Quality of Beech Standing Trees Related to Properties of Structural Timber

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Abstract

Beside the traditional spruce structural timber, beech is one of the hardwood species that is recently more utilized for structural purposes in Europe. This study deals with a quality of standing trees that could predict properties of structural timber. Beech trees originated from two different silvicultural stands were evaluated using nondestructive technique. From stands, 14 dominated trees were selected. The sound velocity was measured on 2m length above breast height at four places that were related to slope of a stand and North-South direction. From each tree, 4 plain sawn boards (50x100x2000 – R, T, L) were prepared. Modulus of elasticity, shear modulus and bending strength were measured according to EN 408. Results showed strong relations between nondestructive assessed properties of standing trees and properties of structural timber. An ultrasound method showed to be an alternative predictor of quality of beech stands that could be harvested for construction purposes.

***Keywords*:** forest stands quality, beech, structural timber, nondestructive, characteristic values.

Introduction

For the last decade, there were several studies performed that tried to use standard assessed features of forest stands for prediction of wood properties. Houllier at al. (1995) analyzed the influence of silviculture, site quality the wood production of Norway spruce from both a quantitative and a qualitative point of view. Tree and stand volume, stem taper, wood basic density, proportion of juvenile wood as well as knottiness their considered as the result of growth processes. Lyhykäinen 2009 used stem and crown dimensions variables for estimating yields and grades of lumber of Scots pine stems. Direct method of quality evaluation of standing trees related to clear wood mechanical properties presented Wang at al. (2001). His stress wave approach showed significant relations of the mean values of stress wave speed and dynamic modulus of elasticity for trees with those determined from small, clear wood specimens. Similar approach used Dzbeński and Wiktorski (2010) and compared wave propagation of Pine standing trees with 1.2m long samples properties tested in bending.
Aim of this study was to address a quality of a forest stand and its relation to quality of structural timber. We used Wang’s approach and compared quality of beech standing trees assessed by an ultrasound method and compared the results to properties of structural beech timber determined according to EN 408.

Materials and Methods

Dynamic modulus of elasticity calculated from sound velocity and density was determined on standing trees. Material from the measured locations was used for preparation a samples for measuring of bending strength, modulus of elasticity and shear modulus according to EN 408. Results were compared and relationship between destructive and nondestructive properties was analyzed.

Materials. Two sets of materials came from two beech forest stands of different silvicultural treatments. From each stand seven trees were used in this study. Ultrasound velocity was taken at 4 positions of a standing tree using Sylvatest Duo device. These positions were related to cardinal points. The first probe of the device (receiver) was plug into a predrilled hole at the breast height. The second probe (transmitter) was plug into a hole that was placed parallel to the trunk, two meters above the first one. The readings were taken two weeks before harvesting of the trees. After cut down, moisture content (MC) samples were taken from four measured positions at the breast height. Four tangential boards from each trunk were cut and dried to final moisture content of 12 % and further conditioned at T=20°C and RH=65% for 1 month. After that, boards were sized to the final dimensions of 50x100x2000 mm^3 (R, T, L).

Mechanical properties. MOR and MOE of boards were evaluated according to EN 408 standard in 4 point bending. For evaluation of shear modulus, a single span method was used. Density and moisture content were tested using a clear sample from the middle part of a board taken immediately after the bending test. Measured properties were adjusted to 12% of MC using the property-MC relationship given by the standard. Dynamic modulus of a standing tree was calculated from the ultrasound velocity and the density at the green MC according to equation (1).

$$Edyn = \rho_{MC}.c^2 \qquad (1)$$

where ρ_{MC} is density of the standing tree at the breast height under the bark and *c* is the velocity measured between two probes at 2 m distance.

Results and discussion

Results published in a previous study (Lagana and Babiak 2011) showed that there is no effects of beech stands or cardinal points position on dynamic modulus of trees. Thus, basic statistics, given in the Table 1, contain all measured data. Average moisture content at the breast height was 87.8%. Density of trees was calculated from the density at 12% of MC, green MC and swelling coefficient.

Table 1. Basic statistic of properties of standing beech trees and boards measured according to EN 408. Velocity is given as measured at green MC, other properties are adjusted to MC = 12%.

	Green MC, %	velocity ms^{-1}	Edyn, MPa	density, kgm^{-3}	MOR, MPa	MOE, MPa	G, MPa
Sample size	54						
Mean	87.8	4 071	17 257	680.0	90.3	13 604	729
Coeff. of var., %	6.9	3.4	7,0	3.9	14.7	8.3	10.1

Practical results are correlations between nondestructive identification property and properties of structural timber. Correlation between ultrasound velocity and bending strength is small (Figure 1). Based on number of samples, the correlation coefficient R = 0.266 was not significant on confidence level a=0.05. Ultrasound velocity readings are not sufficient to predict strength properties of beech timber.

