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SEISMIC CHARACTERIZATION OF TRADITIONAL TIMBER FRAME WALLS: EXPERIMENTAL RESULTS

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ABSTRACT

Traditionally, timber frame walls have been used in various countries throughout the centuries, both for their being a valid construction technique with easily available materials (wood, bricks, stones, mortar, mud, hay, etc.) and for their seismic performance. A thorough experimental campaign has been carried out in order to assess the seismic behaviour of both unreinforced and retrofitted timber frame walls through in plane static cyclic tests. Different types of infill and vertical pre-compression levels have been considered. Results are here presented in terms of cyclic behaviour and seismic parameters performance, such as stiffness degradation, energy dissipation and viscous damping.

Keywords: timber-framed, cyclic test, stiffness, viscous damping.

INTRODUCTION

Timber frame buildings, or half-timbered, 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, as few experimental studies are available and it is important to fill this experimental gap in order to preserve the existing historical buildings.

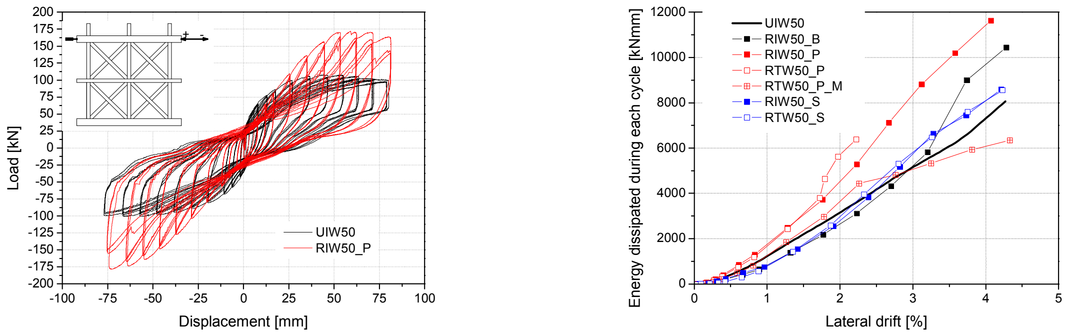
The origin of half-timbered structures probably goes back to the Roman Empire and they later spread throughout Europe, Asia and America (Langenbach, 2007). Different geometries were used, but the common idea is that the timber frame confining the masonry can provide a better resistance to horizontal loads. There is a great variability in terms of sectional dimensions of wood, type of wood and infill type, but all typologies were observed to be able to resist appropriately to seismic actions (Langenbach, 2007; Gülhan, 2000).

In plane static cyclic tests were performed on unreinforced and retrofitted timber frame walls taking into account two vertical load levels and for each one two types of infill, namely brick masonry and wood strips filled with mortar ("fasquio" in Portuguese). The option with no infill was also tested. The walls were subsequently retrofitted considering, for each vertical load level, three strengthening solutions: (1) bolts in main connections; (2) steel plates in main connections; (3) near surface mounted (NSM) strengthening with steel flat bars.

RESULTS AND CONCLUSIONS

All unreinforced infill walls exhibited a flexural behaviour with a significant uplifting of the lateral posts. The timber frame walls without infill instead showed a clear shear behaviour, but with lower stiffness, maximum load and energy dissipation capacity. Moreover, a higher vertical pre-compression level led to higher values of maximum load, stiffness dissipated energy and viscous damping, in accordance to what found in literature (Johnston, 2006).

Retrofitted walls were all able to guarantee a better performance of the walls in terms of maximum load and cyclic stiffness (see Fig.1a), being the cyclic behaviour predominated by shear resisting mechanism. In terms of seismic parameters, steel plates resulted in a considerable stiffening of the walls, leading to a reduced ductility. All retrofitting techniques led to an improvement of both the dissipative and damping capacity of the walls (see Fig.1b).



(a) (b)

Fig. 1 - Typical results obtained: (a) hysteretic response of unreinforced wall (black) and wall retrofitted with steel plates (red); (b) energy dissipated by walls during test.

To conclude, the strengthening techniques proposed were able to prevent the highly flexural behaviour of unreinforced walls. The latter still presented a good seismic response, which has been improved through the retrofitting solutions proposed. The presence of infill greatly changes the response of the timber frame wall, whereas the infill material doesn't appear to have a major role on the differentiation of the response. Moreover, a higher vertical load led to higher values of all parameters analysed.

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