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Structural Characterization of 13th Century Building placed in Trás-os-Montes Region

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Abstract

The objective of this work is the study of the structural characterization of a 13th century building, placed in Trás-os-Montes, Portugal. In the rehabilitation of a building, the study of the architectural and structural plants is very important, being, usually, necessary to do an architectural and structural inspection and mechanical campaign, to characterize the building completely. With the support of the architectural and structural designs it is easier to locate the damages and/or pathologies, understanding the structural behavior and the influence of the detected damages in the response of the structure, assessing the degree of risk of those damages in the structural stability of the building, leading to a better rehabilitation plan. It is imperative to know the mechanical characteristics of the materials that compose the structures, to repair, and if needed replace them, according to its features, conducting to a sustainable rehabilitation, and preserving the original characteristics.

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Keywords: Masonry structures; Wood structures; Historical buildings; Rehabilitation; Sructural characterization.

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1. Introduction

Old city centers are history physical testimony of the human adaptation [1, 2]. The architectural and structural knowledge of a historic structure and the correct identification of its pathologies and their origins are the base for a correct and viable rehabilitation and maintenance plan [3]. The architectural and structural knowledge is important to select the right inspection tools, conducting to a correct preservation status, leading to an economic/good rehabilitation [4]. Historic structures rehabilitation and conservation is interesting and difficult due to the many peculiarities of each case-study [5]. The information transmission between the various performers in the rehabilitation process must be clear, being necessary to do a detailed and complete architectural, structural, material and pathological characterization [6]. This paper presents the structural behavior characterization of the case-study building, concluding with some inferences that could be made.

2. Structural characterization

2.1. Introduction

The case-study building has a medieval based architecture, which gives grate value to it. It's composed by Inn and the cereals storage buildings in the surroundings. In Fig. 1 are presented the plants of the two floors of the building and the roof and in Fig. 2 the cuts of the building. The building is made with stone masonry walls and wood roof structure covered with ceramic tile. The building has a rectangular plant, with external access made by stairs in stone. In terms of interior spatial organization, in the basement, were the storage rooms and on the first floor, the kitchen, living room and bedrooms.

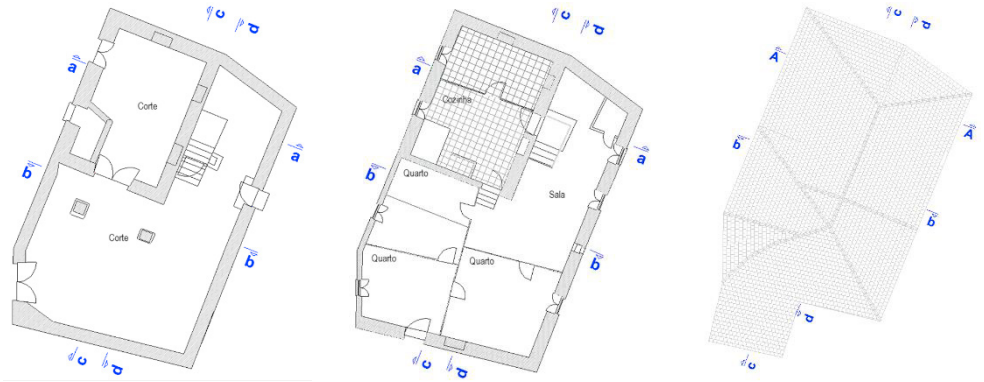

Fig. 1. Architectural survey of the building: (a) basement plant; (b) first floor plant; (c) roof plant (Images from: [7]).

Fig. 2. Cuts of the building: (a) cut a-a; (b) cut c-c; (c) cut d-d; (d) cut b-b (images from: [7]).

2.2. Structural characterization

A complete structural characterization requires to have the original structure design, and if it is the case, the records of the interventions that occurred. It's necessary to know the structural materials properties. The visual inspection should be complemented with those designs to do a critical analysis of the observed damages in the behaviour of the structural elements. In Fig. 3 are presented the structural plants of the basement, first floor and roof.

