ASEC 2025 Conference

The 6th International Electronic Conference on Applied Sciences

09–11 December 2025 | Online

MDPI

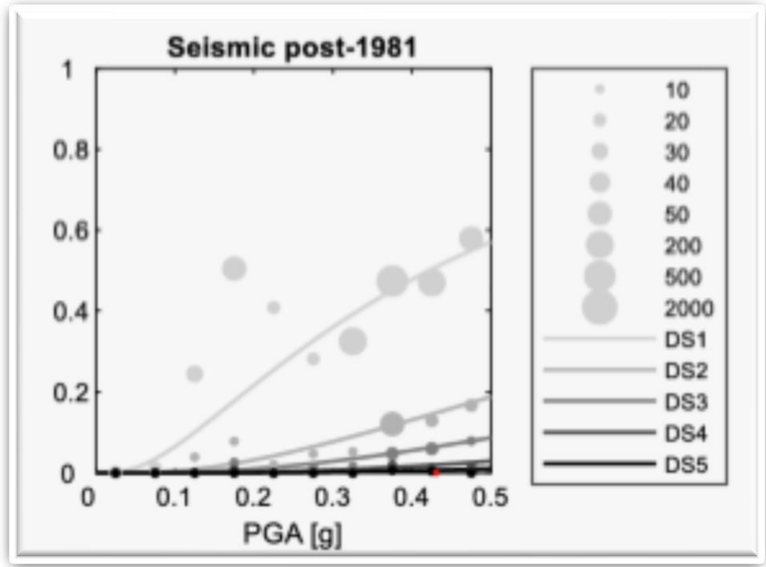
GENERALIZED EXTREME VALUE-BASED FRAGILITY CURVES

