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Reliability of visual inspection, an example of timber structure in Valencia, Spain

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ABSTRACT: In the process of surveying a building, the detailed assessment of historic timber structures is fundamental in order not to encounter unexpected issues during project and construction phases. Due to the general lack of knowledge about historic timber structures, this assessment it is often underestimated or not done, leading to the complete elimination of significant heritage. This article deals with the reliability of the assessment of wood degradation through visual inspections and the use of wood awls. The case study is a timber roof in Valencia, Spain, yet this method is easily applicable to many other cases. The comparison between the assessment and the real state of conservation will show how the prediction is more reliable the more accessible the analyzed elements are. Finally, even when the accessibility is reduced, the assessment can anyway show to the designer where further studies are needed and where conservation issues could emerge during the restoration works.

Keywords: timber, visual inspection, assessment, wood degradation, roof structure, Valencia

1 INTRODUCTION

In the Valencian region the presence and use of wood in traditional architecture is limited to roof and floor structures. The simple configuration of these structures in the common civil architecture produces a generalized lack of interest about their conservation. During the restoration of these historic buildings, the timber structures are not usually properly analyzed and therefore the probability of their preservation is significantly reduced.

Even without the use of sophisticated instruments it is possible to perform a visual inspection on the timber elements with the help of a wood awl in order to identify the material decay and consequent reduction of the cross section caused both by wood boring insects and rot. This type of assessment can be easily done in the majority of timber structures.

The goal of the inspection is to get near enough to the wood so that all the faces of each element can be observed from very close and through piercing the material with a wood awl is possible to identify the degradation under the surface. The depth that can reach the wood awl with the manual strength and the resistance of the wood are clear indicators of the health of the material.

It is clear that, without the help of instruments that can reach the hidden parts of the timber elements, the assessment has a degree of uncertainty. In order to evaluate this uncertainty a case study has been considered. A timber roof in Valencia has been visually inspected

Figure 1. Mid-19th century building in the historic center of Valencia, Spain. Case study.

