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MAKING OF TENSION TESTING SAMPLES BY TURNING AND MILLING IN SINGLE PROCESS

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Abstract

In this work the authors present the process of making and testing, using the tension test, wooden cylindrical samples. In general, samples of this type are not in accordance with norms, with the exception of old American and Australian norms. In spite of that, the making of cylindrical samples was validated by two reasons. Firstly, such samples can be made with ease and a high degree of precision using a combination of milling and turning. Secondly, cylindrical samples seemed to give greater chances for obtaining higher tensile strengths, which is desirable in the wood strength theory.

The cylindrical samples were made of beech and ash woods, and their tests were compared with analogous samples with a rectangular section. The results obtained for the cylindrical samples turned out to be as good as for the normative samples.

Key words: *tension strength, cylindrical sample, beech, ash, turning, milling*

INTRODUCTION

Tensile strength tests are some of the most demanding tests wood samples are subject to [8]. It is mostly about the proper alignment of grains in raw wood and then in a prepared sample. Also the shape of the samples is more complex than in case of compression, bending and even shearing strength tests. Thus, such samples are a challenge in terms of their preparation. The most often used method is planing (or milling), carried out in a few stages in order to avoid chipping.

Tensile strength test of wood is characterised by a high coefficient of variation [2, 3]. This is probably why the enormous American wood strength database [5] does not provide this important parameter. Tensile strength and compression strength should determine bending strength. In reality, this implication is not as trivial and it is the subject of research one of the authors of this article. Performed research suggest that tensile strength may be slightly lowered. Thus we decided to test cylindrical samples. The motivation behind this decision came from the fact that a sample with circular section minimises the lateral area at a determined cross-section and height of a sample. Small lateral area reduces the probability of surface defects. Also, a cylindrical sample does not have any sharp edges prone to be damaged. A counterargument is the anatomic structure of mature wood at the macro and microscopic level. Due to annual growth rings, beams and the geometry of the cell walls, paradoxically, wood structure inscribes much better into a rectangular shape. The above issues can only be resolved in the process of experiments.

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At the end of the article is a list of XI norms concerning determining tensile strength of wood along the fibres. All current norms for small laboratory samples and large samples of sawn wood concern rectangular section. In the representative norm [VIII] the base of the sample for tensile strength is 4 x 20 x 90 mm [4]. Very similar samples with base dimensions of 4 x 18 x 90 mm are in the still popular, although abandoned, Polish norm [IX]. Similarly different samples ([VIII] versus [IX]) were tested, in a largely simplified manner, in work [7]. It is also worth to mention the British norm [III] which describes a very thin, 3 x 6 x 50 mm sample base. While the wood tensile strength test at microscopic level is presented in work [10].

The attached list of norms has two old norms of turning cylindrical samples. The American norm [VII] used wooden rods with 1” diameter and 48” length which at their ends were glued into thicker drilled boards at a length of 6” [9]. While the Australian norm from New Wales [XI] was based on a sample fully turning, with the base thickness of 1.25” and length of 10” (Fig. 1).

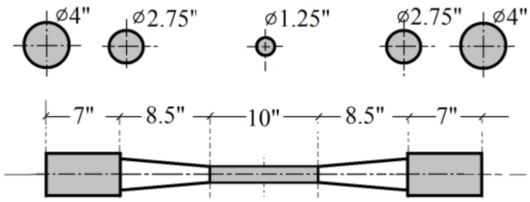

Fig. 1. Design of old tension test used in New South Wales (Australia) [9]

The testing of tensile strength of large construction elements is determined by norms [II, V, X]. Some details for the American norm are described in work [2], while in work [1] sawn exotic wood samples were tested for their tensile strength. The remaining norms [I, IV, VI] concern the testing of small laboratory samples.

MATERIAL AND METHODS

In order to prepare samples, two species of wood - beech[1] and ash (sap-wood and heart-wood) - were used. Two types of samples were made: with round section (Fig. 2) and reference samples with rectangular section.

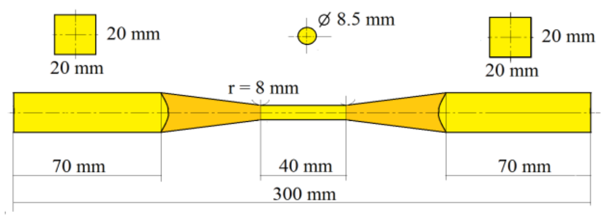

Fig. 2. Dimensions and shapes of the cylindrical samples

The cylindrical samples were made using a precision lathe with installed electrospindle instead of a cutter holder. The lathe was adjusted so that it allowed

[1] On the basis of work [6], we can compare tension and compression for beech.

to precisely make samples using a template. Removing the cross-feed bolt allowed us to obtain an indenting feed of the cutting tool controlled manually with an installed feed control lever. Material holders (with square section) were seated in a round grip of the lathe's spindle and tail centre.

The process of making samples with cylindrical bases started with placing a 300 x 20 x 20 mm wooden beam in the grips. The material rotated by the spindle was also milled with a cylindrical milling cutter installed in the electrospindle grip. Triple feed of the sample in the milled section with simultaneous in-feed limited by the template allowed us to ideally copy the shape of template.

The use of special grips (Fig. 3) allowed us to stiffen the machined material while retaining the axial alignment. Thanks to this the machined material was under only a slight axial pressure, unlike in case of traditional clamping between the clamp and the tail centre. This type of clamping reduces the risk of the material bucking. It is particularly important in case of samples with small diameter necking (8–9 mm).

The parameters of turning and milling were tested experimentally and the maximum possible speed were used: lathe spindle – 1750, milling electrospindle – 25000 (Fig. 4). The diameter of double-bladed milling cutter was 16 mm and that of the mandrel was 8 mm. The milling cutter length was 20 mm.

