

EXPERIMENTAL TEACHING IN WOOD TECHNOLOGY

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Abstract

The purpose of this work is to present certain procedures and equipments that were implemented in the course of Xilology and Wood Technology held at the University of Padua. The objective was to offer to the students the opportunity to directly attend some experiments, usually explained only in theory.

In the first level degree course in Wood Technology and Timber Industry, the course of Xilology and Wood Technology ranges from biological characteristics of the wood material up to its physical and mechanical performance, a wide review with the intended purpose to form wood technologists. In the course program wide spaces should be left to the practise and applicative aspects, from microscopic observations of woody plant tissues to physical and mechanical properties determinations. The experimental educational approach, as known, helps the understanding of content and, above all, allows to understand the mechanisms underlying the experiments.

However, the need to combine educational activities with practical experience done directly by the students in a conventional classroom, crashes with the difficulty concerning the equipment and the time required for carrying out the experience. The equipment required for a basic exercise in wood technology range from common laboratory equipment, normally present in educational Faculty workshops, to sophisticated and specific test machines, expensive and used only by properly trained technicians.

Here we present simple equipment, specially set up for student self use, designed to carry out static tests on wood samples in order to determine the mechanical parameters module of rupture and module of elasticity in an easy and safe way.

From the other way, some determinations can not be carried out in the classroom because they require an incompatible time period for the educational programming of the lessons. For example in the study of the relations between wood and water, it is necessary to completely dehydrate wood. This operation is, in the proper way, conducted in an oven and requires a long time (1-4 days). In order to perform determinations related to wood water content is here explained a set up procedure that runs through microwave drying, that produces certain results in a lower time.

Keywords

Learning and teaching methodologies, wood properties, wood moisture content.

1. INTRODUCTION

The wood technology and xilology study program of the master's degree in Wood Technology and Wood Industries held at the University of Padua, ranges from the analysis of biological characteristics of wood material up to its physical and mechanical performance, in an extensive review to constitute the foundations of future knowledge of wood technologies.

The study of the wood is presented using a biological and technological approach in order to highlight the origin of wood and the influences that its cellular and chemical constitution have on behavior and final uses of the material.

In particular, the program provides education to address the anatomical structure of wood from Gymnosperm and Angiosperm and with the principal purpose using an anatomical approach for getting identification of the indigenous timber which is of more frequent use in the Italian market. The analysis of cell wall ultra-structure and of the elementary chemical composition follows next, with the peculiar intent to describe their relationship with the mechanical properties and the relationship between wood and water. The macroscopic observations to identify the timber and its defects, especially on samples collected and cataloged, complete the formation of the student.

The teaching on the subject provides theoretical lectures and practical exercises. In the planning of the course ample room is left for the practical part of the topic, from microscopic observation of wood tissue to the determination of its physical and mechanical properties.

The experimental didactic approach, as is known, helps to understand the theoretical content and, especially through practical exercises, helps to interpret the results of simple experiments in the light of the characteristics of the material studied.

However, the need to combine educational activities with practical experience, possibly to be implemented directly by students in educational facilities, is faced with the difficulty that from getting the equipment and the time required to perform such exercises. The equipment required for a basic lab exercise on technology of wood, in fact, range from simple laboratory equipment, normally present in the teaching laboratories of the faculty, to a more sophisticated, specific and expensive machines, which should be used only by properly trained personnel.

Our intention was to make students participate to all the lab exercises, allowing them to take an active part in activities with the aim to make them understand how the wood reacts to the phenomena that it gets subjected to.

Like other teachers we wondered if "there is no simple demonstration that can be used to show how a familiar material such as wood behaves. Better still are there not ways of showing why?" [1].

We have concentrated particularly on experience on the relationship between wood and water and on mechanical properties of wood, to limit the use specialized equipment for these types of tests and the time that is usually required.