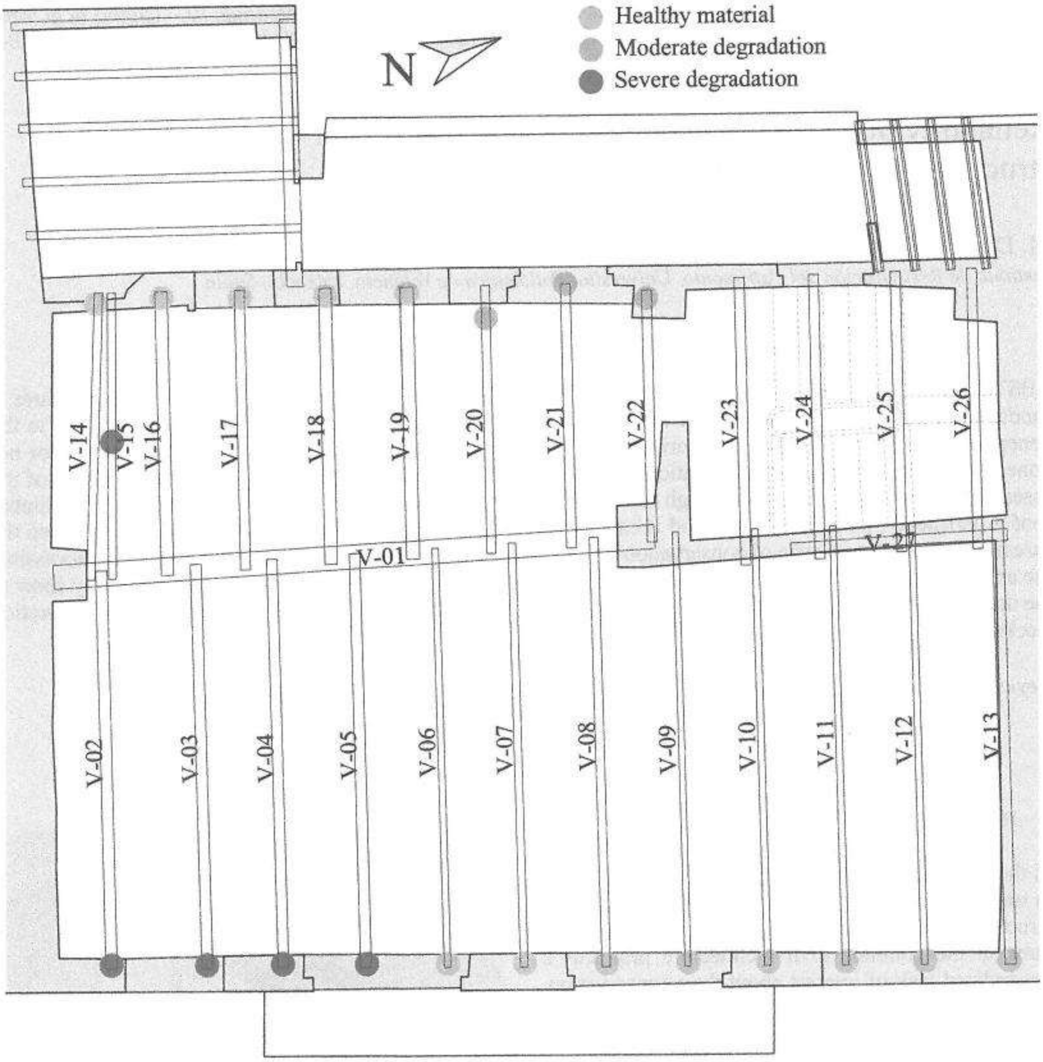

Figure 2. Plan of the roof with the codes of the timber elements studied.

in order to assess its degradation and afterwards this assessment has been compared with the actual state of conservation that became visible once the layers that covered the roof structure were removed. This comparison finally allowed the estimation of the reliability of this method.

2 DESCRIPTION OF THE STRUCTURE

The case study is the roof structure of a mid-19th century building in the historic center of Valencia, Spain.

The building has a gable roof; the structure has a main beam with a square section (22 × 22 cm) that shapes the roof's ridge. This beam rests on top of two pillars and two timber brackets which are supposed to be contemporary to the construction of the structure since they are embedded in the masonry of the pillars and the nails used in the union with the main beam seem hand made.

The main beam supports two series of rafters with different slopes profiling the two fields of roof: 12 rafters supported by the façade wall, facing east, and 13 rafters supported by the rear wall, facing west, four of these are not analyzed because hidden behind the false ceiling above the staircase (V-23 to V-26), three of them are supported by a plate inside the wall, V-27. The sections of these rafters are variables because some of them are replacements: the original ones, V-02 to V-05, V-13 and V-16 to V-22, have a cross section of approximately 10 × 20 cm while the

Figure 3. Roof structure.

substitutions, V-06 to V-12, have a cross section of approximately 6×21 cm; finally V-14 and V-15 have completely different and smaller sections. The timber structure was covered, on the west field of roof, with a layer of flat bricks on top of a series of battens perpendicular to the rafters, finally protected by a layer of tiles; on the other hand, the east field of roof was built with fiber cement corrugated sheets with almost no secondary structure. As the rafters, also the battens have very different sizes: 8×3.5 cm, 6.5×4 cm or 4.5×7.5 cm.

The two rooms added west to the main building use to be the kitchen and the bathroom, the roof structure of the first has four beams (7.5×11 cm) which hold another layer of flat bricks, while the second is covered by four beams (8×8.5 cm) decorated with two three-quarter molding. These two structures are new additions from the mid-20th century and will remain outside the present analysis although, as the rest of the structure, have been preserved and restored during the conservation works.

The microscopic identification of the wood species revealed that the original elements of timber belonged to the *Pinus nigra-sylvestris* group of species. Considering the population of trees in the Valencian inland and supply area, it is very probable that the wood is *Pinus nigra*.

3 ASSESSMENT

3.1 *Visual inspection*

In the effort to understand the structure, it is important to systematize the process of knowledge to every single supporting element so each structural timber piece has to be designated with a univocal code. The fundamental issue with timber structures is that it is impossible to extrapolate the presence of decay from one rafter to another.

