Progetto DPC-ReLUIS 2022-2024 WP 18

Task5: Terremoto di progetto

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Macrozonation of Italian territory for earthquake magnitude to be used for liquefaction assessment

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IMPORTANCE OF M ON LIQUEFACTION ASSESSMENT

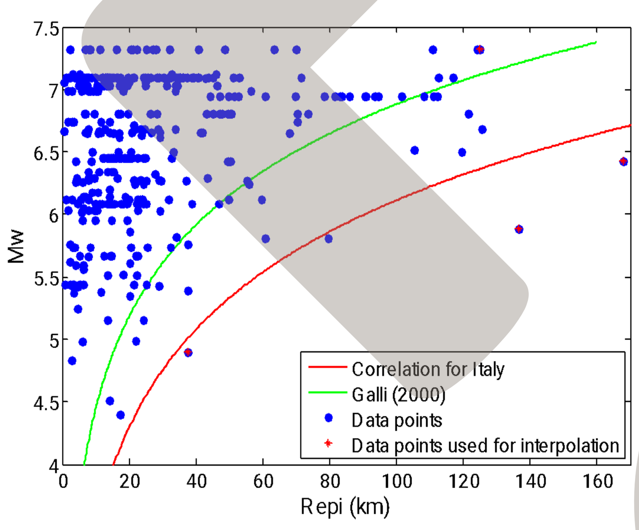
Assessment of the triggering of soil liquefaction and its consequences are relevant topics of earthquake geotechnical engineering attracting the attention of practitioners. The complex nature of the liquefaction phenomenon requires inter- and multi-disciplinary expertise for the definition of local site conditions (e.g., geotechnical characterization and its modelling), engineering seismology for the definition of the seismic source-related characteristics (e.g., determination of earthquake magnitude and seismic demand) and structural engineering for the evaluation of the impact of the liquefied soil to the structural and infrastructural systems (e.g., foundations, buried structures, etc.).

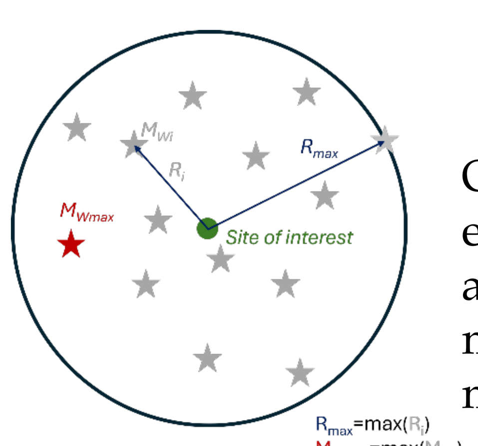
DETERMINATION OF M IN ITALIAN PRACTICE

(1)Disaggregation of the seismic hazard according to the current Italian seismic hazard maps.
(2)Maximum magnitude obtained from the current Italian catalogue of macroseismic intensities.
(3)Maximum magnitude obtained from the current Italian earthquake catalogue and seismogenic zones.
(4)Magnitude assigned based on magnitude versus source-to-site distance threshold relationships.
(5)A probabilistic approach based on the Italian catalogue of macroseismic intensities.
(6)The combined use of Eurocode8 working draft with the code-prescribed (NTC-18) acceleration design spectra spectra

THE METHODOLOGY

STEP 1: the magnitude M_W of each event of the earthquake catalogue (CPTI15, Rovida et al., 2020) located inside the circular area describing the seismicity at the site is compared with the upper bound M_W provided by the M_W-R relation proposed by De Marco *et al*. (2022).





Once this magnitude comparison is completed for all the events of the earthquake catalogue inside the circular area, the seismic zone of interest is defined using the maximum epicentral distance (R_{max}) and maximum magnitude (M_{Wmax})

STEP 2: the annual exceedance seismicity rates (λ) of each magnitude bin are computed for the historical events located inside the circular area having radius R_{max} and centered at the site of interest, taking into account the completeness of the earthquake catalogue.

STEP 3: the seismicity exceedance rates associated to the circular seismic zone are computed using the double truncated G-R model (α,β,ν) with a prefixed minimum magnitude (M_{Wmin})and M_{Wmax} obtained from Step 1 above. The double truncation is implemented based on the following equations.