2. STUDY ON MOISTURE CONTENT AND DIMENSIONAL MOVEMENTS OF WOOD

More than ninety percent of the problems that have to do with the use of wood derive from its close relationship with water [2]. The interaction of water and wood is due to chemical attraction between the polar water molecules and macromolecular constituents of the wood. This heavily influences the properties and uses of the material [3]. By varying the wood's moisture content, its properties vary: shrinks and swells, mechanic, thermal, acoustic and electric properties. It is therefore important to understand how the phenomena influencing the wood results from changes in its water content.

In the study of the relationship between wood and water it is necessary to completely dehydrate the wood sample, in order to measure the minimum size and weight limit of the wood in a completely dehydrated state. This is usually done in thermostatic ventilated oven at a temperature of 103°C, according to procedures laid down by specific regulations [4]. The procedure of complete evaporation of all the water in the wood can take several hours if not days, in relation to the size of the sample.

Such experiences can not be done in the classroom because it requires a time-lapse incompatible with the educational program.

Presented here is a procedure developed in order to perform in the classroom experiments related to the wood moisture content (MC), which provide to the drying of wood using a microwave oven commonly used in households. This procedure leads to reliable results for this purpose in due time to the teaching time frame.

The conventional methods for drying wood, involve the use of warm air ovens or stoves, which base dehydration on the transfer of heat energy needed for evaporation of water by convection through the material. The microwave technology instead transfers the energy needed for evaporation directly to the molecules of water, which absorb immediately the electromagnetic radiation.

The procedure followed during the exercises is that proposed by Benvenuti and Cavalli [5]. The tests are carried out by drying samples of wet wood of beech (*Fagus sylvatica* L.) the size of 50x50x15 mm (minimum size parallel to fibers); each student has its own sample. After the weight and volume of each sample was determined, drying is done in a microwave oven. Successive cycles of heating using 750 W power are applied; the number of cycles is not defined *a priori*, as it varies with the water content of the initial sample, its size and tree species. The early rounds have a duration of 4-5 minutes, which are then reduced to 3 minutes as the water evaporates from the sample. Between two consecutive cycles samples are placed to cool in glass bells (dryers) containing silica gel to absorb water vapor emitted by the wood. After each cooling the sample is again subjected to a cycle of warming and this procedure is repeated until the weight difference between two successive cycles indicates a difference of 5% of the initial weight of the sample.

The time needed with this method to dry a sample of beech the standard size above mentioned is about 90-100 minutes, including cooling time between a drying.

This procedure allows to determine moisture content and size change of wood samples over a two-hour lecture, having similar results by oven dry method usually take 2-3 days.

In tab. 1 the results of an experiment conducted by this method is shown. A sample of beech wood was immersed in water until it fully sunk. Its weight was then determined to the state of maximum water content and subsequently subjected to treatment with microwave drying. At each drying cycle the sample was weighed to ascertain the progress of moisture content over time. After 10 rounds of drying it was considered to have reached a state of dehydration near to zero water content and weight was calculated to get total

initial moisture content of the sample. It is measured as the ratio of the weight of water in the piece of wood to the weight of the wood when it is completely dry.

During the experiment, which lasted about 100 minutes, it was then possible to observe the moisture variation in the sample, making a number of considerations on the moisture curve obtained.

Cycle drying	Weight [g]	Tang. [mm]	MC [%]
0	35.60	57.3	78.0
1	33.61	57.3	68.1
2	32.60	57.3	63.0
3	29.13	57.2	45.7
4	28.12	57.0	40.6
5	26.34	56.4	31.7
6	25.83	55.9	29.2
7	24.81	54.6	24.1
8	23.28	53.0	16.4
9	21.75	50.8	8.0
10	20.00	48.3	0.0

Table 1. Weight, tangential length and moisture content of beech sample which underwent microwave drying

