Inspection and diagnosis of a wooden floor structure of the Monastery of Santa Maria de Pombeiro

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Abstract In this paper the practical application of a methodology for the inspection and diagnosis of a wooden floor structure of the Monastery of Santa Maria de Pombeiro, near Felgueiras, Portugal. The methodology uses visual inspection and non-destructive testing, including Pilodyn, Resistograph and ultrasounds. The use of NDT in this case study allowed the definition of guidelines for the performance of the tests, identifying the difficulties and advantages of each test procedure. 17 oak beams of the floor structure of the corridor of monk's cells were inspected and diagnosed, being tested at three different locations - on each end of the beam and at middle span. The results suggest that visual inspection is a good approach when complemented with inspection by Pilodyn and Resistograph. The use of ultrasound showed a large scatter in results, and therefore not suitable for practical applications in irregular wooden elements, or with difficult access.

Keywords NDT, diagnosis, visual inspection, heritage, Pilodyn, Resistograph

1. INTRODUCTION

1.1. Overview

Currently, when rehabilitating old buildings with wooden structures, an uneconomic attitude is adopted but the technician must be able to contribute to the safeguarding of the building, by identifying which elements are to keep, to be replace, or to be repair, and therefore leading to significant savings in the cost, not to mention the conservation principle of maximizing preservation of the original.

In this article a description of a method of inspection and diagnosis using non-destructive testing (NDT) is given. It is applied to asses the conservation status of 17 oak beams from the wooden floor of the corridor leading to cells, on the second floor of Monastery of Santa Maria de Pombeiro, near Felgueiras. As a result it is hoped the beams to be kept, partially replaced or totally replaced is defined. The various NDT used, such as the penetration with Pilodyn, the Resistograph drilling, and the use of ultrasound, will be evaluated to determine the scatter of results among different methods, their advantages and limitations, and in addition, the relationship between these and the results obtained by visual inspection.

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2. STUDY OF THE WOODEN FLOOR STRUCTURE

2.1. Inspection methodology

Visual inspection was used to search for biological attacks, to observe construction details, ventilation, water content and wood defects. The penetration with Pilodyn, the boring with Resistograph and the ultra-sound testing were applied at three test locations (A, B and C). Locations A and C are approximately 10 cm away from the masonry support, and location B is located mid-span.

2.2. Test results and analysis

Based on the test results of the Pilodyn, and for the beams examined, a test location with low hardness is observed where the Pilodyn penetrates 21 mm. This result shows that the beam at this location is quite possibly damaged by the action of woodworm. For an analysis of water content of the beams inspected, it appears that the average is above 18 %, which favours the appearance of woodworm and fungi. The water content of the beams is clearly superior at location A, where 76 % of the beams have values above 18 %, since location A is in the exterior masonry wall of granite. Analyzing the Resistograph profiles of all the beams inspected, location A has the highest number of Resistograph profiles with smaller area, for the range of 20 to 140 mm deep. These results may possibly be related to the fact that this location is a predominance of biological attacks due to higher humidity. Considering the results obtained by the ultrasonic method for beams inspected, location B is that which has the highest number of beams with lower propagation speed waves.

3. CONCLUSIONS

The main conclusions of this paper is possible to location out that visual inspection reveals itself as an effective method for diagnosis and inspection of wooden structures, and that it agrees with the results obtained by Pilodyn and Resistograph tests. Although purely qualitative, visual analysis is useful and should work in support of various non-destructive tests that can be applied in the remaining process of inspection and diagnosis. The ultra-sound test has a large scatter in the results and show no relation with the other tests. In many visually degraded areas, it showed values higher than expected and confirmed by other tests. The poor performance of ultrasound can be explained by human error in the test procedure, the physical difficulty of conducting the trial (under the beam and on top of a metal ladder) that varies the pressure of the transducers. In addition, the irregular surfaces of the beams also contribute to the erratic propagation speed of the waves. In conclusion, the ultra-sound is a test that reveals limitations when applied in situ. The Resistograph proved to be a test with good performance for the inspection and diagnosis of wooden structures, detecting damaged areas inside the beams that are impossible to detect by visual inspection. The Pilodyn showed a good performance in the inspection of the beams under study, presenting high depths of penetration beams that were superficially attacked by woodworm. Based on the obtained results, it is concluded that six beams are to be partially replaced in one of the supports. Three beams should be completely replaced by new beams, as they are in poor condition. In turn, eight beams are in good condition and should be kept.

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