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# SEISMIC BEHAVIOUR OF NEW CONCRETE BLOCK MASONRY BUILDINGS

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**ABSTRACT**

In the last years the design of seismic resistant masonry buildings has used mainly experimental approaches for the evaluation and assessment of the seismic response of these structures. In the literature is possible to find an important amount of related research. It is found that due to cost, feasibility and good agreement with real cases most of the experimental tests have been performed on masonry elements, for instance, individual walls by means of cyclic tests assuming the in-plane failure mode as the governing behaviour. The Present work aims to evaluate the seismic behaviour of masonry buildings implemented a new construction system by means of dynamic testing on entire buildings using shaking table, attained more accurate results in terms of the influence of out-of-plane failure and connections between structural elements, the possibility of comparison with cyclic tests results and the start point for the design guidelines of new masonry buildings.

## GENERAL OVERVIEW

Masonry buildings have showed critical performance during earthquakes due to a common feature: low tensile strength (Lourenço et al. 2009). However its easy construction and economy of its materials have made this composite in one of the most used for the construction of residential buildings since first civilizations and is still implemented nowadays.

Current codes allow the construction of buildings using masonry materials but with severe limitations. A new construction system in which concrete block units are used is proposed, the system has already been studied by experimental and numerical approach in masonry walls by means of static cyclic tests (Haach 2009). However the response of this construction system on a whole building is lacking. Shaking table tests represent the most accurate device for the simulation of real earthquakes (Tomaževič 1999; Benedetti et al. 1998; Calvi et al. 1996). In view of this aspect an enlarged experimental and numerical analysis is planned in order to assess the seismic behaviour of the new buildings typology.

### Experimental Program

Aiming to fully understand what the response during a real seismic movement of a building constructed with this system is, a symmetrical and asymmetrical geometric plan dimension buildings will be tested on a shaking table, on them the influence of reinforcement will also be studied. With this purpose artificial accelerograms based on the elastic response spectrum of the EC 8 (EN1998 2004) are imposed by several incremental amplitudes on the base of the experimental models.

The dynamic properties of the buildings corresponding to the natural frequencies, mode shapes and damping ratios will be obtained by force vibration methodologies using the shaking table for the input motion. Damage in terms of stiffness degradation might be studied through the incremental input motions and seismic analysis in terms of displacements methodologies will provide the necessary information for the numerical calibration.

### Numerical Simulation

Finite element analysis is the more accurate mathematical approach for the nonlinear modeling of the behaviour of structures. In order to provide a reliable and feasible option for the design and assessment of new masonry buildings a method based on macro-elements will be implemented. Here the experimental results obtained on the shaking table tests will validate the numerical models. Nonlinear static (pushover) and nonlinear dynamic analysis will be

developed. Comparisons between these approaches and fully insight of the dynamic behaviour of the buildings will assist the better understanding of them, towards the provision of design guidelines.

### Partial Results

The experimental analysis of two -reinforced and unreinforced- symmetrical masonry buildings has been done. Figure 1 shows the final conditions after shaking table test.

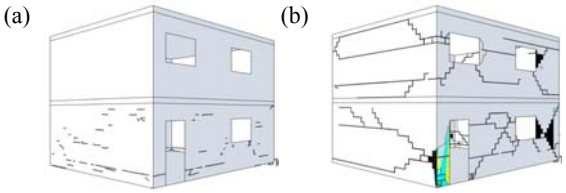


Figure 1: Damage in (a) reinforce and (b) unreinforced masonry buildings

The reinforced building resisted the maximum input acceleration of the shaking table with only cracks in the first level, whilst the unreinforced solution attained severe damage in all facades with 63% of that acceleration. However the last building was able to withstand a PGA higher than 13m/s$^2$ without collapse. Reinforced building showed at the maximum acceleration an in-plane displacement around 5mm whilst unreinforced building presented a maximum displacement over 35mm. The differences in the damage distribution as well as in the displacements and accelerations showed that the reinforced solution is able to sustain relatively high dynamic excitation.

Further information related to the seismic behaviour of this system in asymmetric buildings will be studied, obtaining essential information for the design and construction of new masonry buildings.

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