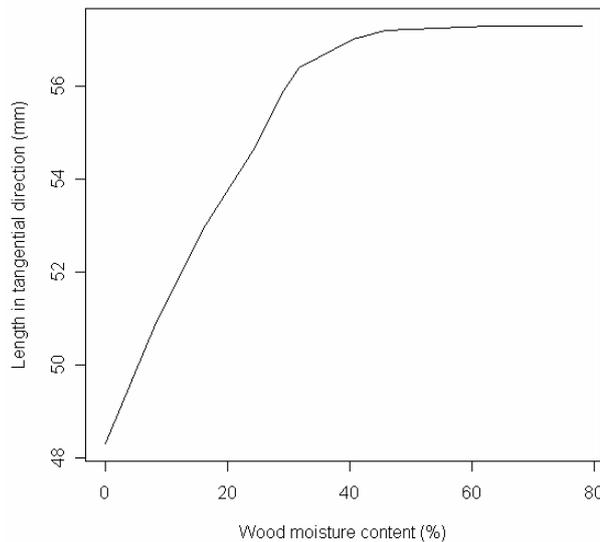


Fig. 1. Tangential shrinking in function of moisture content decrease

The proposed procedure has technical limits dictated by the requirements to have test results in short time. In particular it is difficult to determine exactly when you can interrupt the drying cycle, and when to consider the last weight value as the anhydrous weight value. It follows that the values of moisture and shrinking so determined are fairly approximate, but effective from the didactic point of view.

It is also possible to reduce the time it takes to complete the lab work by beginning with samples of wood which are not completely hydrated by the water, but with humidity just above the fiber saturation point (40%). In this state, the cell cavities are emptied of (free) water, but the cell walls are still saturated; only when leaves the cell walls does the wood begin to shrink.

This experience has not been conducted using samples of wood from other wood species; duration of the lab experiment could be very different for each cycle for different species of timber, or in different conditions. However, these limitations on the procedure, which must be clearly highlighted during the exercise, do not compromise the effectiveness of teaching that directly involve students to measure the weight and size of the samples and to develop the graph. It is beneficial for learning behavior in the course of drying the wood sample.

3. STUDY OF WOOD MECHANICAL PROPERTIES

The study of the properties and mechanical strength of the wood is possible if one is able to perform mechanical tests on the material. This possibility depends on the availability of a testing machine properly equipped for testing wood.

The mechanical tests that are more frequently applied to wood for research purpose is static, and this is also highlighted in the lectures of the wood technology course. A static test is characterized by its slow performance: essentially a stress is applied to the wood sample through a probe that moves very slowly (so as to appear stationary or "static"), in a impact bending test, loading is almost instantaneous. This requirement stems from the fact of having to meet a certain proportionality between the load applied on the wood sample and the time required to cause the rupture.

Allowing a student to observe, for educational purposes, a test of this type does not stimulate curiosity because the whole test appears static over time, up until the sudden rupture of the sample. The educational input in such a test may be much amplified by the chance to see on a Cartesian graph the deflection as a function of the increased load. The load/deflection chart showing the increasing deformation as the sample is loaded is subject to many considerations related to the theoretical maximum supported by the sample before it breaks, its elasticity modulus and its behavior in various stages of stress.

Therefore even having a testing machine for wood material to be used for educational purposes, this may show the students only the graph load/deflection, without involving them in the process, but leaving them a mere spectator.

With the aim of engaging students in two classic mechanical tests for wood, the determination of modulus of rupture (MOR) and the modulus of elasticity (MOE), a simple equipment is presented here, especially created for the course that will be run directly by students which do static flexibility tests on strips of wood to determine the mechanical parameters easily and safely.

The test scheme is presented in Figure 2.

