Semana de Engenharia 2010
Guimarães, 11 a 15 de Outubro

CHARACTERIZATION OF THE SEISMIC BEHAVIOUR OF TRADITIONAL TIMBER FRAME WALLS

Elisa Poletti and Graça Vasconcelos
ISISE, Department of Civil Engineering, University of Minho
E-mail: elisapoletti@civil.uminho.pt

KEYWORDS
Half-timbered structures, shear walls, cyclic tests, hysteretic model.

ABSTRACT

Traditional half-timbered structures are very common all over the world and represent an important cultural heritage for many countries, but very scarce information is available on their behaviour. An investigation is going to start in the next months that aims at filling this research gap. Static in-plane monotonic and cyclic tests will be carried out both on connections and walls and the results will be validated with non linear numerical simulations. Numerical analyses will then be carried out to study the influence of half-timbered walls on the behaviour of masonry buildings. This project is still at a preliminary stage, so only general information on the outline of the work will be given.

INTRODUCTION

Timber and masonry structural solutions have been used since ancient times and they constitute an important built cultural heritage that still exists today. The conservation of ancient construction heritage is a demand of modern societies and a great research effort has been made on ancient materials and structures in order to better understand their mechanical behaviour and to propose remedial and strengthening measures. One of the main reasons for the need of strengthening is the vulnerability of these structures to seismic hazard.

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.

USE AND DISSEMINATION OF HALF-TIMBERED BUILDINGS

Half-timbered buildings are diffused all over the world (Figure 1). Their origin probably goes back to the Roman Empire, as in archaeological sites half-timber houses were found and where referred to as Opus Craticium by Vitruvius (Langenbach, 2009). These constructions later spread not only throughout Europe, such as Portugal, Italy (casa baraccata), Germany (fachwerk), Greece, France (colombage), Scandinavia, United Kingdom (half-timber), Spain (entramados) etc., but also in India (dhaji-dewari) and Turkey (himis) (Cóias 2007; Langenbach 2009). These structures generally consist of exterior masonry walls with timber elements embedded which tie the walls together and internal walls which have a timber frame with rubble masonry infill and act as shear walls.

Figure 1: Typical half-timbered structures: a Pombalino wall in Lisbon (left) and a half-timbered building in Herefordshire, England (right)

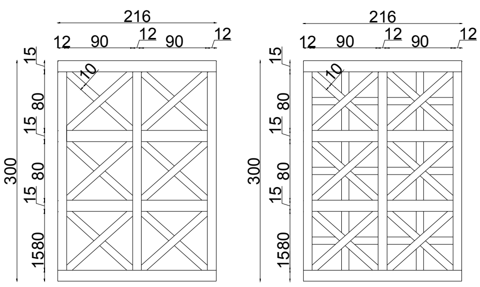
Traditional connections

The behaviour of such structures is mainly governed by the behaviour of their connections. Concerning the global rigidity of the structure it is fundamental to understand how the connections work, in particular the allowed movement of the various parts. The possibility of having relative displacements and rotations among the parts could contribute to confer ductility to the timber structure. Besides, in the pombalino buildings it is important to analyze not only the timber structure but also its connection to the masonry. In traditional connections, such as mortise and tenon connections, overlapping connections, dovetail joints, notched ones, bird's mouth, scarf joints, etc., the stresses are transmitted through friction and compression on the interface of the elements to be connected. Nails are sometimes introduced to stabilize connections and prevent possible inversions of stresses.

EXPERIMENTAL PROGRAM

Given the complexity of the behaviour of timber structures under seismic action, especially concerning traditional timber joints, and due to the lack of expertise on the mechanical behaviour of Pombalino timber frame walls, sound research on the monotonic and cyclic behaviour of these walls is needed.

At first, the material properties will be deduced, a fundamental task as they will be later applied to the numerical analysis that will try to find a correspondence with the experimental results. The same will happen with the results obtained from the connection tests, from which a hysteretic model will be deduced and will then be applied and fitted to the numerical models of the walls. This is an important point, as the same results should be obtained in terms of ultimate strength, stiffness, ductility, etc. Connections will be tested both under monotonic and cyclic loading, in order to obtain information on their dissipative capacity. Different connection configurations will be envisaged, considering different geometries, notch depth for the mortise and tenon connections, use of steel fasteners, influence of the diagonal elements.
Cyclic tests will then be carried out on the walls and the comparison among the hysteretic behaviour of the connections and of the walls will be made, to appreciate how the connections control the behaviour of the wall. For the walls, different geometries of the timber frame will be considered (Figure 2) as well as different infill materials, which can be rubble masonry as well as a composite gypsum and cork based material (Vasconcelos et al. 2010). All the results will be evaluated against numerical analyses and as a last task a whole half-timbered building will be analyzed and the influence of the walls will be studied.



Figures 2: Different geometries for timber frame walls

CONCLUSIONS

In this paper the outline of an experimental and numerical campaign is presented. The work is still being planned and possibly some changes will be made, but the authors aim at filling the research gap on the behaviour of traditional timber frame shear walls.

REFERENCES

Cóias, V. 2007. *Reabilitação estrutural de edifícios antigos.* ARGUMENTUM, GECoRPA.
Langenbach, R. 2009. *DON'T TEAR IT DOWN! Preserving the earthquake resistant vernacular architecture of Kashmir*. UNESCO. New Delhi.
Vasconcelos, G., Poletti, E., Medeiros, P., Mendonça, P. Carvalho, P., Cunha, S. 2010. Innovative masonry blocks for partition walls. In *Proceedings of the 37th IAHS World Congress on Housing Science* (Santander, Spain, Oct.26-29).

ACKNOWLEDGEMENTS

The first author would like to acknowledge the Portuguese Foundation for Science and Technology, for her PhD grant, with the reference SFRH/BD/61908/2009.

AUTHOR BIOGRAPHIES

ELISA POLETTI was born in Parma, Italy and went to the University of Parma, where he studied Civil Engineering obtaining her Bachelor's Degree in 2006 and her Master's in Structural Engineer in 2009. After graduation, she moved to University of Minho, where she is now doing her PhD in Civil Engineering. Her e-mail address is : `elisapoletti@civil.uminho.pt`.