Assessment and intervention on the timber structure of a XVII century building in Lisbon; an example of seismic retrofitting.

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Abstract The present work aims describing the interventions performed on the timber structures of Valadares Palace, a building reconstructed after the 1755 Lisbon earthquake and endowed with some of the constructive techniques applied to the Lisbon post-seismic constructions, namely a large number of timber structural elements at floors, roofs, interior walls and even within the exterior stone masonry walls. The Nucleus for the Conservation and Rehabilitation of Buildings and Built Heritage (NCREP) of the Faculty of Engineering of Porto University (FEUP) was responsible for the structural rehabilitation project, which aimed simultaneously the improvement of the global behaviour of the building through localized interventions using traditional materials and techniques and the preservation of the majority of the building's structural elements.

Keywords Structural assessment, timber structures, seismic retrofitting

1. INTRODUCTION

In the scope of the rehabilitation project to provide Valadares Palace with the adequate conditions to receive a Museum, and to evaluate and improve, if necessary, its seismic behaviour for current performance requirements, a full structural assessment was performed: a survey using non destructive techniques (namely Resistograph in the timber elements and in situ dynamic tests), followed by a structural numerical analysis. The elements' degradation was analyzed and the response and vulnerability of the structure to the static and dynamic design code actions were evaluated.

The location of the building in Lisbon, a region of moderate-high seismicity, was naturally taken into account in the project and the seismic actions conditioned the level and the type of intervention to carry out, leading to a commitment between intrusiveness level and heritage preservation, within safety conditions. Minimal, heritage respectful and, simultaneously, structurally efficient solutions were then designed to promote a more global behaviour of the building, namely through: the increase of the in-plane stiffness of floors and roofs, the improvement of the links between horizontal and vertical elements in order to increase the redundancy of the structure and to prevent the out-of-plane collapses of the masonry and, if possible, the use of traditional techniques and materials such as wood, steel, stone and lime based mortars.

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2. THE STRUCTURAL INTERVENTION

The implementation of the intervention measures, sustained by the conclusions of the structural assessment (phase 0), was divided in two phases. The phase 1 aimed preparing the building to receive a temporary exhibition. It's important to mention that, due to a tightened schedule related to the opening day of the exhibition, the period of time to conclude the intervention was very limited. In this phase, the main structural interventions were: a) the strengthening of the connections between horizontal and vertical structural elements, i.e., between timber roofs and walls; b) the design of new glue-laminated timber roof trusses, according to fire and seismic-resistant code requirements; c) the rehabilitation and strengthening of the existing support structures of the ceilings.
The phase 2 of the intervention, which is still under development, aims the rehabilitation of the remaining building structures, namely the timber floors, the "frontal" walls and the stone masonry walls. Thus, the designed solutions aimed the promotion of a more global behaviour of the building, namely through the improvement of the connections between structural elements (floors, walls and roofs). The main structural solutions foreseen for this phase were: a) strengthening of the connections between timber floors and walls; b) strengthening of the in-plane and out-of-plane characteristics of the timber floors, ensuring an efficient diaphragm behaviour; c) reinforcement of the connections between the "frontal" walls and the stone masonry walls to ensure a global "box" behaviour, as required for seismic resistance; d) improvement of the local continuity of the "frontal" walls and of their global in-plane behaviour through the introduction of bracing elements.

Figure 1 – Exterior photo of Valadares Palace and details of the structural intervention.

3. CONCLUSIONS

The intervention in built heritage is a way of preserving cultural identity. Therefore, it demands special care and knowledge. In particular, the rehabilitation of old buildings concerns not only façades, but all the structural elements, namely floors, roofs, and inside walls, as part of a more consistent heritage. However, most of the interventions on old buildings consist in the substitution of the structural elements instead of their rehabilitation. This situation results mostly of a lack of knowledge and understanding of the existing materials and of the rehabilitation/strengthening techniques. An effort should be done to invert this situation i.e., to show the community that it is possible to preserve timber structures and, at the same time, to use traditional materials and techniques.
The rehabilitation of Valadares Palace is an example of an intervention in which those concerns were considered. After a careful assessment of the materials and the state of conservation of the structural elements, a series of rehabilitation/strengthening solutions with traditional materials and techniques was specifically designed for the building. The objective of this procedure was to improve the building's seismic and static performance, but still making use of the existing structural elements, increasing and protecting its heritage value. As a final result, the so-called "box behaviour" was ensured by improving the connections between the vertical elements and the strengthened timber roofs and floors.

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