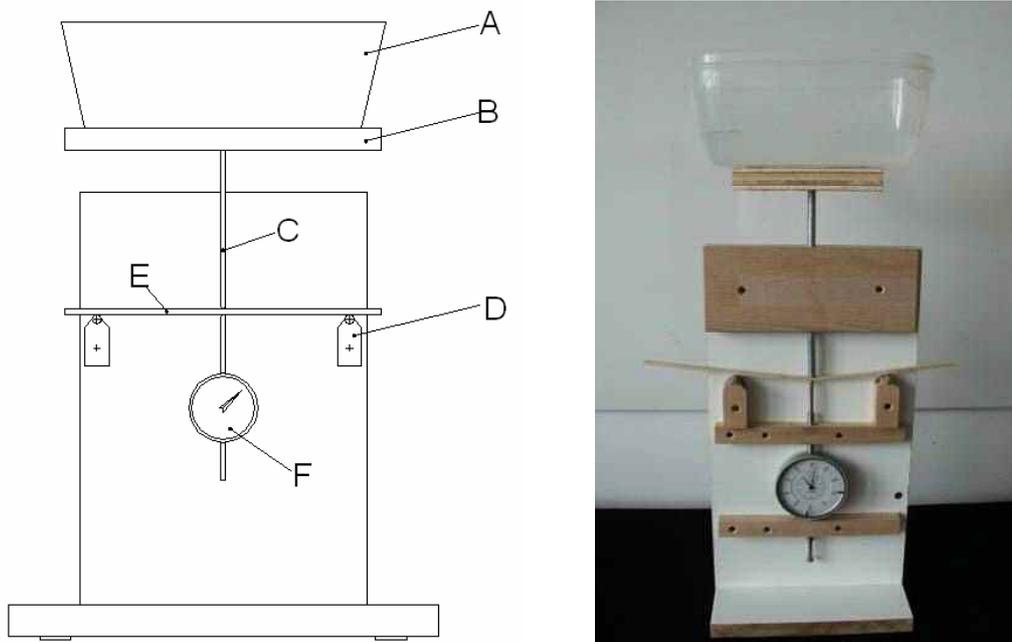


Figure 2 The experimental apparatus for the bending test. A: water container, B: tablet support, C: shaft, D: supports for the sample, E: wood sample, F: deflection gauge.

The apparatus which applies the load is composed of a plastic water container (A), a tablet support (B) and by a metal shaft (C) which applies the load directly on the sample. The metal shaft runs vertically in a system that maintains an orthogonal direction in relation to the face of the wood sample.

The wood sample (E) has a square section of 4 mm and a length of 20 cm, based on two supports (D) which can be regulated to accommodate different sample sizes.

Directly under the evidence, in correspondence of the upright metal shaft, is a deflection gauge (F) for the measurement of deformations corresponding the load increase. You also need a lab balance and 1-2 liters of water.

The test is conducted in the following phases:

1. the sample is placed on the supports;

2. underneath the sample the deflection gauge is positioned and reset;
3. the support frame + tablet support + water container is weighted. The weight of this equipment is the first load applied to the wood sample;
4. the deflection gauge is used to measure and record the deformation corresponding to this first load;
5. 100 ml of water are weighed, and are then poured in the container;
6. the deflection gauge is used to measure and record the deformation corresponding to this second load;
7. the load is increased by 100 ml of water at a time, and deformation will be recorded in a spreadsheet, represented in figure 3;
8. the process is repeated until the break of the wood sample.

The recorded measurements of the deformation after applying increasing loads is reported in a simple table with two columns. The experimental data collected in the table includes the size of the evidence, its weight (for the calculation of the density), the distance between the supports, the values of stress and strain at the elastic point. You can then determine the modulus of elasticity (MOE) and the modulus of rupture (MOR).

