Specific Characteristics of Maple Wood as Material Used for Musical Instruments

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Introduction

In Europe and especially in Central Europe, high–quality maple (*Acer pseudoplatanus L.*) wood used for back plates of string instruments is relatively expensive. It can therefore be useful to find new maple sources and to compare perfect wood coming from traditional localities with that from new or unknown areas. For this reason, the experimental study of such maple wood is topical.

At the evaluation of wood for the top and the back plates of violins, the following procedure is used in practice: the violin maker first takes a piece of wood in the hand finding out its density, engraving the surface to determine the hardness or workability. Afterwards, he visually judges the regularity and the width of annual rings and the casual occurrence of defects as knots, resin, ducts, fungi attach, etc. [1].

For high quality (master) instruments, curly maple for the back plate is preferred. This attribute, as it is generally known from the age of old Italian violin makers;, represents one of the basic aesthetic criteria in order to classify an instrument as top–quality product, e.g., [2].

Recently, along with the subjective empirical experience, significance of exact methods of wood examination based on physical laws has increased (e.g. [3], [4], [5], [6], [7]). Modal testing [8] is one of the basic methods for vibration investigation. It has been used for material properties investigation of various wood samples. When the modal testing is applied to two–dimensional objects, such as plates of different shapes, visualization of the eigenmodes should be performed e.g. [9].

This study is devoted the experimental research of maple from Slovak mountain area indicating a chance to give wood suitable for musical instruments. The data obtained were compared with experimental data obtained on two sets of maple evaluated by experts for violin manufacturing as high and lower quality.

Experiments

In wood, generally considered as anisotropic material, three anatomical directions [10, 11,] possess quite different elasticity which is represented by a value of the Young's modulus. Its value parallel to grain is the most important. In the case of a plate with free edges, the so–called first bending beam mode "2; 0" can be namely quite easily generated [12]. The natural frequency corresponding to this mode enables us to determine the Young's modulus. Let us define a set of the physical and acoustical characteristics: density ρ, Young's modulus E and acoustic constant A as the relevant from the viewpoint of physical as well as musical acoustics [13].

The expression for the first bending mode in a free rectangular orthotropic plate relates the physical and acoustical characteristics ρ (density) and E (Young´s modulus) and is given as [8]

$$E \approx 0.947 \frac{f^2 \rho a^4}{h^2}, \qquad (1)$$

where a is the length, h – the thickness of the plate and f is the corresponding natural frequency. The acoustic constant A is given by the relation [14]

$$A = \sqrt{E / \rho^3}. \qquad (2)$$

Material, method and apparatus

The bending beam mode resonances in plates and sticks were found by means of a widely used method of Chladni patterns [8, 15]. When using this method, acoustic energy from a loudspeaker forces the bending vibrations in a plate (Fig. 1). Powder sprinkled on the plate surface is moving to nodes when the plate is vibrating at its natural frequency. The picture quality was improved by standard digital image processing procedures, namely histogram equalization, contrast and brightness improvement.

Experiments were carried out on maple wood (*Acer pseudoplatanus L.*) from a non traditional locality. From the forestry aspect, this locality is supposed to become a hopeful resource of maple wood suitable for musical instruments. The data obtained were compared with experimental data obtained on standard sets.

The standards of lower– and high–quality wood were obtained in the way as follows: Two experts for string instruments making [16] provided us with two selected sets of maple wood: for high–quality (a HQ set) and for lower–quality (a LQ set) violins. The HQ set was preserved to be used for high–quality master violins and the LQ set for lower–quality school violins. The defects (eccentricity of stem, twisted fibers, knots, decay, etc.) were absent in both sets. The HQ set can be described as the curly maple; the regularity and the wavy grain is apparent. The LQ set can be described as non wavy.

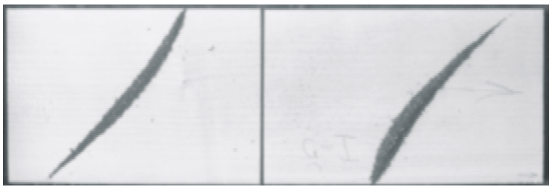
Experimental measurements were performed on seven radial cut maple plates from three trunks denoted as C, Z and N. The second part of the experiment was performed on sticks 1.5 cm wide obtained from these boards. The largest dimension of boards and sticks is parallel to grain of wood.

