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Characteristics values of beech timber for potential construction applications

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Abstract: ***Characteristics values of beech timber for potential construction applications.*** Paper deals with characteristic values of beech timber determined for possible utilization in structural applications. The timber originated from two different silvicultural techniques stands. From stands, 14 dominated trees were selected. From each tree, from 4 to 14 plain sawn boards (50x100x2000 – R, T, L) were prepared. Modulus of elasticity, shear modulus and bending strength were measured according to EN 408. Mean and characteristic values and strength grade were evaluated according to EN 342 and EN 338. Based on mean modulus of elasticity E_{0mean} and characteristic density ρ_k the beech timber complied with D50 strength grade requirements. Based on mean density ρ_{nean}, characteristic strength $f_{m,k}$, and shear modulus G_{mean}, the timber was assigned into D40. Results also showed very low correlation between bending strength and clear density caused by high grain deviation and knot defects in tension zone and very low variability of density. Despite of implicational problems of structural beech wood such as durability, distortion or common occurrence of reaction wood, beech timber could be used as optional resource for structural applications of high strength properties.

Keywords: structural timber, beech wood, quality, modulus of elasticity, modulus of rupture, wood density, shear modulus

INTRODUCTION

Norway spruce *(Picea abies, L.)* is the main wood species used for structural applications in Europe. Moreover, it is the only wood species used in Slovakia and Czech Republic. The other species are neglected for various reasons. One of them is that known characteristic properties of structural timber of other species have not been recognized.
On the other side, US and European market utilize hardwood species for engineering applications. For example, Wacker and Cesa (2005) reported a case study about using low grade hardwood materials such as red oak, red maple, beech, black locusts and many others hardwood species for building highway bridges.
The aim of this study was to evaluate several characteristic properties of beech timber and to show a potential in construction applications.

MATERIAL AND METHODS

Two sets of materials came from two beech forest stands of different silvicultural treatments. From each stand 7 trees were cut down. A log was prepared from the butt side of a trunk. Several 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 1month. After that, boards were sized to the final dimensions of 50x100x2000 mm^3 (R, T, L).
Modulus of elasticity and bending strength of structural timber were determined according to EN 408 (4 point bending test). In order to determine shear modulus a single span method was used. Density and moisture content were tested using a clear sample taken from the middle part of a board immediately after the bending test.
Altogether, 108 boards were tested, while a set of boards from one forest stand represented one sample. Characteristic strength $f_{m,k}$, mean modulu E_{0mean}, characteristic density ρ_k, mean density ρ_{mean} and mean shear modulus G_{mean} were evaluated according to procedure described

in EN 384. Modulus of elasticity and shear modulus were adjusted to 12 % of MC and bending strength was adjusted to the specific cross section. Based on a smaller sample size of the 2nd stand (n=47), the adjustment factor k_s for two samples (stands) was 0,84. Other factors k_v and k_l were equal to one. Strength grades of the batch were assigned according to EN 338 based on these characteristic and mean values.

RESULTS AND DISCUSSION

Average MC of all specimens was 10,8% with low coefficient of variation of 4,3%. Measured properties recalculated to 12% of MC are listed in the table 1. As it was expected, the bending strength of structural timber is lower than the strength of clear wood (124 MPa, Pozgaj et al. 1997).
Results showed very low correlation between bending strength and clear density. A closer look at specimens of low strength revealed that it was caused by the grain deviation in timber, knot defects in tension zone and also very low variability of density (Figure 1). The latest one is a consequence of uniform density profile of beech wood throughout the annual ring in radial direction and low differences in density between earlywood and latewood. These features are independent of clear sample density.

Table 1. Basic statistic of properties from both forests stands measured according to EN 408 and adjusted to MC = 12%.

	density, kgm^{-3}	strength, MPa	MOE, MPa	G, MPa	MC, %
Stand 1					
Sample size	47				
Mean	686	89,3	14024	802	10,7
Coeff. of var., %	3,8	17,8	9,6	11,2	5,0
Stand 2					
Sample size	62				
Mean	698	89,4	13996	844	10,9
Coeff. of var., %	4,4	23,0	10,4	10,5	3,6

Characteristic and mean values with representative strength grade are shown in table 2.

Table 2. Characteristic and mean valus evaluated according to EN 384 and strength grade according to EN 338.

