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METHODOLOGY FOR SAFETY EVALUATION OF EXISTING TIMBER STRUCTURES

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EXTENDED ABSTRACT

The work present in this paper is part of the ongoing PhD thesis entitled "Methodology for Safety Evaluation of Existing Timber Structures". The main objective of this PhD is to establish a more reliable methodology to evaluate the safety level of existing timber structures and therefore making possible to take better and substantially more informed decisions with respect to maintenance actions. In this work, an experimental campaign conducted in order to assess the variability of mechanical properties of old timber beams is described. With these results a database for implementation and calibration of a hierarchical model was established.

Introduction

Along the length of a wood element it is expected to find different defects with influence in the mechanical properties. Cross sections with defects are considered weak points and failures are more probable to take place on the weakest section relative to the stress variation along the element. The properties of wood located between defects (clear wood) are expected to correspond a better mechanical behavior, thus, mechanical tests that only assess small wood samples without defects must be complemented with an analysis to the number and extent of defects. In this experimental campaign, 20 old chestnut beams (with more than 100 years) were studied with resource to non or minor destructive tests (NDT and MDT) and destructive tests (DT). The intended result of the test campaign was to analyze the influence of defects in timber elements regarding different scales and also to assess the correlations between tests. For that purpose, the timber elements were systematically cut in order to minimize the presence of defects and tested in each phase. The order of testing and sample origin is shown in Figure 1.

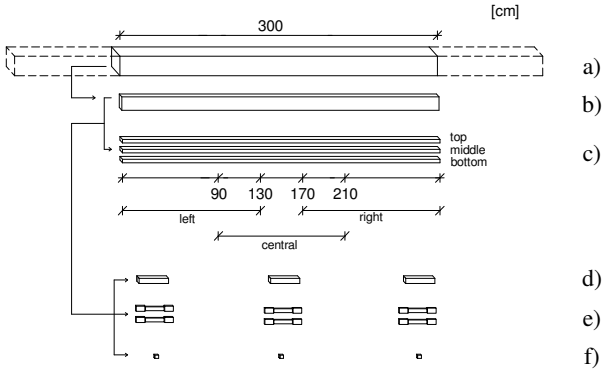

Figure 1: Samples used for each test: a) original beams; b) sawn beams; c) sawn boards; d) compression; e) tension; f) density and moisture content.

Experimental campaign

Test procedure and specimens.
Initially, the old chestnut beams were visually inspected (Figure 2) and graded with respect to Italian norms (ENIU, 2003, 2004) and complemented with NDT's (penetration impact and drilling resistance tests).

a) b)

Figure 2: Visual inspection: a) old beam; b) knot identification and measurement

Then the exterior degradation was removed and the beams were sawn in order to have rectangular cross sections. The beams were marked on segments of 40 cm and the defects were accounted. Then 4 point bending tests (CEN, 2003) were made to each beam (4 beams until failure and 16 only in elastic range), obtaining

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local ($E_{m,l}$) and global ($E_{m,g}$) modulus of elasticity in bending. After the bending tests, the beams that were not taken to failure were sawn into 3 boards each. The boards were visually inspected and assessed by NDT. To assess the variation of stiffness along the timber elements, each segment of each board was tested in a 4 point bending test. After the completion of the bending tests, clear wood samples were removed from each set of three boards in order to perform compression parallel to grain, tension parallel to grain and density tests. Ultra-sound pulse velocity tests were made for each sample before the respective destructive test.

Data analysis and results.
The strength grading according to visual inspection was considered over conservative compared to the DT's. The data obtained from NDT's and DT's was correlated. The data was analyzed regarding the different scales of the elements. The first analysis conducted to the beams regarding the wave propagation speed of the ultra-sound tests shown that two groups of elements with distinct properties were present (Figure 3), thus being assessed separately in further analysis.

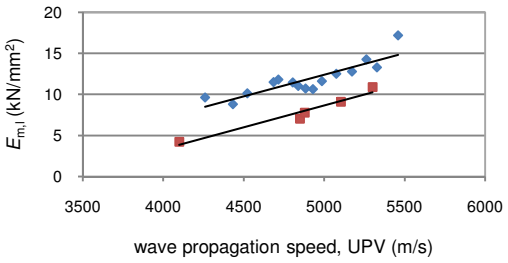

Figure 3: Visual inspection: a) old beam; b) knot identification and measurement

Density was found to be a key parameter, since the consideration of mean value of density per element scale produced different values of correlation. For full size beams or boards the mean density regarding all 20 beams produced better correlations, whereas the mean density per beam produced better correlations for the tested clear samples. Nevertheless, it was found that it is advisable to use the mean value of the three measurements of density per beam even regarding the clear samples. Better correlations were found when considering the stiffness properties between the ultra-sound testing and the bending tests with $r^2 \approx 0.80$, in compression parallel to the grain with $r^2 \approx 0.60$ and tension parallel to the grain with $r^2 \approx 0.70$.

Conclusions

The purpose of this work was to establish empirical correlations that may permit to assess existing timber elements. A considerable test campaign was made to 20 old chestnut beams in order to assess its mechanical properties and to provide a suitable strength grading. For that purpose, different tests in different scales were made to analyze the influence of defects in the local and global behavior of the timber elements.

Further work

Future work will address the implementation of a probabilistic hierarchic model. The data gathered in the experimental campaign will be used for the calibration. Analysis of decay models and implementation to study cases is also to be considered.

Acknowledgment

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AUTHOR BIOGRAPHY

HÉLDER S. SOUSA was born in Guimarães, Portugal, and obtained his civil engineering degree in the Univesrsity of Minho in 2009. Since 2009, he has been working in his PhD concerning "Methodology for safety evaluation of existing timber structures". In 2010, he participated in a STSM in Aalborg University, Denmark, within the E55 European Action about "Modeling of the performance of timber structures".