In this case, the two fields of roof have a very different degree of accessibility. The east field of roof

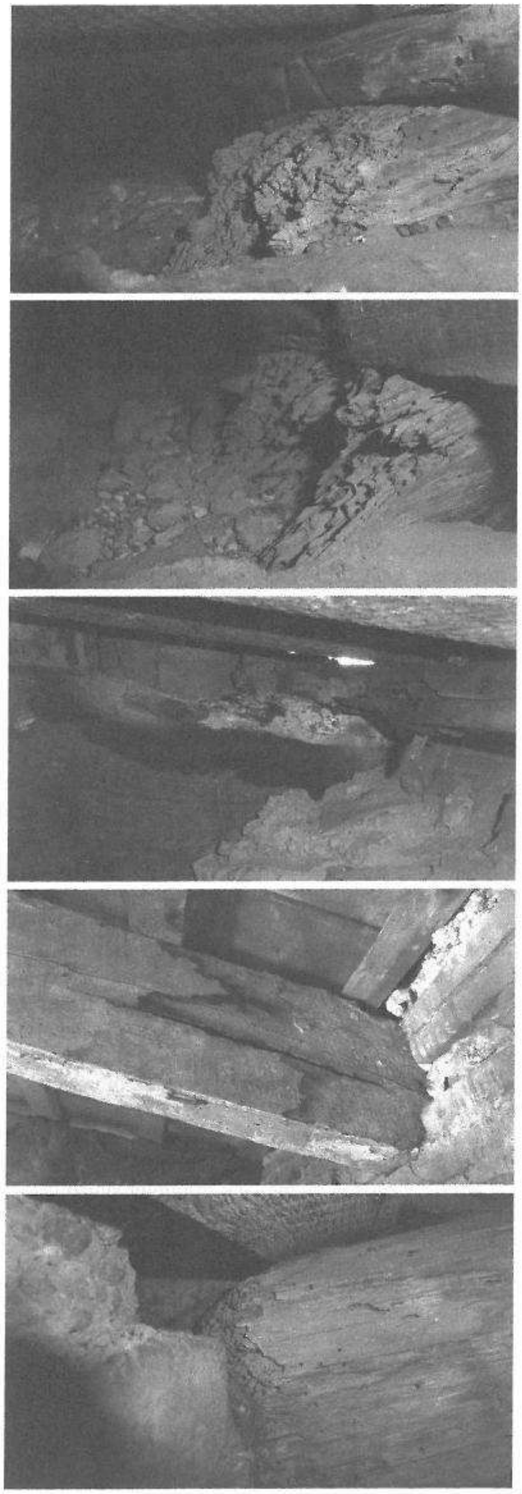

Figure 4. Rafters: V-02, V-03, V-13, V-20 and V-22.

with its light and almost provisional structure leaved a small space that could be used to access with a camera to the rafters' end while in the west field of roof the rafters' ends were fully embedded within the masonry.

So, even if the most part of the rafters' surface was visible, the inspection concentrated on the usual problematic points: the ends. The difficult access and the direct contact with the masonry can results in the unsuspected entrance of both water and termites.

As a general fact it should be noted that the attack of wood-boring insects from the family of *Anobiidae* from the *Coleoptera* order, however not active, had been widespread. Nonetheless the damage caused concerned only the superficial centimeters and it was not a risk for the stability of the structure.

The fundamental agents that can cause a deep damage and a significant reduction of the rafters' section are two: the rot caused by the proliferation of fungal attacks on humid wood due to infiltrations and the termites of the order *Isoptera*, and especially the species *Kalotermes flavicollis* and *Retuculitermes lucifugus*, endemic in the Valencian region.

As can be seen in Figure 2 the degradation seemed to be concentrated in two specific areas.

Concerning the eastern rafters, the ends of V-02 to V-05 could be photographed and the damage made by the termites was clearly revealed (Fig. 4) however no insects were detected. Similarly, rafter V-13 was visibly affected by the infiltration of water due to the poor condition and execution of the roof. In all these cases the supporting area was greatly reduced.

Regarding the western rafters the interpretations were more uncertain. Even if it was not possible to assess in details the state of conservation, the ends of rafters V-21 and V-22 seemed damaged, while in rafter V-20, near the end, some infiltration water had been channeled inside the element that was partially rotted; this decay could be prolonged also to the material inside the wall.

Finally rafter V-15 had a diffuse attack of insects of the family of *Cerambycidae* or *Curculionida*, which had significantly decreased its section. This element, together with the V-14, appears to be a last-minute remedy possibly caused by the lack of bigger substitution element.

