology, and geostatistical methods can be integrated to map some liquefaction susceptibility indexes and represent proxies for land- planning in municipalities located in liquefaction-prone- areas.