Zahra Haqi, Matteo Dalmasso, Dr. Marco Civera

Polytechnic University of Turin

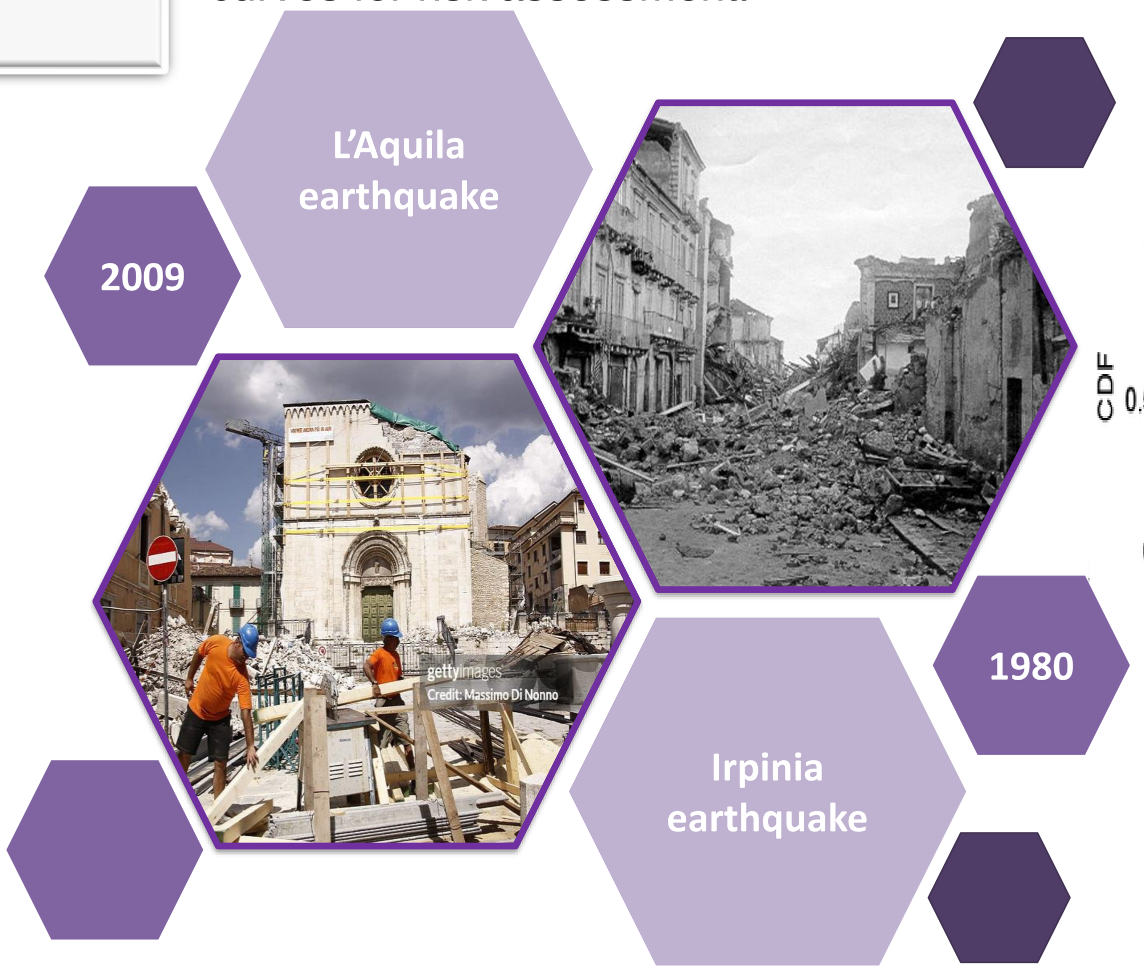
Italy

INTRODUCTION & AIM



Fragility curves show how likely buildings are to sustain damage as earthquake intensity increases, supporting better mitigation and emergency planning. Rosti et al. developed widely used empirical fragility curves for Italian buildings using Da.D.O. post-earthquake data, fitting them with lognormal distributions to create national reference curves for risk assessment.

We analyzed residential RC and masonry buildings, grouped by height and design level. Rosti et al. produced national fragility curves using a lognormal distribution, but unclear data filtering and curve-generation steps limit reproducibility. We recreated their curves with multiple approaches and introduced the Generalized Extreme Value (GEV) distribution to better represent extreme damage behavior.