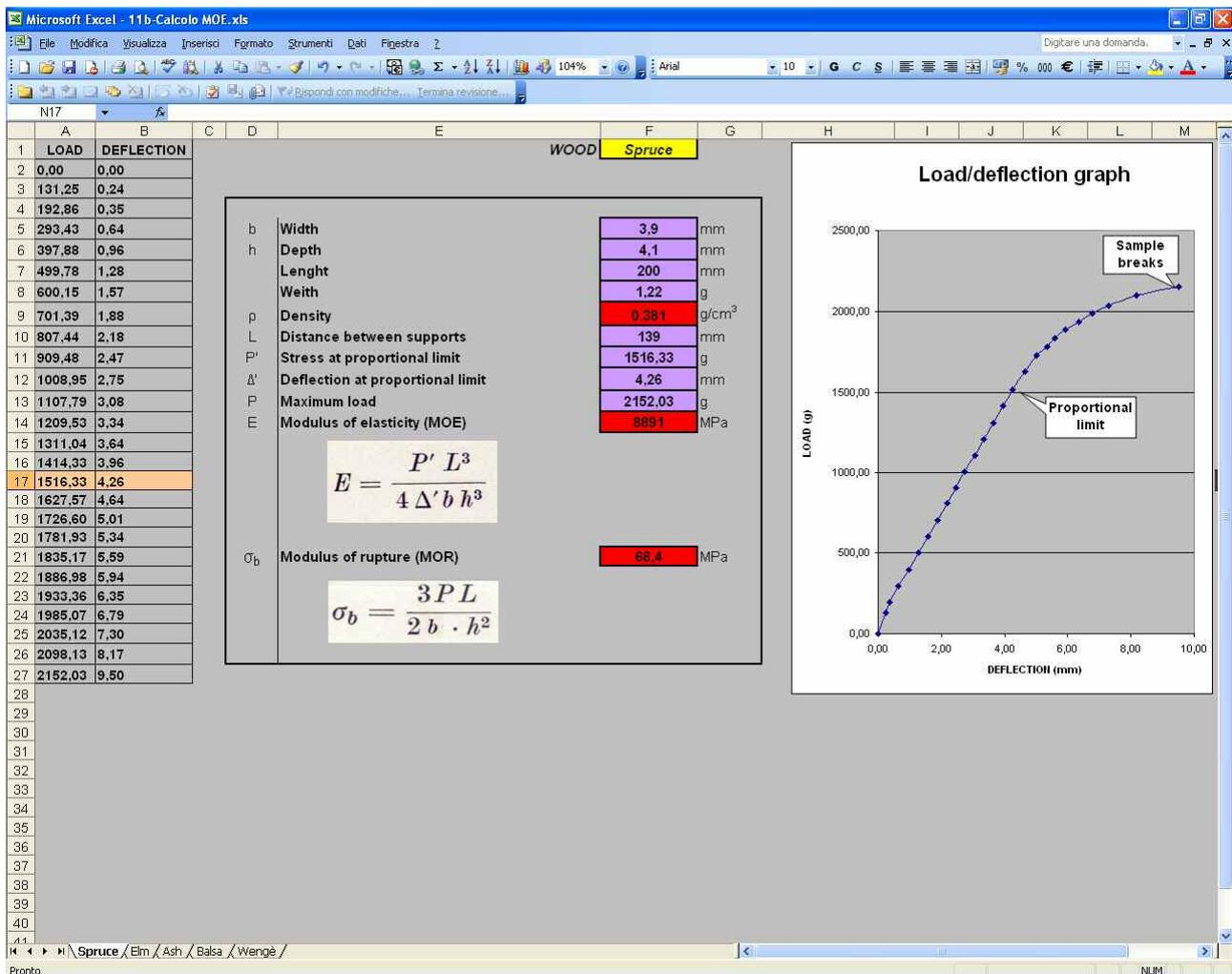


Fig.3. Spreadsheet table reporting the experimental results: while the load increases in the test the diagram representing deformation as a function of applied load is updated by the program. It is therefore possible to directly follow the deformations and the MOE and MOR.

The test requires active collaboration of four students; two are assigned to apply the load, one reads the deformation and the fourth records the data on the spreadsheet (fig. 4).

The spreadsheet is projected on the wall allowing to observe the behavior of the wood after each load increase, having all the students check step by step the evolution of the chart and enabling them to draw considerations of the case.

One of the limitations of this procedure is that the size of samples and the test procedure do not meet the standards imposed by regulations for tests on wood samples.