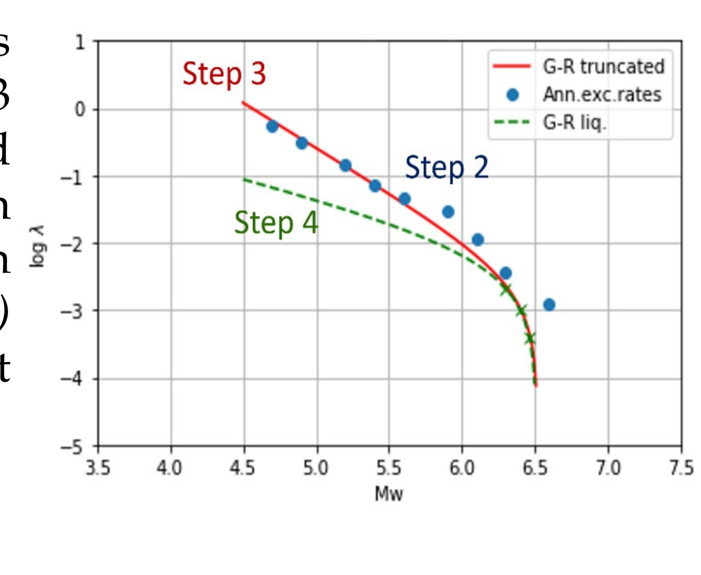
$$\lambda = \nu \cdot \frac{exp\left(-\beta[M_W - M_{Wmin}]\right) - exp\left(-\beta[M_{Wmax} - M_{Wmin}]\right)}{1 - exp\left(-\beta[M_W - M_{Wmin}]\right)}$$

$$\nu = exp\left(\alpha - \beta M_{Wmin}\right)$$

$$\alpha = 2.303 a_{GR} \qquad \beta = 2.303 b_{GR}$$

STEP 4: The annual seismicity occurrence rates of the truncated G-R model of Step 3 ($\vartheta_{G-R}(M_{Wi})$) calculated for finely spaced magnitude intervals (M_{Wi}) are multiplied with the probability of occurrence of liquefaction inside the circular area of radius $R(M_{Wi})$ conditioned to the maximum distance R_{max} at which this phenomenon could be triggered.

$$\vartheta_{liq,G-R}(M_{Wi}) = \left(1, \frac{R^2(M_{Wi})}{R_{max}^2}\right) \vartheta_{G-R}(M_{Wi})$$



from Özcebe et al. (2024)

THE ROLE OF MAGNITUDE IN THE CONVENTIONAL UNCOUPLED LIQUEFACTION ASSESSMENT

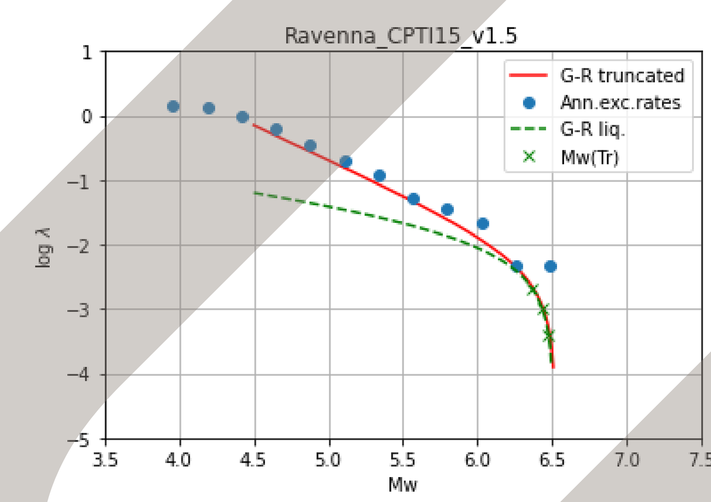
$$CRR = CRR_{M=7.5,\sigma'_{v0}=1atm}\left(q_{c1N}, N_{1,60}, V_{s1}, FC\right) \cdot MSF(M) \cdot K_\sigma \cdot K_\alpha$$

$$CSR = \frac{\tau_c}{\sigma'_{v0}} = 0.65 \cdot \left(\frac{a_{max}}{g}\right) \cdot \left(\frac{\sigma_{v0}}{\sigma'_{v0}}\right) \cdot r_d(z, M, \ldots)$$

PURPOSE OF THIS WORK

- The work presented in this poster to propose an innovative methodology to define the earthquake magnitude in probabilistic liquefaction triggering studies which can be applied at specific sites or in multi-scale zoning (e.g. micro-, meso-, macro- and mega-zonation) of a territory.
- The proposed methodology allows the definition of a hazard-compatible moment magnitude in liquefaction triggering studies, which lacks in the current Italian practice
- This work provides a set of return-period-dependent macrozonation maps for the Italian territory for expected earthquake magnitude for liquefaction assessment purposes.