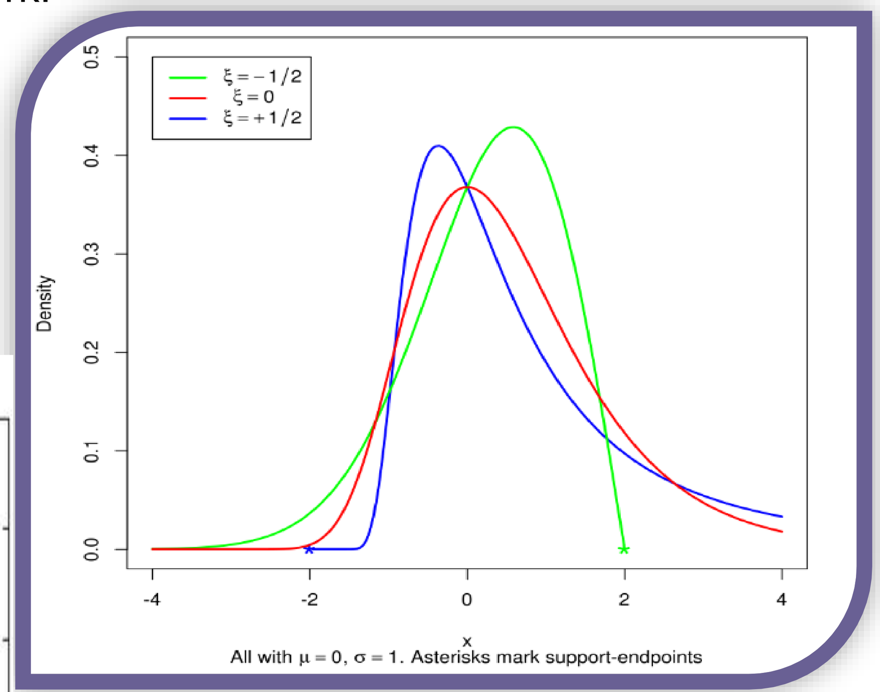


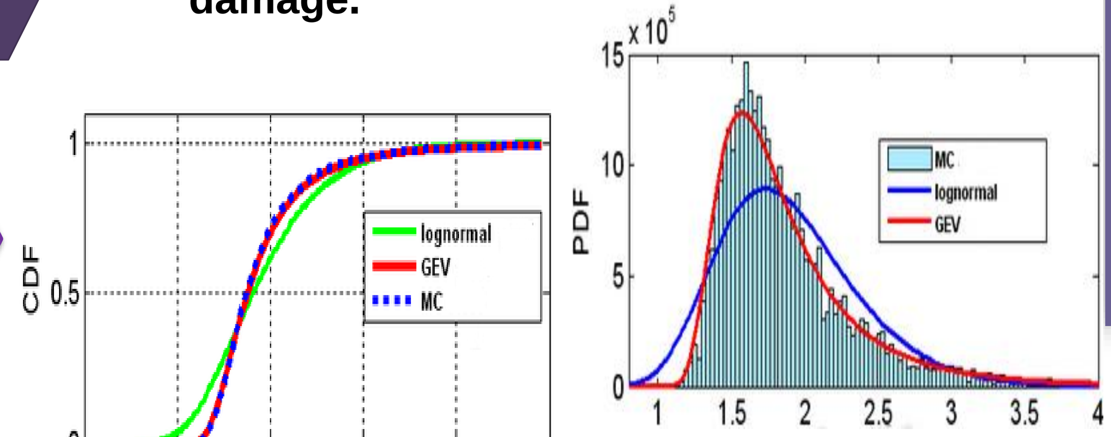
GEV Application

The Generalized Extreme Value (GEV) distribution is a statistical model used to analyze and predict the behavior of extreme values—rare but impactful events. It unifies three types of extreme value distributions into a single framework:

- Gumbel (Type I)
- Fréchet (Type II)
- Weibull (Type III)

The GEV captures the peak more precisely and also matches the right tail better, which is crucial for modeling rare, severe damage.





The shape parameter ξ, which controls the tail behavior; the location parameter μ, which shifts the distribution along the axis; and the scale parameter σ, which determines the spread. Together, they define the distribution's flexibility in modeling extreme events.

optimization techniques:

» Non-linear Least Squares (NLS)

» Maximum Likelihood Estimation (MLE)

METHOD

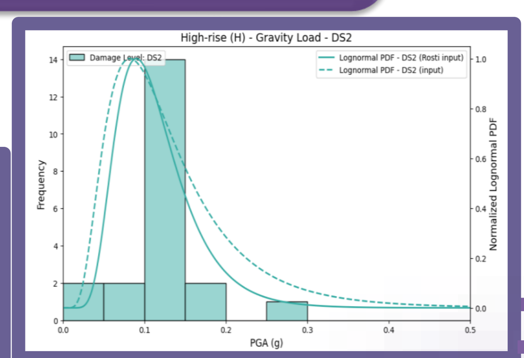
Method One

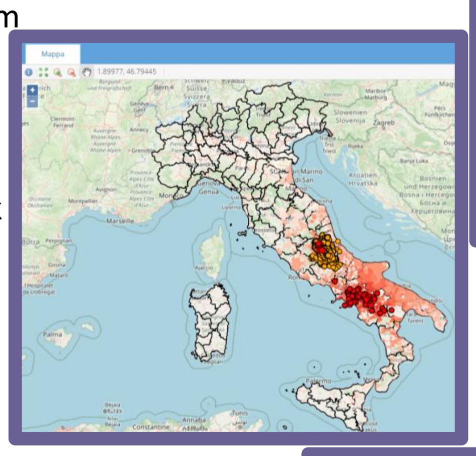
input
- Data collection from the Da.D.O. platform

