Progetto DPC-ReLUIS 2022-2024 WP3

PROTEZIONE CIVILE
Presidenza del Consiglio dei Ministri
Dipartimento della Protezione Civile

Task 4. Italian seismic risk maps derived by three-dimensional structural models of existing structures

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INTRODUCTION

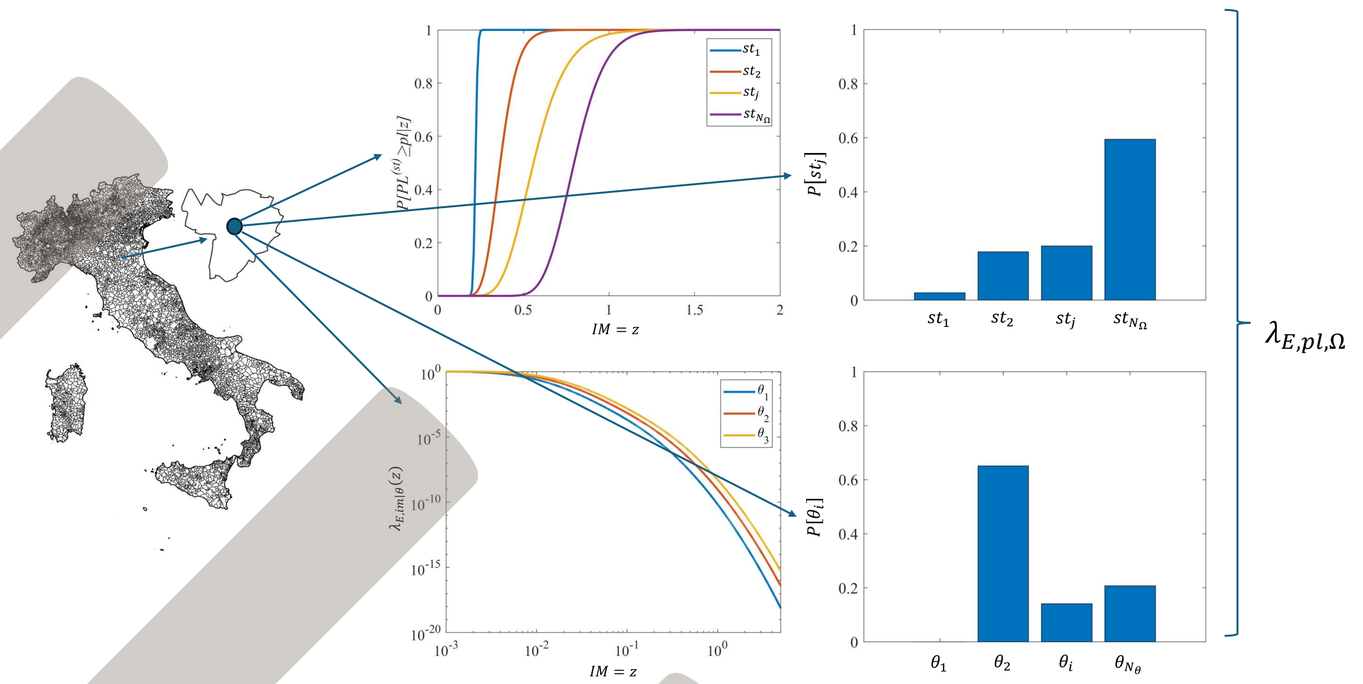
In 2014, the national research project named *Implicit Seismic Risk of Structures – RINTC* [1] was funded by the Italian Civil Protection (DPC) with the goal of quantifying the annual failure rate of Italian structures designed in accordance with the Italian seismic code [2,3]. The project yielded a number of significant resultd, including the identification of uneven structural reliability across the country and its underlying causes, as well as the development of fragility functions for each analyzed structure and performance level [4]. Additionally, the fragility functions produced were used to develop maps of the Italian seismic risk under an *ideal* scenario where all existing (residential) buildings are replaced by code-compliant structures [5]. In 2019, the DPC funded a second project, named *RINTC-e*, which shared the same objectives as the first RINTC project but focused on existing Italian structures [6]. RINTC-e was developed to be consistent with the RINTC project in terms of structural typologies, locations, modelling and analysis approach, and performance levels considered. One of the project's outcomes was the development of seismic risk maps for existing residential buildings in Italy, providing a benchmark for the ideal seismic risk maps. This is the topic presented in the following.