Experimental data analysis, physical and acoustical characteristics evaluation and grading of material were performed by means of AKUSTOMAT [13]. The complex system of AKUSTOMAT consists of two parts. Measuring part is represented by the Chladni patterns experiments in this case. The data calculated using the equations (1) and (2) from the measured values of mass, dimensions and frequencies, were plotted by the system in 3D material selection charts with co–ordinates ρ, E, A. Afterwards, estimation of investigated maple wood was performed. The evaluation in 3D plots were supported by mathematical–statistical tests.

Results and conclusions

The Chladni patterns in one plate is shown in the Fig. 1a. As we can see on this Chladni pattern, the nodal lines in this figure are tilted; possess not perpendicular direction to the edge of the plate. This effect is evoked by heterogeneity of wood. When the plates were cut to sticks, the tilt of nodal lines was also present (Fig. 1b), but the angles were different due to distribution of the density, the elasticity, the internal stress, etc. within the sticks.

The physical and acoustical characteristics of the test specimens from trunks C, Z, N are all denoted as the set of tested maple. This set is depicted together with the high–quality maple (Fig. 2) and with the lower–quality maple (Fig. 3).



C 1

Fig. 1a The typical shape of the Chladni patterns in the tested plate C1.

Fig. 1b The Chladni paterns in sticks obtained from plate C1.

From two–sample Student's t–test of significance of differences [17] it follows that:

– The density and the acoustic constant of the high–quality maple (see Fig. 2) differ from the density and the acoustic constant of tested maple on the significance level of 0.05. The density of tested maple is lower and the acoustic constant of tested maple is higher than the values of the high–quality maple.

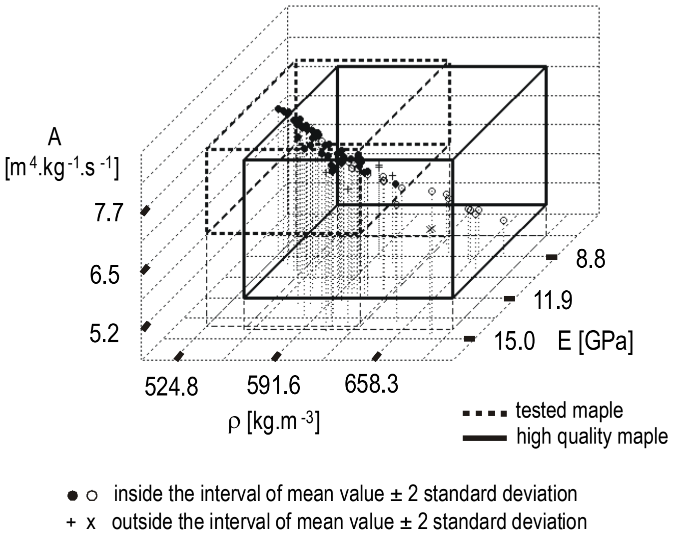


Fig. 2 The density ρ, the acoustic constant A and the Young's modulus E of individual test specimens of the high-quality maple and the tested maple.

– When the tested maple was compared with the lower–quality maple (see Fig. 3), the t–test showed no significant difference in the density. There was however a significant difference in acoustic constant on the level 0.05. The acoustic constant of the tested maple is lower than the standard what is appreciated for the tested wood.

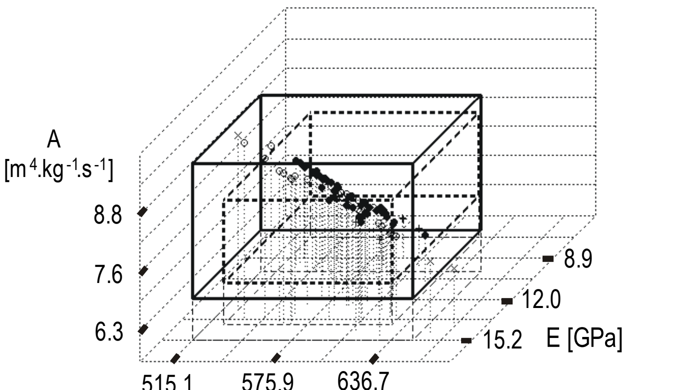


Fig. 3 ρ, A and E of the lower-quality maple and the tested maple.

From the viewpoint of tendencies in the physical and acoustical characteristics of high– and lower–quality maple for violin making, this result implies that our tested maple can be evaluated as material of lower quality. It means that – from the point of view of physical acoustics – it may be usable for back plates of at least "school" string bowed instruments.

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