Fig. 3. Sample clamping in the grips and in the bushing and the tail centre

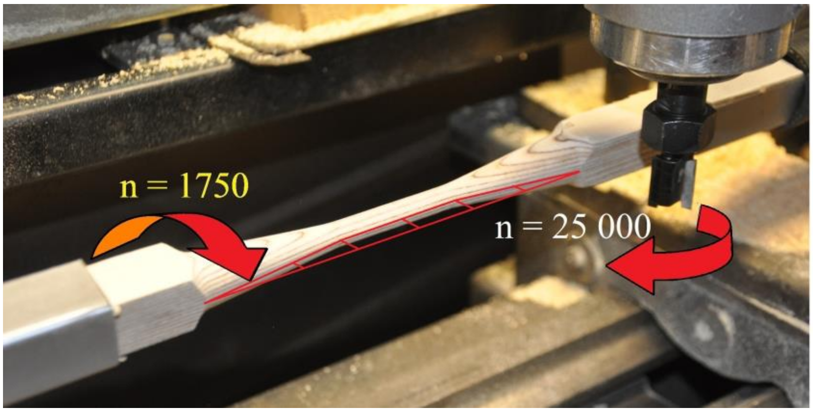

Fig. 4. Clamping of the sample in the lathe and the kinematics of the process

Comparative samples with rectangular sections were made using a bottom-milling machine in accordance with the norms described in the introduction.

RESULTS AND DISCUSSION

Parameters of the beech samples for tensile strength test are in table 1 and the strength values are presented in graph (Fig. 5). Of the three sets of rectangular samples, only the third set (20 x 4 mm) was made of twin pieces of wood in relation to the cylindrical samples (Ø 8.5 mm).

Table 1. Values of tension strength of beech wood for rectangular and cylindrical samples

Properties of samples	Rectangular	Rectangular	Rectangular	Cylindrical
Dimension of cross section [mm]	18 x 4	10 x 4	20 x 4	Ø 8.5
Density [kg/m^3]	732	694	694	694
Moisture content	9.3%	6.5%	7.6%	7.1%
Mean tension strength [MPa]	163.8	154.2	140.0	143.1
Standard deviation [MPa]	19.8	30.6	20.8	21.3
Standard error [MPa]	3.8	11.6	7.4	6.4
Minimum value [MPa]	106	135	124	131
Maximum value [MPa]	189	222	176	175

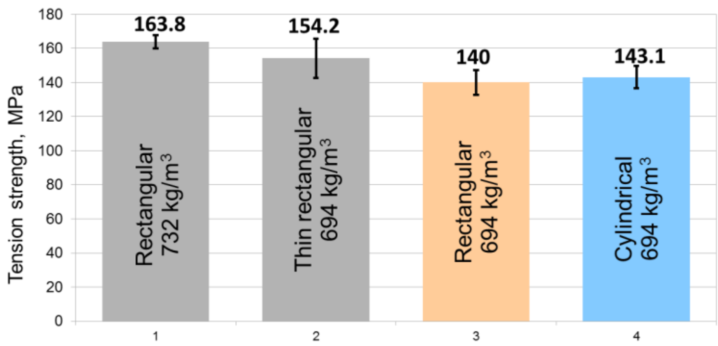

Fig. 5. Mean values of tension strength (with standard errors) of beech wood for rectangular and cylindrical samples

Table 2. Values of tension strength of ash for sap-wood and heart-wood

Properties of samples	Rectangular	Cylindrical
Dimension of cross section [mm]	10 x 4	Ø 8,5
Density [kg/m^3]	627	742
Moisture content	6.0%	7.5%
Mean tension strength [MPa]	148.5	173.0
Standard deviaton [MPa]	27.9	17.1
Standard Error [MPa]	11.4	5.4
Minimum value [MPa]	134.0	148.4
Maximum value [MPa]	180.7	201.6

Testing of the ash samples proved to be more of a comparison of sap-wood and heart-wood rather than of rectangular and cylindrical samples (table 2, Fig. 6). The result meeting the expectations for such a comparison indirectly shows that the cylindrical samples do not fall behind in strength from the rectangular samples.

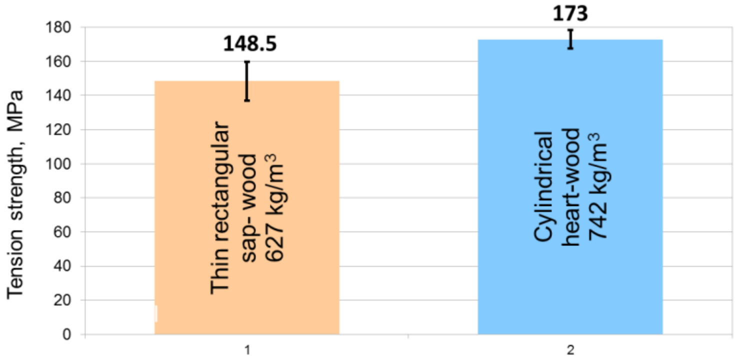

Fig. 6. Mean values of tension strength (with standard errors)
of ash for sap-wood and heart-wood (rectangular and cylindrical samples)

CONCLUSION

The use of turning and milling in a single process and using of stiff clamping of the processed material allowed to obtain precise and repeatable samples with circular section. The results for tensile strength tests for those samples did not differ much from the tests of the samples with rectangular section.

Simultaneous turning and milling allows to simplify the sample making process and allows for a greater tolerance in the material flaws. This manner of material processing allows to prepare a miniaturised versions of cylindrical samples on the basis of the old norms.

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