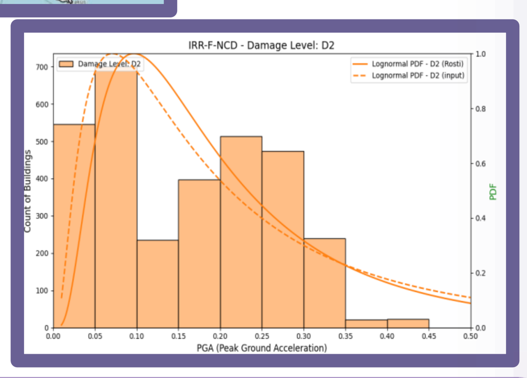
filtering
- Completeness ratio check
- Structural type filtering
- Material filtering

Damage level verification
- Based on the surveyed data

Fragility curves







Method Two

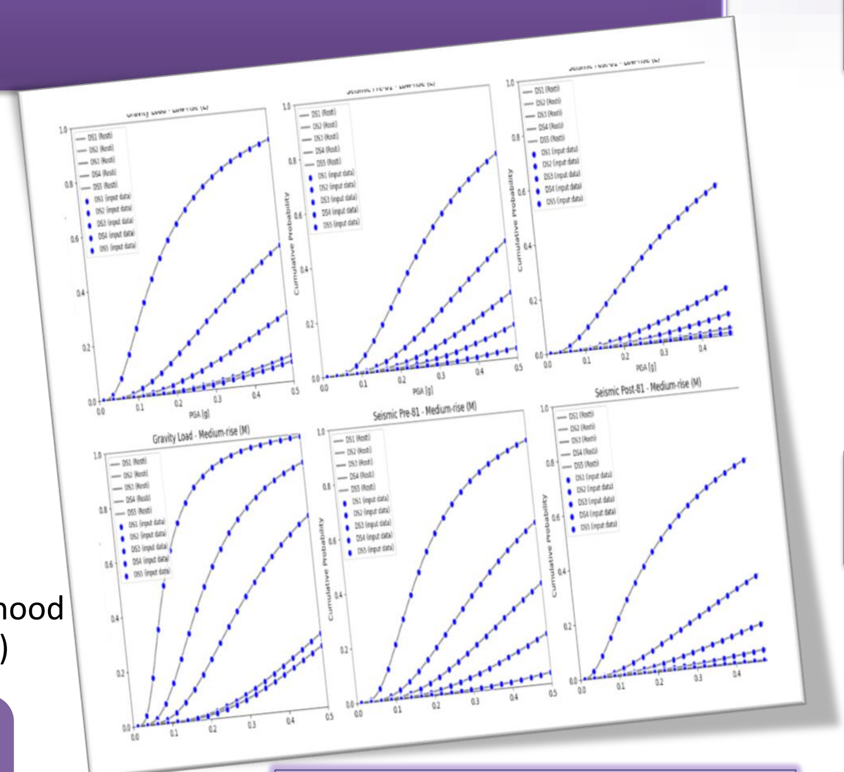
GRABIT Tool
- Extract Data from Rosti et al. Curves

smoothing
- Apply Smoothing & Interpolation (Generate 5000 Uniform Points)

Curve Fitting Scripts
- Non-linear Least Squares
- Maximum Likelihood Estimation (MLE)