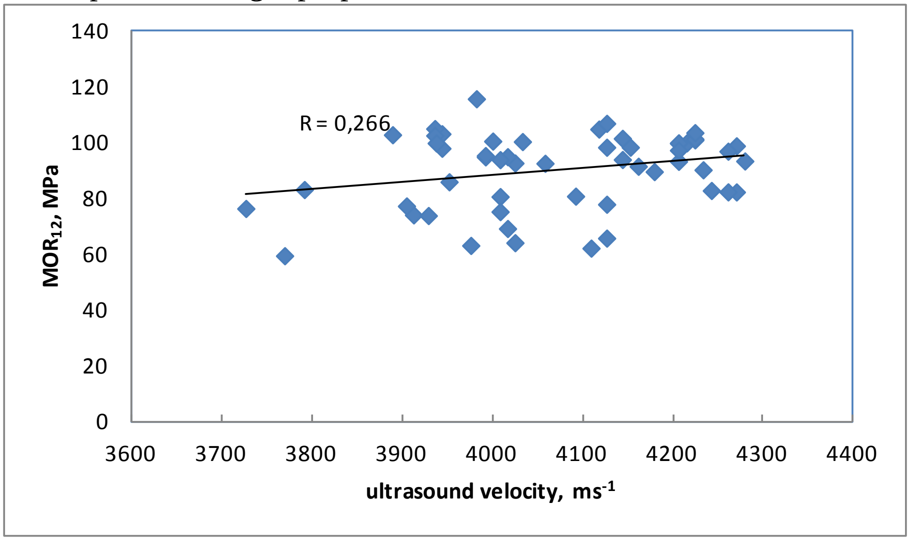

Figure 1 Correlation between ultrasound velocity of a standing beech tree and MOR at 12% of MC determined according to EN 408.

More reliable correlation is given, when density is involved in calculation of dynamic modulus according to equation (1). Figure 2 shows significant correlation of dynamic modulus of standing trees and MOR at 12% of MC.

The next two figures (Figure 3 and 4) show correlation of MOE and shear modulus of dynamic modulus of standing tree. The correlation was the highest between dynamic and static moduli. It could be conclude that the dynamic modulus of elasticity is more reliable feature of a beech standing tree and should be used for quality evaluation rather than ultrasound velocity. Unfortunately, this will involve a challenge in fast and precise determination of tree density.

It should be pointed out that the correlation coefficients are lower than those obtained in Wang's (2001) or Dzbenski's (2010) studies. A reason can be seen in specific properties of beech wood that are related to its structure. Despite of the uniform density of beech wood, this ring-porous species performed much higher variability in MOR than coniferous species. Another possible reason could be high variation of spiral grain angle within beech trunk that was observed in failure modes of bending tests.

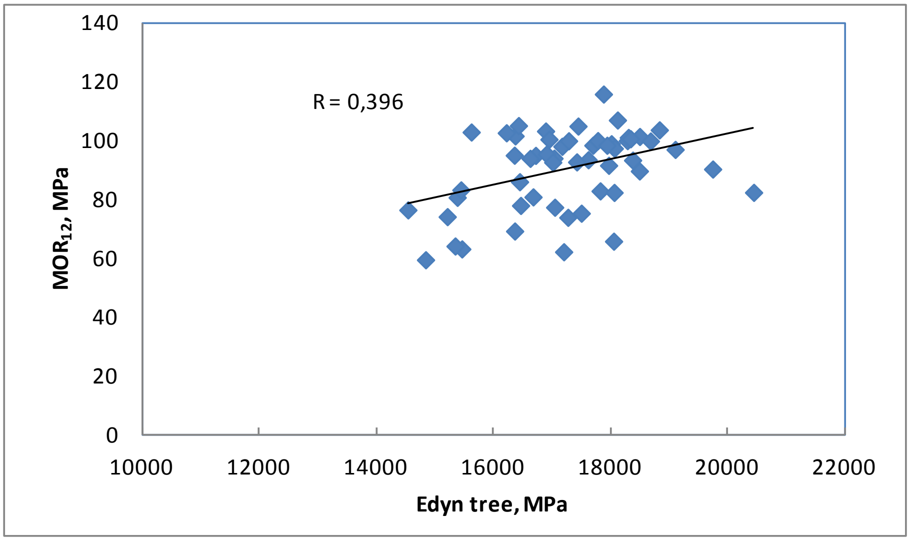

Figure 2 Correlation between dynamic modulus of a standing beech tree and MOR at 12% of MC determined according to EN 408.