BENCHMARK COMPARISON: RAVENNA

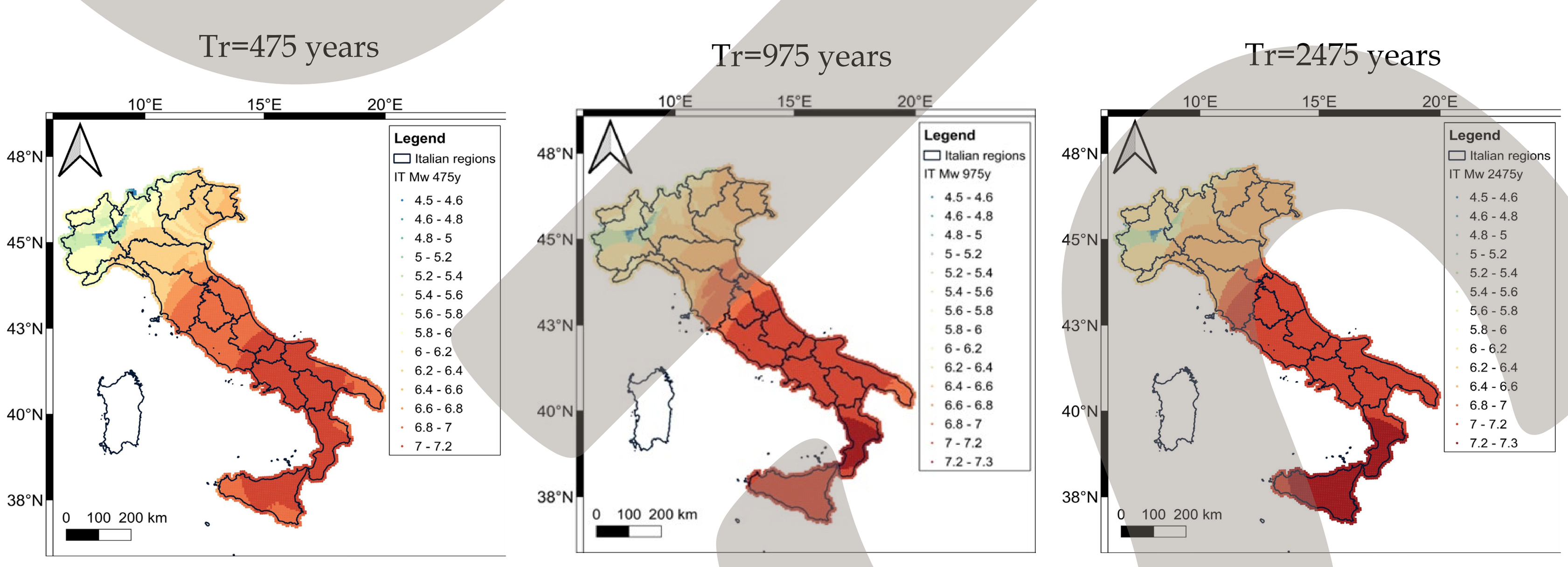


from Özcebe et al. (2024)

Methods	M_W (T_r=475)	M_W (T_r= 975)	M_W (T_r= 2,475)
1	5.0	5.0	5.1
2	6.1	6.1	6.1
3	6.1	6.1	6.1
4	6.1	6.1	6.1
5	5.8	5.8	5.8
6	6.3	6.5	6.5
This work	6.4	6.4	6.5

MACROZONATION OF THE ITALIAN TERRITORY

The procedure is repeated for 10751 points inside the Italian territory to create the moment magnitude macrozonation maps for the entire Italian territory.



from Özcebe et al. (2024)

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