Extract Best-Fit Parameters

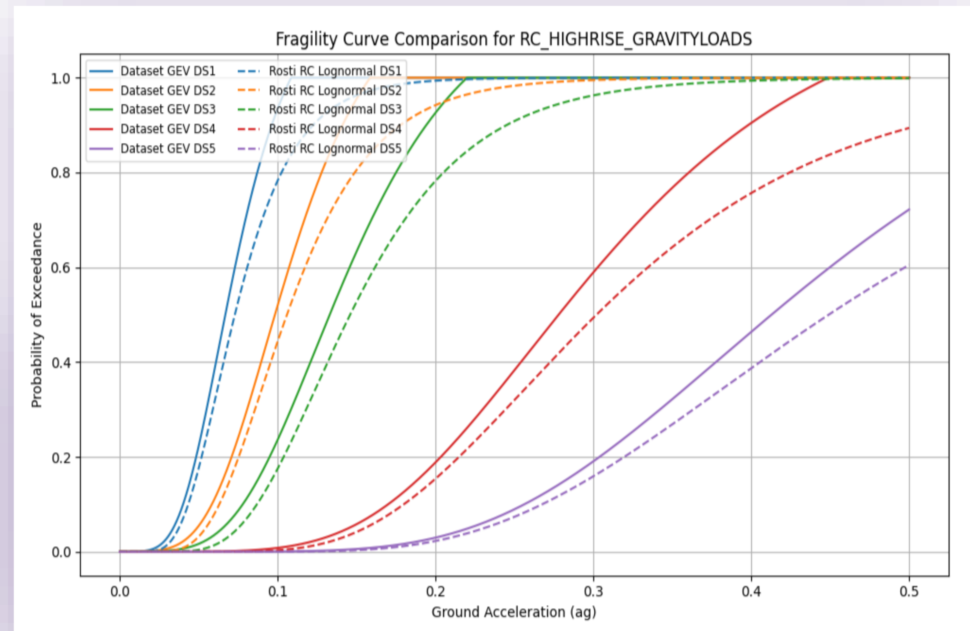
Compute Fit Quality

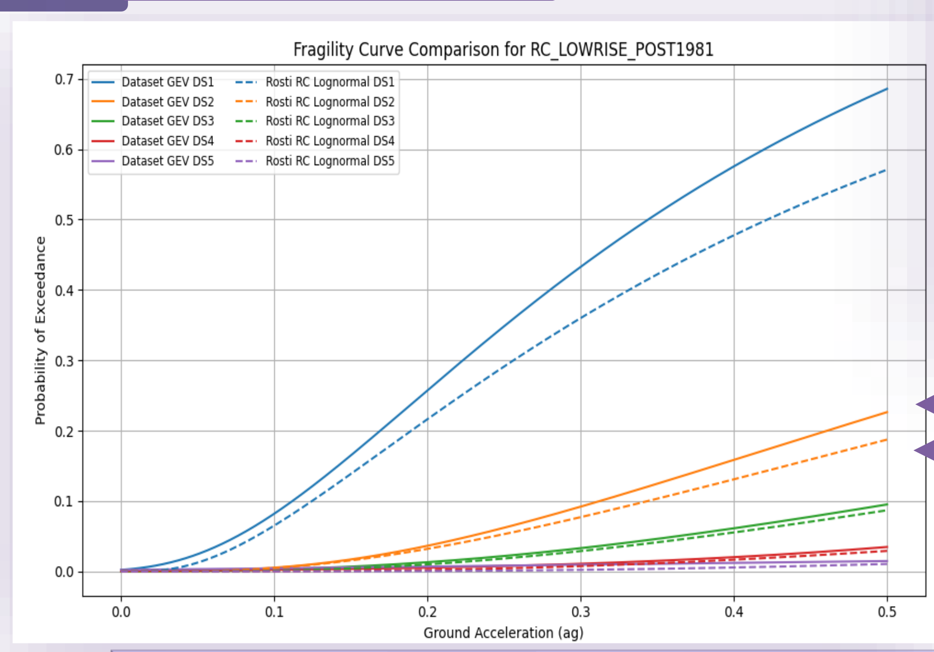


The reconstructed fragility curves showed excellent agreement with the reference curves. The estimated median spectral displacement and dispersion parameters were consistent with those provided in the literature.

RESULTS & DISCUSSION

- Reproduced Rosti et al.'s fragility curves using multiple MATLAB fitting methods.
- Parameters μ (location), σ (scale), and ξ (shape) estimated via nonlinear fitting and MLE closely match empirical data.
- GEV-based curves better capture rare, high-damage events compared to traditional lognormal models.





CONCLUSION

- GEV provides a more robust statistical alternative to the traditional lognormal model for seismic fragility analysis, especially in representing structural behavior under extreme intensities.
- GEV-based fragility curves capture rare, high-damage events more accurately, improving the reliability of seismic risk assessments for severe earthquakes. This enhanced modeling supports better disaster mitigation decisions, addressing limitations of lognormal assumptions in the upper damage states.

FUTURE WORK / REFERENCES

- Extension of the method to multiple building typologies.
- Validation using damage observations from past earthquakes.