	$\rho_{0,mean}$ kgm^{-3}	ρ_{05} kgm^{-3}	$f_{m,k}$ MPa	$E_{0,mean}$ MPa	G_{mean} MPa
Value	691	644	41,7	15521	825
Grade	D40	D50	D40	D50	D40

Based on characteristic density ρ_{mean} and modulus $E_{0,mean}$, these evaluated properties assigned the beech timber into strength grade D50. Other properties assigned the timber into D40. Similar difference in strength classes based on characteristic and mean density was observed by Widmann (2008). Characteristic density permitted to assign thermally treated beech wood of Widmann's study into strength grade D35, comparing to higher D35 according to mean density. Since thermal treatment does not significantly change MOE, $E_{0,mean}$ values of thermally treated beech fitted also into strength grade D50.

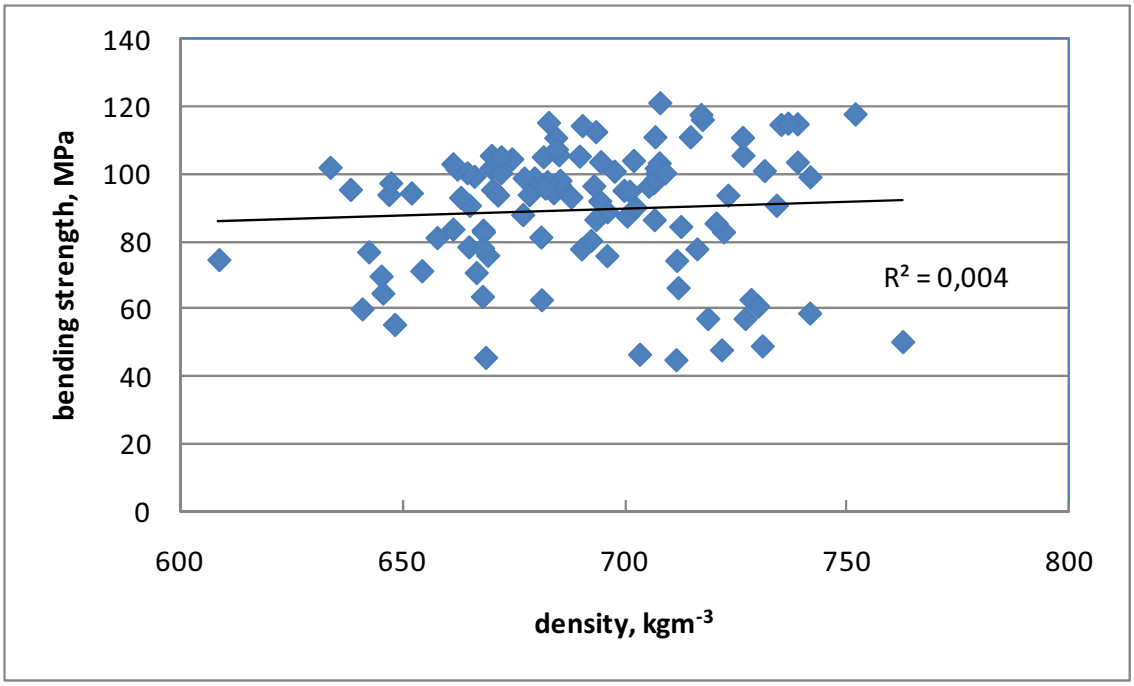

Fig. 1. Relationship between bending strength of beech timber and clear sample density

With high confidence, it can be concluded that timber from beech wood from selected Slovakian forests stands is assigned into strength grade of D40. If properly designed, beech wood can be used in engineering applications. The characteristic strength values are almost twice as higher as the most commonly used spruce timber of grade C24.
There exists an opinion that the beech is not the ideal wood species for structural applications. Features of beech wood, such as durability, distortion or common occurrence of reaction wood could devalue beech timber. Nevertheless, proper grading techniques and processing with an aim to increase durability of the timber can overcome obstacles for utilization in engineering structures.

CONCLUSION

Beech timber from selected forest stands can be assigned into strength grade D40 according to mean density ρ_{0mean} and characteristic strength $f_{m,k}$. There was a low correlation between strength and clear wood density. Beech timber could be used as optional resource for structural applications with very high strength properties when other feature of beech wood such as durability, distortion or common occurrence of reaction wood are not in concern.

ACKNOWLEDGEMENT

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