However the values obtained from tests performed with this equipment are compatible to what is found in literature, the instrumentation therefore fully performs its educational goals without boasting to want to provide benchmarks for the mechanical properties of the samples tested.

The size of the section of the sample test must first be studied for the various species of wood according to the scale of the maximum load applicable to prove: for timber which is less resistant to bending the section should be slightly over 4x4 mm, while very resistant wood should be smaller.

The equipment is lightweight and easily transportable to classrooms where it is used. It is low-cost because it is realized with easy to find materials and requires no special equipment to be built.

From an academic point of view this apparatus allows a comparison between different wood species, or between samples of the same wood species, but with different moisture content or with different defects. This method also involves students both in the procedure and in post processing of the data.

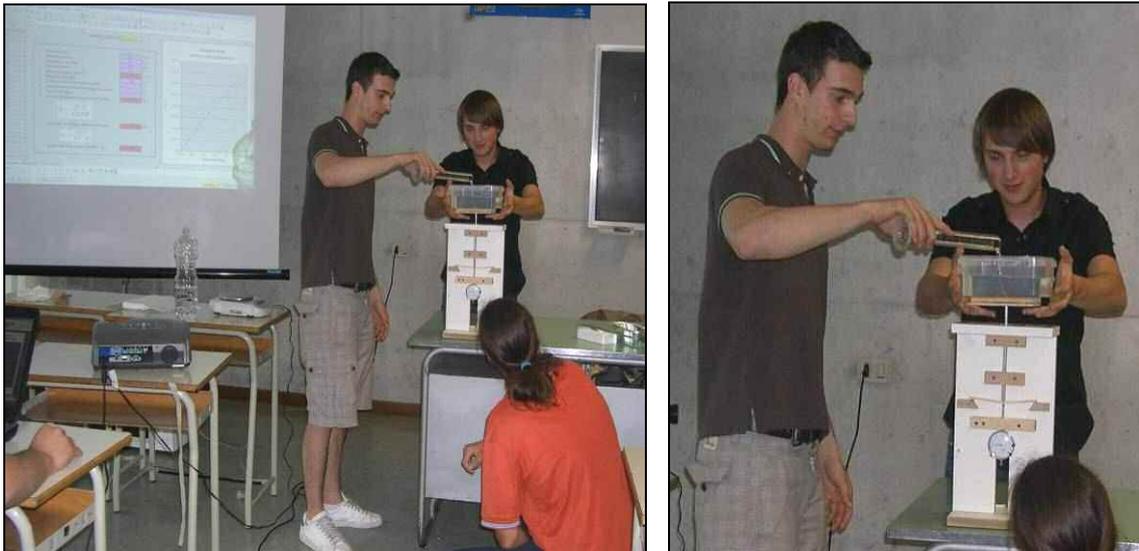


Figure 4: The test in the classroom

4. CONCLUSIONS

This approach undoubtedly stimulates the curiosity of students by making them understand in an easier way difficult and often abstract topics due to objective difficulties to observe in first person procedures that are usually done in professional labs and that cover larger time spans.

Without doubt many of these demonstrations can be improved, and there is little reason why new studies in this area should not be devised by the teacher or thoughtful imaginative students working on this science topic.

References

- [1] Foulger A. N. 1969. Classroom demonstration of wood properties. U.S. Department of Agriculture Forest Service Forest Products Laboratory.
- [2] Hoadley, R.B. 2000. Understanding wood: a craftsman's guide to wood technology. New York: The Touton Press.
- [3] Kollmann F. P., Côté W. A. 1968. Principles of wood science and technology, Springer Verlag, Berlin
- [4] EN 13183-1:2002. Moisture content of a piece of sawn timber - Determination by oven dry method.
- [5] Benvenuti L., Cavalli R. 1999. L'impiego del forno a microonde di tipo domestico per la determinazione rapida dell'umidità del legno. Rivista di Ingegneria Agraria 2: 117-122.