

Evaluation of the seismic vulnerability of the unreinforced masonry buildings constructed in the transition between the 19th and 20th centuries in Lisbon, Portugal

Summary

The main objective is the assessment of the seismic vulnerability of the unreinforced masonry buildings constructed between 19th and 20th century in Lisbon. These masonry buildings are well-known within the scientific community and the general public for their structural weaknesses, thus representing a major concern for life and property safety in the event of an earthquake. The work proposes the derivation of analytical fragility functions based on detailed models and non-linear procedures. First, a detailed architectural and structural characterization of the unreinforced masonry buildings with timber floors is conducted. This includes the possible reasons for the negative impression attributed to the buildings, which end up being known as "gaioleiro" (meaning bird cage). A group of three buildings is defined as study case for the seismic performance-based assessment in order to consider the effect of the aggregate. The variability of seismic response is evaluated by analysing the uncertainty propagation of model parameters (aleatory uncertainties) and by considering different prototypes representative of the class (epistemic uncertainties).

The assessment is addressed to 1) the global seismic response of the structure, mainly governed by the in-plane capacity of the masonry walls, and to 2) the local response, related to the activation of out-of-plane mechanisms of parts of the structure. The global behaviour is determined by means of non-linear static analyses considering the equivalent frame model approach. Epistemic uncertainties are treated by means of a logic tree to account for variations in the geometry of the buildings, constructive details and modelling assumptions. Aleatory uncertainties related to the randomness of the mechanical properties of materials and elements, are treated by means of Monte Carlo simulations. The local behaviour of possible out-of-plane mechanisms are evaluated by limit non-linear kinematic analyses, based on the macro-block approach. In this case, the propagation of uncertainties is evaluated through the Response Surface method. The seismic performance-based assessment is set by comparing the capacity curves of the equivalent nonlinear single-degree-of-freedom systems with the seismic demand, expressed by an Acceleration-Displacement Response Spectrum (ADRS), after considering different performance levels. The evaluation of the corresponding displacement demand is obtained the Capacity Spectrum Method. Finally, the fragility functions for this class of buildings are derived and compared with other curves available in the literature.

Keywords

Unreinforced masonry buildings, seismic vulnerability, fragility analyses, performance-based assessment, non-linear static analysis, pushover analysis, limit non-linear kinematic analysis, in-plane behaviour, out-of-plane behaviour, aleatory and, epistemic uncertainties, Monte Carlo simulations, Response Surface method.



Unreinforced masonry buildings constructed in the beginning of the 20th century in Lisbon.



PhD student

Ana Gabriela Gaspar Simões

PhD program

Civil Engineering (IST, University of Lisbon)

Supervisor

Rita Bento (CERIS, IST, University of Lisbon)

Co-supervisors

Sergio Lagomarsino (UNIGE) and Paulo Lourenço (EE-UM, University of Minho)

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