3.2 *Real state of conservation*

Once the protection of the roof structure was dismantled it was possible to see the real state of conservation of the elements and their ends and to compare the results with the visual inspection.

In the case of rafters V-02 to V-05 and V-13 the visual assessment had a 100% of correspondence to the real damage. The rafters' ends had completely disappeared due to termites even if the attack was not active. It also seemed that the problem was amplified by the humidity caused by the integrated gutter that historically passed near the rafters' ends and that maybe caused also the degradation and former substitution of the rest of rafters in the same field of roof.

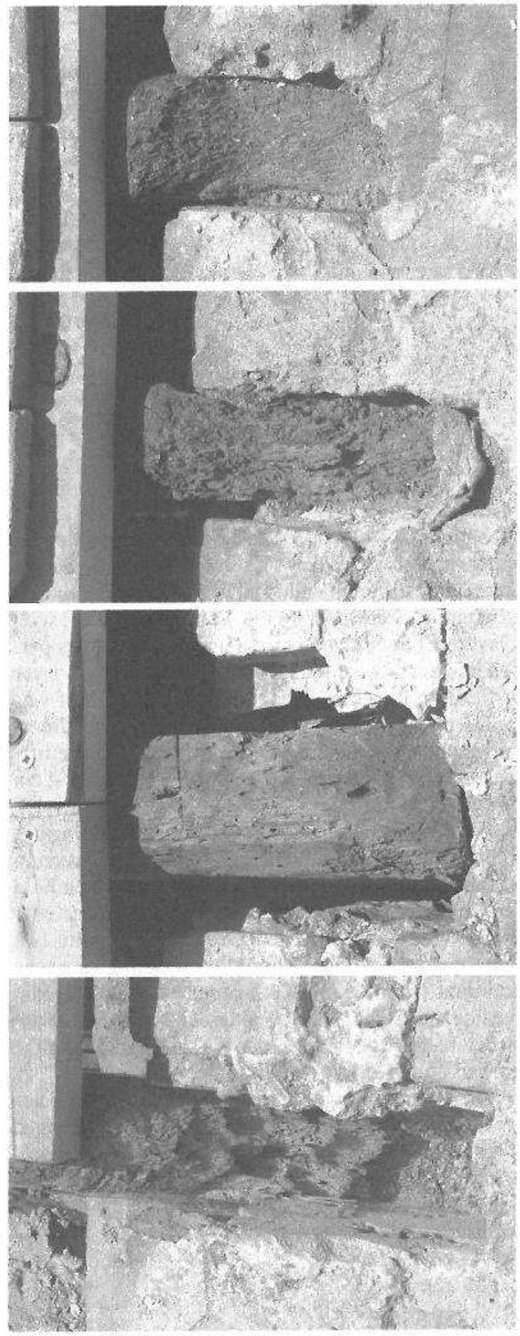

Figure 5. Rafters: V-19, V-20, V-21 and V-22.

On the other hand, in the western rafters where the inspection had been more difficult because of the reduced accessibility to the ends inside the masonry, the reliability was partially reduced.

Rafters V-20 to V-22 were considered with the same degree of degradation while, once revealed, they have different extent of decay (Fig. 5).

V-22 had a great damage similar to the eastern rafters that could just be glimpsed from outside. V-21 was in good health as the rafters V-16 to V-18. Finally V-20 had a moderate extent of damage that is similar to the one found in V-19 which however was not detected in the inspection.

4 CONCLUSIONS

From the described example, can be inferred that the reliability of the assessment method through visual inspection and testing with wood awl is good.

While in the case of having visual access, at least with a camera, to the analyzed elements ensures the absolute reliability of the assessment, this is slightly reduced in the other cases. In the circumstance where is not possible to fully examine the rafters' ends because they are inside the masonry, the prediction given by the use of wood awls can give an indication of where further problems may be found. Although this part of the results will not give a 100% of correspondence with the reality, the indications are very helpful during the design and mainly during the construction works so the designer and the builder are prepared and alert to manage issues in specific areas of the building that they may need a detailed intervention.

With this simple method it is then possible to adjust the contingencies that always rise up the prize of the restoration work.

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