METHODOLOGY

For each Italian municipality, the rate of earthquakes causing a generic building of a group, Ω, of structural typologies to reach or exceed a performance level, $\lambda_{E,pl,\Omega}$, is computed using the following equation:

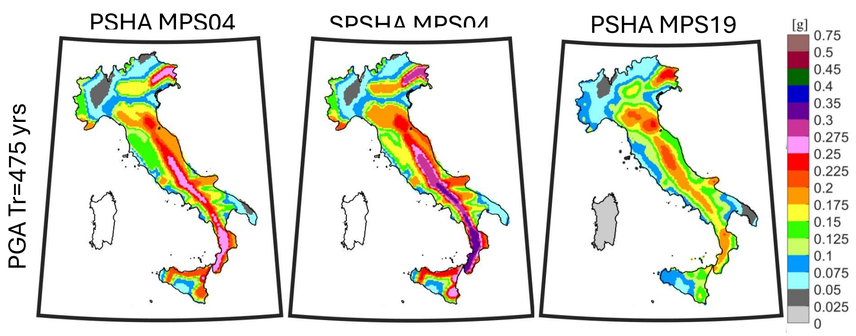
$$\lambda_{E,pl,\Omega} = \sum_{j=1}^{N_\Omega}\sum_{i=1}^{N_\theta}\left\{\int_{im} P\left[PL^{(st_j)} \geq pl|z\right]\cdot\left|d\lambda_{E,im|\theta_i}(z)\right|\right\}\cdot P[\theta_i]\cdot P[st_j].$$

In the equation, $\lambda_{E,im|\theta_i}(z)$ is the annual rate of mainshocks causing the exceedance of a ground motion intensity measure (IM) value, $IM = z$, at the site of interest and for a known seismic soil class, θ_i; $P\left[PL^{(st_j)} \geq pl|z\right]$ is the probability that a building of the structural typology, st_j, reaches or exceeds a performance level, pl, conditional to an intensity measure value equal to z (i.e., fragility function); $P[\theta_i]$ is the probability that a generic building of the municipality is located on each possible soil condition, say N_θ in total; $P[st_j]$ is the probability that a building of the municipality belongs to structural typology, st_j, of a group of N_Ω structural typologies. Considered performance levels are global collapse (GC) and usability preventing damage (UPD).

