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INNOVATIVE SOLUTIONS FOR MASONRY INFILLS

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EXTENDED ABSTRACT

Seismic design has two main objectives, namely: i) to prevent local or global collapse of the structure in the event of the design seismic action, retaining structural integrity and residual load bearing capacity after the event - Ultimate Limit State requirement; ii) to withstand a more frequent seismic action without significant damage – Serviceability Limit State requirement. In other words, human lives have to be protected and damage has to be limited in order to keep the rehabilitation of the structure economically feasible. These are the objectives clearly stated in Eurocode 8 (EC8) (EN 1998-1).

Furthermore, this new standard imposes new rules for non-structural members, as in the case of masonry infills. It is stated in article 4.3.6.4 of part 1 of EC8 (EN 1998-1) that the brittle collapse of the infills has to be avoided and that light wire meshes or bed joint reinforcement have to be used. Besides this general information, no more details are given, so there is insufficient information for the structural engineer to correctly design the infills. Therefore, with the goal of contributing to the creation of simple design rules for these infills, a shaking table test program of reinforced concrete frame buildings with infill walls, reinforced and unreinforced, is being be carried out.

The shaking table experimental program, using the shaking table of the National Laboratory of Civil Engineering (LNEC), in Lisbon, includes three different specimens, sharing the same geometry, Figure 1. The definition of these buildings was done regarding the buildings constructed in the last 20 years, in Portugal. Taking into account the limitations of the referred shaking table, the models were reduced to a scale of 1:1.5, using Cauchy-Froud's Similarity Law. This Law relates all the key properties of the prototype (1:1) and the model (1:1.5), enabling its correct design using the prescriptions of the design standards.

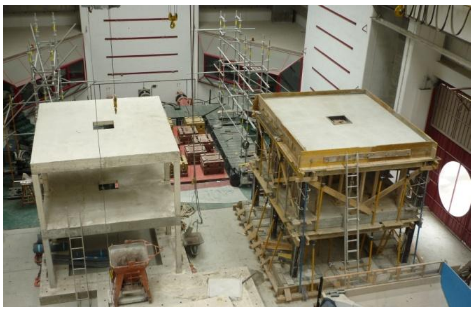
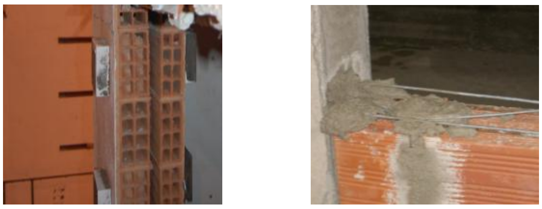


Figure 1: The construction of the first two models at LNEC

The different models were obtained by varying both the standard, from which the design of the reinforced concrete structure was done, and the enclosure system. The first model tries to replicate the buildings constructed in the last two decades and it was designed following the two effective standards: Standard for Reinforced and Pre-Stressed Concrete Structures (R.E.B.A.P. 1983); Standard for Security and Actions of Buildings and Bridges (R.S.A. 1983). The enclosure system also reflects the most common solution: a double leaf, unreinforced, clay brick masonry wall, using blocks with horizontal perforation, Figure 2 (a). In addition, C20/25 concrete and S400 rebar materials were chosen.

The other test specimens represent two enclosure systems that could be future constructive possibilities, both reinforced, and designed using Eurocodes 1, 2 and 8 (EN 1991-1; EN 1992-2; EN 1998-1). Following what could be a simple, not expensive and effective solution, one infill is made of a single leaf, clay brick wall with bed reinforcement, Figure 2 (b). The reinforcement, applied every two bed joints, consists of a simple truss connected to the reinforced concrete columns. The other system consists also of a single leaf, clay brick masonry wall with light wire anchored to the concrete frame. As for the construction materials, a C30/37 concrete and S500 rebar were applied.



(a) (b)

Figure 2: Infill solutions: (a) model one with a double leaf unreinforced infill; (b) model two with a single leaf reinforced infill

EC8 (EN 1998-1) defines in article 2.1(1) that the design seismic action should have 475 years of return period, although depending on the importance class of the structure, table 4.3 of the standard, the maximum surface acceleration should be changed, therefore changing the return period of the seismic action. Part 3 of EC8 (EN 1998-3) states in article 2.1 that there are three different Limit States, in order to assess and classify the seismic performance of a structure. Each one (NC – near collapse, SD – significant damage, DL – damage limitation) has to be assessed using a seismic action with different years of return period (225, 475 and 2475 years, respectively).

The stages of the shaking table test were defined regarding these limits, Table 1, and for each one an artificial accelerogram, based on the response spectrum, was generated and used as the input signal.

Table 1: Stages of the experimental tests for each model.

Stage	Years of return period
1	225
2	475
3	2475
4	1,5 x stage 3

Models one and two have already been tested using the four stages above defined. Model one collapsed during the last stage, Figure 3 (a). Model two was severely damaged but withstood all stages, Figure 3 (b). All the infill walls of the first floor of model one, during the last stage and before the failure of three columns, were expelled out-of-plane. None of the walls of the second model fully collapsed.

As the first conclusions, taking into account only the observed damage and collapse mechanisms, the structure designed with the previous Portuguese standards and a double leaf cavity wall, model one, had a poor behaviour. In comparison, model two, designed according to Eurocodes and with a single reinforced leaf infill wall, had a better performance, however it developed an inadequate failure mode with a possible brite collapse of the columns, mainly due to the influence of the masonry infills.

(a) (b)

Figure 3: Observed damage at the end of the shaking table test: (a) model one; (b) model two

The main reason for the better seismic behaviour of the infills in model two, which did not collapse out-of-plane, was the presence of bed joint reinforcement connected to the infill frame.

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JOÃO LEITE was born in Braga, Portugal. In 2008, he obtained his degree in Civil Engineering (5-years graduation) at University of Minho, Portugal. Afterwards, he worked as Scholarship Researcher and did his MSc thesis, at the same university, which was finalized in 2009. In the same year he started his PhD. His e-mail address is: joaoleite@civil.uminho.pt