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CHARACTERIZATION OF THE SEISMIC BEHAVIOUR OF TRADITIONAL TIMBER FRAME WALLS

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ABSTRACT

The reconstruction of Lisbon Downtown after the 1755 earthquake was based on a novel constructive system based on masonry buildings with an internal three-dimensional timber-framed structure named "gaiola pombalina", which improved the global stability of the buildings, enhancing their capacity to dissipate energy under seismic loadings. This Ph.D project aims at getting experimental insight on the mechanical behaviour of such timber–framed walls subjected to in-plane loading. A brief description of the preliminary tests is here presented.

INTRODUCTION

Half-timbered constructions have been popular since ancient times in many countries, since they have a good seismic performance, but also because of their low cost and the strength they offer (Cóias 2007; Langenbach 2009).

In Portugal, typical half-timbered structures are the 'Pombalino' buildings, which are old masonry buildings developed after the 1755 Lisbon earthquake which destroyed Lisbon Downtown. A Pombalino building is characterized by external masonry walls and an internal timber structure, named "gaiola" (cage), which is a three-dimensional braced timber structure.

The aim of this PhD project is to study the behaviour under a cyclic shear load of the *frontal* walls present in such buildings, i.e. half-timbered walls, which present S. Andrew's crosses and an infill which can be either rubble bricks or stone, in order to assess their effective performance to seismic actions.

EXPERIMENTAL CAMPAIGN

The experimental campaign will consist of cyclic tests on timber walls with and without infill and of strengthening solutions to be applied.

Material characterization

In a first stage, the materials used to build the walls, i.e. timber, mortar, bricks and masonry, have been characterized. Some results are reported below.

Timber

Tensile, compressive and bending tests have been carried out on timber specimens with structural dimensions (cross section 12×16cm). The timber used is *Pinus Pinaster*. Table 1 shows the compressive strength of the specimens tested. The average values are in accordance with what is found in literature, but the scatter is quite high, due to the many imperfections, such as knots, fissures, etc, present in structural sized specimens.

Table 1: Compressive Strength Results of Timber

SPECIMEN	TIME [s]	$F_{c,0}$ [kN]	$\sigma_{c,0}$ [MPa]	$E_{c,0}$ [MPa]
PNPN_01_C	240	724.07	37.89	9658
PNPN_02_C	180	684.44	35.67	9892
PNPN_03_C	200	741.10	38.02	11838
PNPN_04_C	238	728.17	38.62	10159
PNPN_05_C	367	777.57	41.07	12073
PNPN_06_C	310	773.19	41.04	12278
PNPN_07_C	237	677.74	36.01	11996
PNPN_08_C	211	695.14	35.98	9421
PNPN_09_C	356	918.33	48.08	15688
PNPN_10_C	273	773.75	40.30	11180
PNPN_11_C	239	707.89	36.87	10611
PNPN_12_C	245	549.64	28.58	7704
		Average	38.18	11042
		C.O.V.	11.95	18.05

Mortar

Mortar has been studied in terms of flow, workability and strength. The ratio of the mortar is 1 cement :2 hydrated lime :4 fine sand :2 medium sand in volume. The W/C ratio is of 1.5 in volume. Specimens were prepared in the lab according to standard EN 1015:11 (1999) and compared with specimens prepared during the construction of the walls. Figure 1 shows the comparison at different ages for the compressive strength. Some walls present a slightly lower strength mortar, possibly indicating a mix with more water.

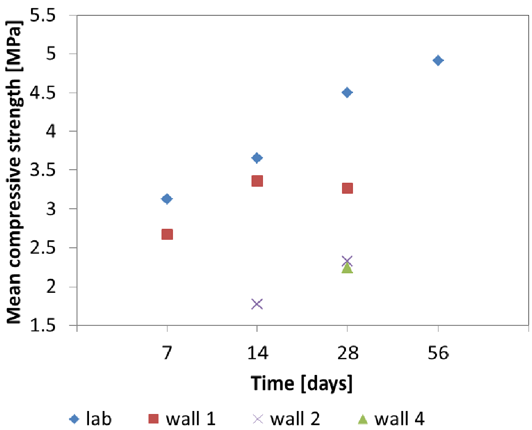

Figure 1: Mean Compressive Strength of Mortar Specimens at Different Ages

Cyclic tests on walls

Cyclic tests, and the preliminary monotonic ones, on half-timbered walls are currently underway, following past experiences (Vasconcelos et al. 2010). The tests are carried out according to standard ISO DIS 21581 (2009). Figure 2 shows the setup for such tests.

Figure 2: Assembled Test Setup

The initial tests have shown a tendency of the wall of rotating out-of-plane, due to the eccentricities in the geometry of the wall. In fact, the connections are overlapped ones, as those usually met in the original walls (Mascarenhas 2004), thus creating clearances only on one side of the walls. A system to prevent this movement is being implemented.

CONCLUSIONS

An extensive experimental campaign is underway to better understand the behaviour of half-timbered walls, which represent an important historical heritage for various countries. Strengthening solutions will also be addressed. A numerical part will follow the experimental one step by step.

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AUTHORS' BIOGRAPHIES

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