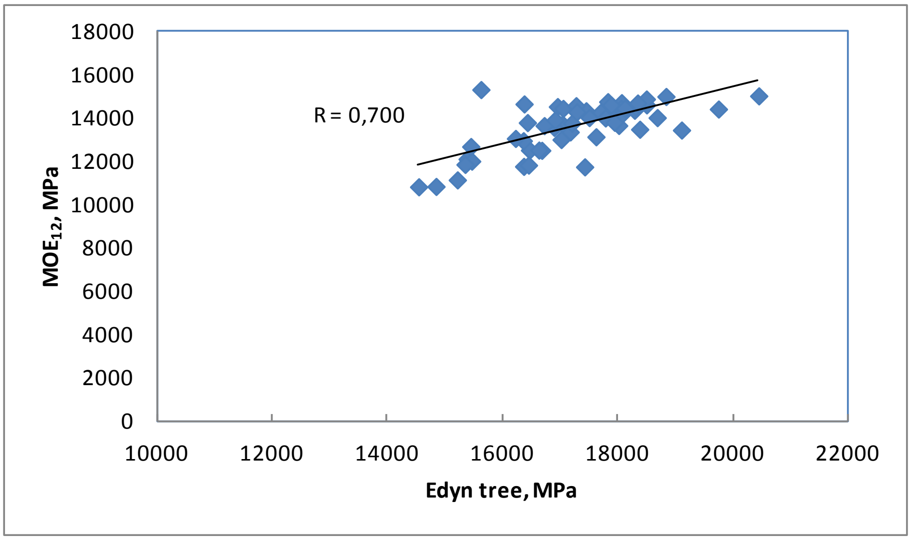

Figure 3 Correlation between dynamic modulus of a standing beech tree and MOE at 12% of MC determined according to EN 408.

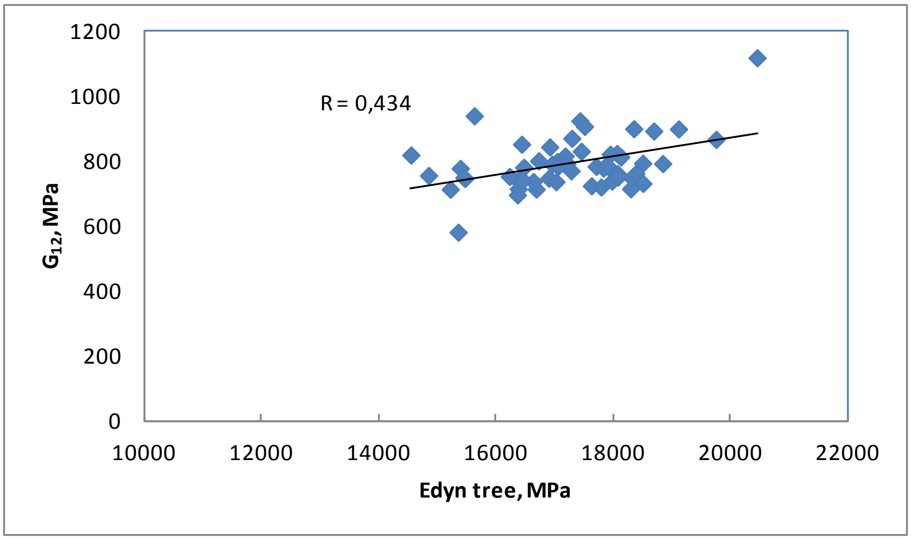

Figure 4 Correlation between dynamic modulus of a standing beech tree and shear modulus at 12% of MC determined according to EN 408.

Conclusion

Quality of structural beech timber could be reliably evaluated on the standing trees using an ultrasound method. Quality assessment should also include determination of green wood density. Results showed significant relations between nondestructive assessed dynamic modulus of standing trees and properties of structural timber such as bending strength, modulus of elasticity and shear modulus. Comparing to other wood species, the studied correlations were smaller than correlations of coniferous species such as pine or spruce. Nevertheless, an ultrasound method was confirmed to be an alternative predictor of quality of beech stands that is harvested for construction purposes.

Acknowledgement

This contribution is a result of the project implementation: Extension of the centre of Excellence „Adaptive Forest Ecosystems“, ITMS: 26220120049, supported by the Research & Development Operational Programme funded by the ERDF

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