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COMBINE USE OF NDT/SDT METHODS FOR ASSESSMENT OF STRUCTURAL TIMBER MEMBERS

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A METHODOLOGY FOR THE DETERMINATION OF THE TIMBER DENSITY THROUGH THE STATISTICAL ASSESSMENT OF ND MEASUREMENTS AIMED AT IN SITU MECHANICAL IDENTIFICATION

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Abstract

The research context [1-5]. A wide experimental activity has been developed in the framework ofthe Italian project DPC-RELUIS 2010 – 2013, Line 1, Task 1 and it is ongoing on the current DPCRELUIS 2014, with the aim to provide a procedure for in situ mechanical identification of ancient timber members made of old chestnut wood (Castanea sativa Mill.) by means of non-destructive techniques (ND) and to define standardized guidelines to be used for practical applications [STAR Paper 1]. The following specimens with standard dimensions according to UNI EN 480 (2004) UNI ISO and 3789 and 3132 Italian codes (1985) were obtained: structural elements in actual dimensions (SA), squared elements in small dimensions (SS) and defect-free specimens (DF). The following ND techniques are employed [4]: Hygrometric tests (H), for the evaluation of the moisture content of wood, Ultrasonic (U) tests, for the determination of the elastic properties of wood, Sclerometric (S) tests, for the assessment of the quality and surface hardness, Resistographic (R) tests, for the detection of density variations and internal defects of wood. Destructive tests (DT) in compression (C) and in bending (B) were performed in order to assess stiffness and strength properties, post-elastic behaviour and collapse mechanisms of chestnut timber. By means of a statistical approach, linear regression of the following relations are examined: correlations between NDT parameters, relating the L and T measures by U, S and R tests; correlations between DT parameters, defining the mechanical behaviour in C and B; NDT-DT correlations, using both simple and multiple models for ND estimation of density, modulus of elasticity and strength of the material.

The definition of the methodology

Based on the results obtained, the most reliable correlation for achieving the mechanical properties of timber is the one defining a relationships among the density and the mechanical properties. Therefore the correct determination of density is compulsory. To this purpose, a method that allows the in situ identification of density of old chestnut timber members, through the use of ND techniques, has been developed. Starting point of the procedure consists in the individuation of the most reliable correlation between the examined parameters. The best linear regression equation found is the one between the density (ρ) and the sclerometric (PT) and resistographic (Am,T) parameters in transverse (T) direction, for the small dimensions specimens.

This could be used considering that SA and SS specimens show similar behaviour in terms of strength, stiffness and collapse modes.

Tab. 2. Correlation between density [ρ (kg/m3)] and sclerometric [PT (mm)] and resistographic [$A_{m,T}$ (%)] measures

Transversal tests		Sample	
		S_SC+S_SB	N=50
Model	NDT parameters	R^2_{adj}	Linear regression equation
S_T+R_T	$P_T+A_{m,T}$	0,68	$\rho_t=901.88-23.69P_T+0.76A_{m,T}$

The correlation allow for the determination of a so called theoretical value of the density (ρ_t), it being affected by some approximation. For enhancing the accuracy of the estimation of the actual density (ρ_s), which is measured in laboratory, a correction coefficient $C_{adj,\,\rho}$ is introduced, obtaining

a design density value ($\rho_d = \rho_t/C_{adj,\,\rho}$). Such a coefficient is defined as the maximum value (for the sake of safety) of the ratio ρ_t/ρ_s evaluated for every examined specimen, it being quite always larger than 1. The assumed value is $C_{adj,\,\rho}=1.15$. The proposed method allows the in situ density identification (ρ_d) of timber element by only ND tests with an error quantified at most as 13% of the actual value ρs (in reduction).

Once estimated the density, the strength and modulus of elasticity both in compression and in bending are evaluated through the correlations with density obtained for SA specimens.

Indications for executions

In order to comply to the above procedure, indications for the executions are provided. After the preliminary phases consisting in traditional visual inspections for evidencing any possible significant defect or degradation, lack of members, together with the geometrical survey, the cross sections for testing should be identified. This is a very important task because the selected cross sections should be representative of the timber consistency. The number differs if the members is subjected to compression or bending. Then instructions for the application of sclerometric and resistographic tests are given, concerning either the preparation of the testing surface, or the mapping and the number of the shots (the last differing if the member is subjected to compression or bending), the data reading and elaboration.

Conclusions

The proposed method allows the in situ density identification (ρ_d) of timber element by only ND tests with an error quantified at more as 13% of the actual value (ρ_s). The methodology also allows to perform NDT in the direction transverse to the axis of the tested member. In this way, it is possible to solve the problem of the access at the end sections of members, which often involves the inconvenience of dismantling the entire structures. Further experimental activities would allow to reach more robust correlations for in situ mechanical characterization of existing timber members.

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