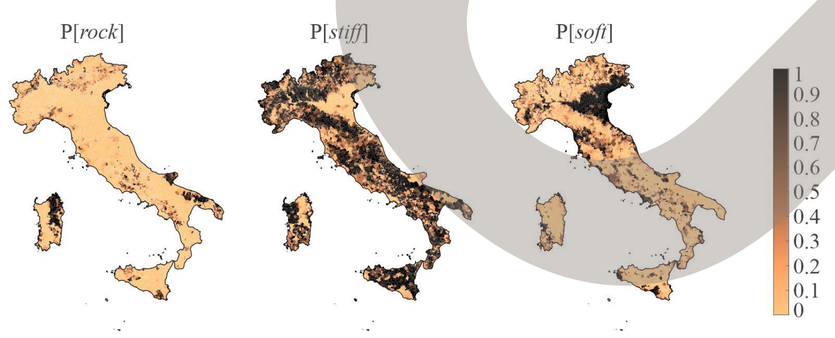


INPUT DATA FOR NATIONWIDE RISK ASSESSMENT OF RESIDENTIAL BUILDINGS

Seismic hazard

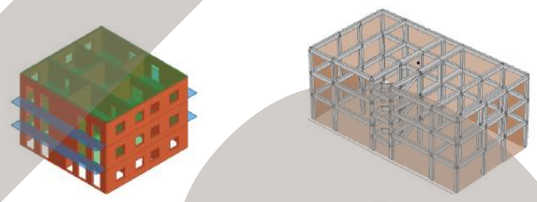


Seismic Soil Classes



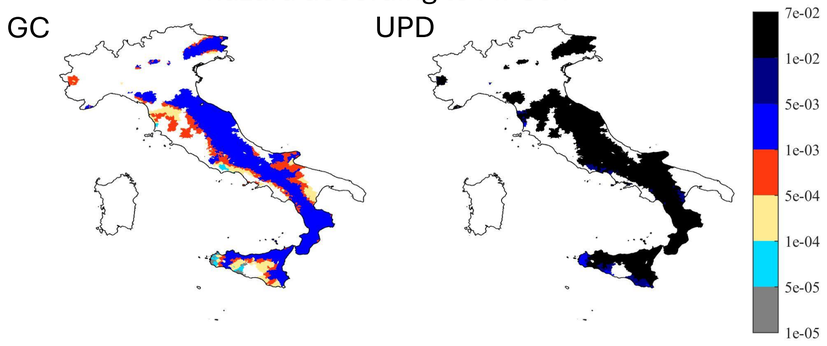
Fragility functions

Fragility functions were developed as part of the RINTC-e research project; those used here refer to masonry buildings ('45-'87 and post-'87), reinforced-concrete (R.C.) buildings (pre-'70, '70s, and '80-'90) and R.C. buildings retrofitted by seismic isolation.

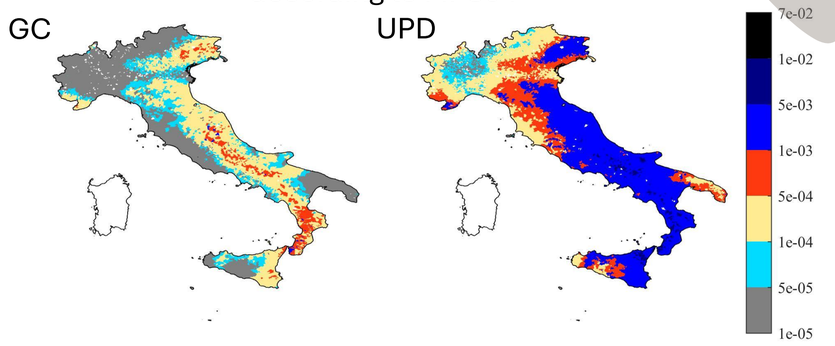


SOME RESULTS

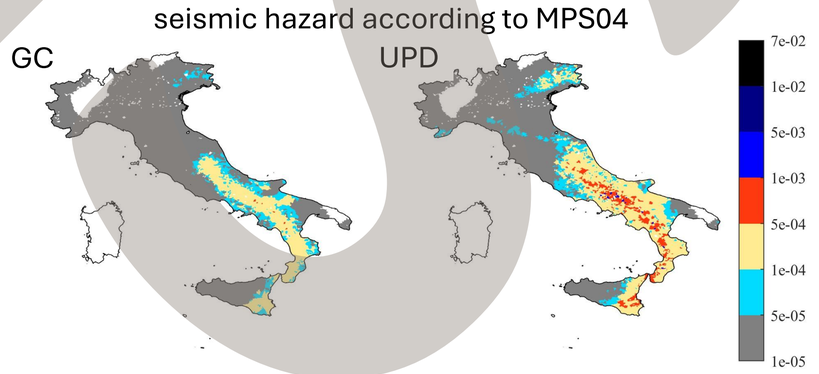
Maps of failure rates for masonry buildings; seismic hazard according to MPS04