Fig. 3. Structural plants: (a) basement; (b) first floor; (c) roof (images adapted from: [7]).

2.2.1. Structural characterization

The foundations are executed in stone masonry, normally with poorer masonry than the used in building, made of brakes or perpend, in depths until they reach firm ground to better stability [6]. It was considered the foundations exists in the alignment of the masonry walls of the basement floor, fact that could not be proven by the difficulty in access the foundations. The foundations are wider than he masonry walls. By visual inspection was seen that the foundation soil was rocky, thus wasn't necessary to use wooden trunks arranged on piles. Masonry foundations, usually, were built by opening a trench, and filling it until it reaches the ground level.

2.2.2. Exterior walls

The masonry walls, made with stone and mortars, have has structural function, resist to the vertical and horizontal loads. It is normal that those walls have a great thickness, resulting in heavy and rigid components, with low tensile strength. There is a relation between the span of the building and the thickness of the resisting walls. The case-study building has resistant walls, made with shale stones, and with thickness of 0.70 m in the basement and 1st floor. The walls in the 2nd floor (roof) have a 0.50 m thickness. Fig. 4 presents the masonry walls of the Inn.


(a)


(b)

Fig. 4. Exterior stone masonry walls: (a) basement/first floor; (b) second floor (roof) (images from: [7]).

2.2.3. Wood floors structure

The division between floors is made with wood (chestnut) structures, composed by a truss of wood, made with grated sticks, with diameters between 0.14 and 0.35m and lengths that depend on the spans between walls of the house, not exceeding 7 m. The rolled sticks are supported in the two extremities by the masonry walls, with a delivery of about 2/3 of the thickness of the walls, and sometimes in all their thickness, and sustenance the floor and ceiling coverings. In some cases, flanks with four faces may be used in the walls. To protection of the beams was made by painting it with oil paint, red lead or tar, after their placement [8]. The rolled beams are parallel to each other, with spacing between 50 to 70 cm. Fig. 5 presents some examples of the pavement structures of the building.


(a)


(b)

Fig. 5. Wooden beams supported by masonry walls (images from: [7]).

2.2.4. Roof wood structure

The roof wood (chestnut) structure of the Gralheira Inn is still the original, with rudimentary form, permits to use the span of the roof that is freed of structural elements. This structure is made with frames, each one composed by two bars (legs), joined top half of wood (like scissors) and supported on a horizontal beam (line) that, rests on the masonry structural walls. Frequently, the frame is locked transversally by another, small dimension, bar, level, placed at about 2/3 of the height, and supported by the legs, by fitting at half-wood. The longitudinal locking structure is made with the mother beams, in the top of the scissors, and the sticks, at half span of both legs. In the transition from the main slopes to the tacan, a beam (corner) rests on the row and on the counterfrech, between the interior walls and exterior walls. All the frame beams are similar to the beams used in wood floors structure, rolled sticks, but some have lower diameters. In Fig. 6 are presented some photos of the beams of the roof structure.


(a)


(b)

Fig. 6. Roof wood structural beams (images from: [7]).

2.3. Structural behavior

The building masonry walls (Fig. 3) are supported by masonry foundations. The pavements between floors and roof structure unload in the exterior masonry walls. In the ground floor, in exists masonry walls basement (Fig. 3 (a)), which are supported by the ground. The wood partition walls of the first floor (Fig. 3 (b)) unload in the floor between ground and first floor.

4. Conclusions

The 13th century building has a simple rectangular plant, made with stone masonry walls and original wood floors and roof. It is important to know the history of the building restorations and materials used, to identify some pathologies due to incompatibility of materials. The structure is the typical of a building of this epoch, with masonry foundations in the perimeter of the building, resistant exterior masonry walls, masonry walls making the division of the ground floor, and wooden partition walls making the division of the first floor in compartments. The beams that support the floor and the roof unload in the masonry walls, which conducts the loads to the foundations. This work aims to help the understanding of antique structures behavior, to be easier correlate it with the existing pathologies, in order to perform a good and economic building rehabilitation.

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