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A METHODOLOGY FOR GENERATING ANALYTICAL FRAGILITY CURVES FOR UNREINFORCED MASONRY BUILDINGS USING NON-LINEAR DYNAMIC ANALYSIS

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Most of the fragility curves of UnReinforced Masonry (URM) buildings are obtained using empirical methods (i.e. observational or expert-based methods) due to the inherent complexity related to their nonlinear behaviour and relative shortage of robust numerical tools for performing nonlinear dynamic analyses in a quick and accurate way. The objective of this paper is to develop a new methodology for obtaining fully analytical fragility curves for URM buildings that considers all sources of uncertainties associated with the demand and capacity, as well as the exposure data. The variability within the exposure data has been considered through selecting a prototype representative of a class of URM buildings that is common in a specific building inventory. The capacity uncertainties have been taken into account considering mechanical parameters of materials (e.g., compressive strength, Young's modulus, etc.) as random variables. Monte Carlo simulations (Pinto et al., 2004; Rubinstein, 1981) has been employed in this study for sampling the uncertain parameters. The uncertainties on demand, which have more effect on the fragility analysis than capacity and simulating techniques, has been taken into account considering variability in ground motion records based on the local site conditions.

The behaviour of URM buildings during earthquakes can be classified into two main categories: buildings with and without box-behaviour. The term box-behaviour refers to a global seismic response of URM structures that prevents the out-of-plane mechanisms of the walls. In the case of a building with box-behaviour, the in-plane behaviour governs the global building response, because the walls are well-connected to the adjacent walls and floor diaphragms. In other words, the assumptions are that the local out-of-plane behaviour of walls and the local floor flexural response are negligible with respect to the global seismic response of the structure. This paper focuses on URM buildings with box-behaviour considering a typical modern European URM building with regular geometry made of concrete block units and cement mortar. The slab floor/roof is in reinforced concrete, which can be assumed as a rigid diaphragm.

Lourenço et al. (2013) carried out shaking table tests on two-story buildings of this URM typology. Tests run were performed as a series of incremental seismic inputs on the 3D shaking table at the national laboratory of civil engineering (LNEC) in Lisbon, Portugal. Due to dimensions limitations caused by the size of the shaking table, tests were developed in a scale 1:2. Regarding the damage pattern of the unreinforced model, it is assumed that the in-plane failure mechanisms are predominant during the earthquake.

Incremental Dynamic Analyses (IDAs) have been performed using structural component model implemented in the TreMuri software (Lagomarsino et al., 2013; Penna et al., 2014) as the only available software for performing IDAs. The software, which was initially developed by Galasco et al., (2004) at the University of Genoa, presents a sophisticated equivalent frame method based on a fundamental hypothesis that the box-behaviour governs the global seismic response.

Each masonry wall is formed by piers and spandrels simulated by macro-elements (see Figure 1a), which are connected by rigid nodes. Masonry walls with both regularly and irregularly distributed openings can be modelled (see Figure 1b,c). The numerical model has been calibrated with respect to the results of shaking table test in terms of capacity curve and damage pattern (see Figure 2).

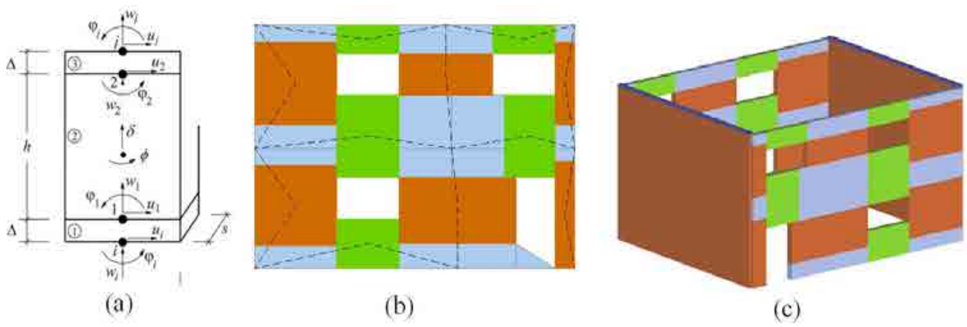

Figure 1. TreMuri software: a) Macro element; b) Modelling a wall with macro elements; c) 3D model

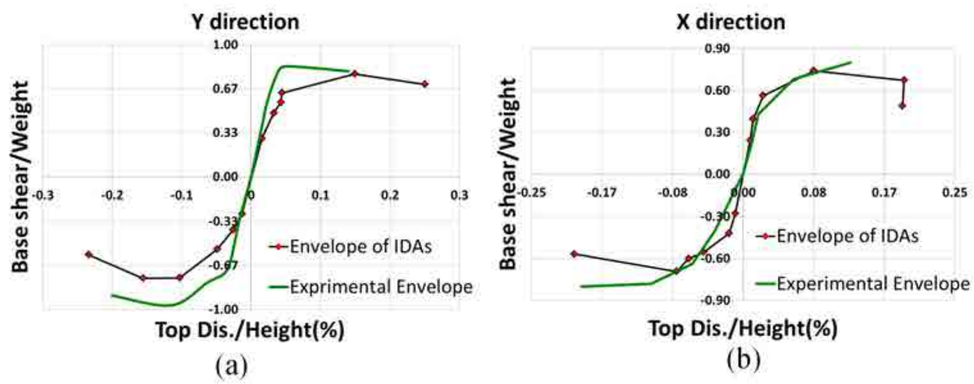

Figure 2. Comparison between experimental and analytical capacity curves as a result of IDAs

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