In-plane shear behaviour of traditional timber walls

Graça Vasconcelos[1], Elisa Poletti[1], Eunice Salavessa[2] Abílio A.M Jesus[3], Paulo B. Lourenço[1], Preecha Pilaon[4]

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 aimed at improving the global stability of masonry buildings under seismic loadings. This paper aims at getting experimental insight on the mechanical in-plane behaviour of such timber–framed walls.

Keywords timber-framed wall, cyclic tests, shear resistance, dissipation of energy, ultimate deformation, hysteresis model

1. INTRODUCTION ON TRADITIONAL HALF-TIMBERED STRUCTURES

Half-timbered buildings are well known as one of the most efficient seismic resistant structures in the world, but their popularity is not only due to their seismic performance, but also to their low cost and the strength they offer. An important issue is to study these kinds of structures under cyclic and dynamic loads to better understand their behaviour when subjected to horizontal loads.
The origin of half-timbered structures probably goes back to the Roman Empire and they later spread throughout Europe, Asia and America (Cóias 2007). Different geometries were used, but the common idea is that the timber frame confining the masonry can provide a better resistance to horizontal loads.

2. TESTS LAYOUT AND ANALYSIS OF TEST RESULTS

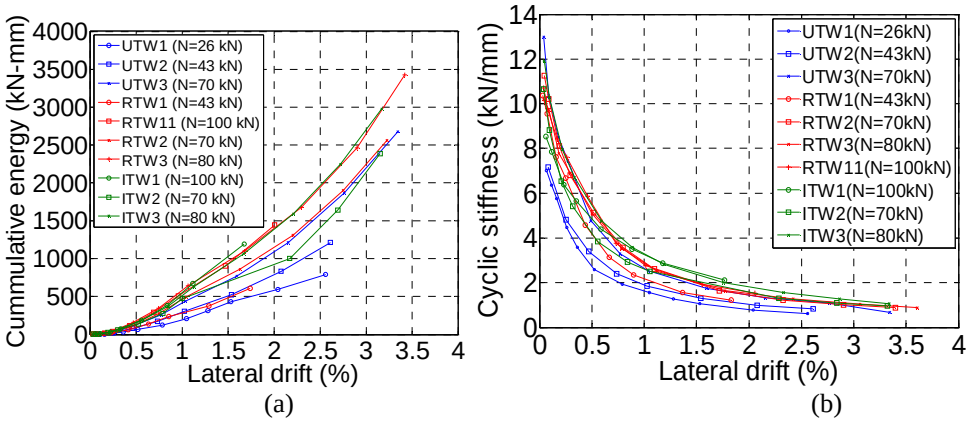
Three wall typologies were considered: unreinforced walls (UTW), reinforced walls with Fiber-Reinforced Plastic (RTW) and infill walls (ITW). Nine wall specimens, three identical samples for each typology, were made and subjected to cyclic loading in vertical and horizontal direction. All walls were 80 × 90 cm. Cyclic tests were performed on the three above described specimens. For each of the three specimens of each type, a different vertical pre-compression was applied.

2.1. Seismic parameters

Seismic parameters, such as ductility, cyclic stiffness, energy dissipation and equivalent viscous damping ratios were derived from the hysteresis loops in order to analyse the behaviour of the walls, which is essential for the design of new timber structures or the rehabilitation of existing structures.

[1]ISISE, Department of Civil Engineer, University of Minho, Portugal (graca@civil.uminho.pt)
[2]Engineering Department - ECT, University of Trás-os-Montes e Alto Douro, Portugal
[3]IDMEC/LAETA/ Engineering Department - ECT, University of Trás-os-Montes e Alto Douro, Portugal
[4]Master Student, Master in Structural Analysis in Historical Constructions

It was observed that the envelope curves from all walls do not have distinct yield points. It appears that ductility decreases with the increase in vertical load up to the level which can induce shear failure. The amount of energy dissipated in the specimens is not significantly different from one another for small values of lateral drift (Figure 1a). For higher values, the energy dissipation exponentially increases with the increase of lateral drift. In general, the UTW walls dissipate less energy, even if in a minimum quantity, pointing out the contribution given by the infill in the other cases (Pilaon 2010).



(a) (b)

Figure 1 – (a) Cumulative energy dissipated by wall specimens and (b) overall cyclic stiffness of the walls.

Considering the change in the overall stiffness (Figure 1b), it is seen that the stiffness decreases exponentially and eventually approaches a certain value of residual stiffness at the end of the test. Moreover, under the same levels of vertical load and lateral drift, RTW has higher overall cyclic stiffness than UTW but lower than ITW. This is attributed to the fact that the damage in ITW is distributed to the infill material, therefore slowing the rate of degradation (Pilaon 2010).
A hysteretic model for the walls was derived based on the model proposed by Takeda (1970), which gave a good comparison with the experimental results.

3. CONCLUSIONS

This paper aims at studying the cyclic behaviour of traditional half-timbered walls typical of Pombalino buildings. Three different wall typologies were considered. Stiffness and strength degradation are higher for timber walls without infill, whilst the infill and strengthened walls are able to dissipate higher amounts of energy. The cyclic stiffness increases with the vertical load. For the same levels of vertical load, strengthened walls exhibited higher overall cyclic stiffness than the timber frame walls. Moreover, the stiffness degradation was slower.

REFERENCES

Cóias, V. (2007). *Reabilitação Estrutural de Edifícios Antigos*. ARGUMENTUM, GECoPRA, Lisbon.

Pilaon, P. (2010). *Experimental cyclic behaviour of timber shear walls*. MSc Thesis, Advanced Masters in Structural Analysis of Monuments and Historical Constructions.

Takeda, T., Sozen, M. A., and Nielsen, N. N. (1970). "Reinforced Concrete Response to Simulated Earthquake." *Journal of the Structural Division*, 96:12, 2557-2573.