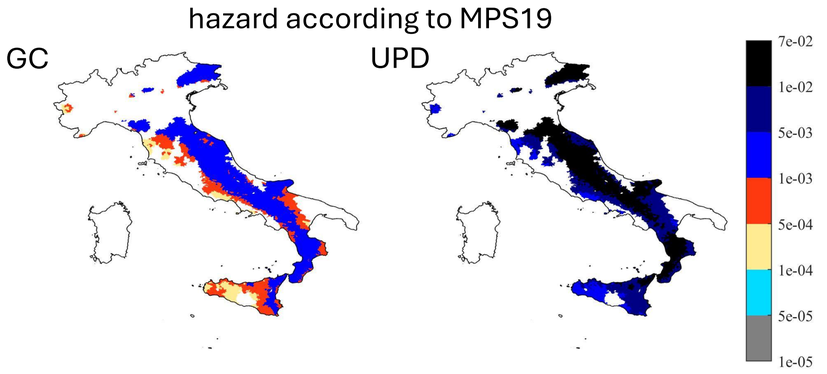
Maps of failure rates for R.C. buildings; seismic hazard according to MPS04



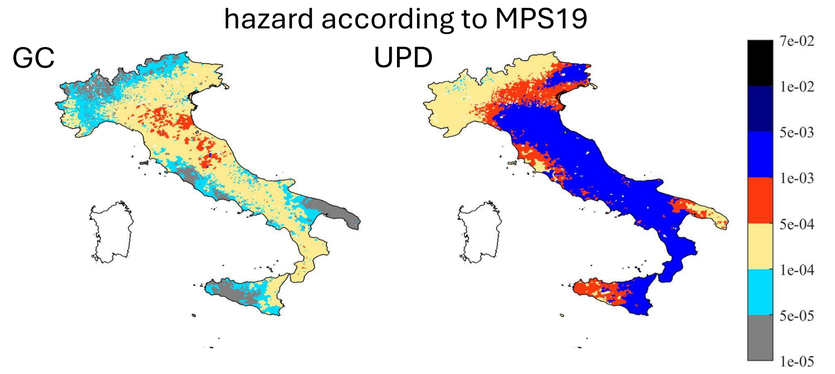
Maps of failure rates for base-isolated buildings; seismic hazard according to MPS04



Maps of failure rates for masonry buildings; seismic hazard according to MPS19



Maps of failure rates for R.C. buildings; seismic hazard according to MPS19



References

[1] Iervolino I, Dolce M. Foreword to the Special Issue for the RINTC (The Implicit Seismic Risk of Code-Conforming Structures) Project. Journal of Earthquake Engineering 2018;22:1–4.
[2] C.S.LL.PP. Decreto Ministeriale 14 gennaio 2008: Norme tecniche per le costruzioni, Gazzetta Ufficiale della Repubblica Italiana, n. 29, 4 febbraio, Suppl. Ordinario n. 30. Ist. Polig. e Zecca dello Stato S.p.a., Rome (in Italian). 2008.
[3] C.S.LL.PP. Decreto Ministeriale 17 gennaio 2018: Norme tecniche per le costruzioni, Gazzetta Ufficiale della Repubblica Italiana, n. 42, 20 febbraio, Suppl. Ordinario n. 8. Ist. Polig. e Zecca dello Stato S.p.a., Rome (in Italian). 2018.
[4] Iervolino I, Baraschino R, Belleri A, Cardone D, Della Corte G, Franchin P, et al. Seismic Fragility of Italian Code-Conforming Buildings by Multi-Stripe Dynamic Analysis of Three-Dimensional Structural Models. Journal of Earthquake Engineering 2023;27:4415–48.
[5] Pacifico A, Chioccarelli E, Iervolino I. Residential code-conforming structural seismic risk maps for Italy. Soil Dynamics and Earthquake Engineering 2022;153:107104.
[6] Iervolino I. Foreword to the Special Issue for the 2019-2021 RINTC (The Implicit Seismic Risk of Existing Structures) Project. Journal of Earthquake Engineering 2024;28:1127–9.