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Correlations between quality parameters of structural spruce wood

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Abstract: The quality of structural spruce wood is described with parameters: modulus of elasticity, modulus of rupture and wood density. They are determined by destructive bending tests according to EN 408. There is a dominant relationship between strength and predictive parameter representing a basis for strength grading of structural wood.

Non-destructive methods based on various principles are used to determine the quality of structural wood. Correlations between parameters from destructive bending tests and non-destructive methods were evaluated. All dependences are statistically significant. This knowledge is used in two-stage prediction method for determination of modulus of rupture.

Keywords: structural spruce wood, destructive bending test, non-destructive method, quality parameter, correlation

INTRODUCTION

When designing and manufacturing timber structures, the quality of structural timber is an important attribute of reliability and effectiveness. It is characterized by prediction and indication parameters derived from both the destructive bending test and the nondestructive methods based on various principles. It is verified in every country processing wood raw material into structural timber.

The aim of this research is to bring closer the significance and justification of the structural timber quality differentiation in strength classes. The following quality parameters represent a basis for the prediction models: bending modulus of elasticity, modulus of rupture and wood density. The models are applied in standardization process and they are compared with parameters used in nondestructive methods. The results describes parameters of the structural timber quality and evaluates theoretical and experimental methods in compliance with the EU standards.

This paper describes the experimental results reached at the Faculty of Wood Sciences and Technology of the TU in Zvolen are significant. The prediction models of the structural spruce wood (Slovakia), application of the selected nondestructive methods and their comparison correlations are original. They represent reliable indicators in quality evaluation of structural wood (PAZLAR et al. 2010, ROHANOVÁ et al. 2010, ROHANOVÁ et al. 2011).

Currently, there is a need to elaborate prediction models of Slovak structural timber from various regions. They would become the basis for more effective and objective grading of structural timber according with EN 338 based on various principles (e.g. bending, ultrasound, vibration) in practice. Prediction models are represented by linear regression dependencies between indicating and indicated parameter (WEIDENHILLER - DENZLER 2009). The basic prediction model is created from indicating parameter $E_{m,g,408,}$ and predicted parameter $f_{m,408}$. The application of other non – destructive methods specifies following

indicating parameters: modulus of elasticity (bending, dynamic), density of wood ρ_{MTG}, velocity of ultrasound in wood c_{II}, natural frequency of wood f, etc.

In this paper, correllations for measuring parameters are described on the basis of measured values acquired from 3 non – destructive methods and destructive bending test (EN 408).

MATERIAL AND METHODS

Spruce (*Picea abies)* sawn wood of Slovak origin was tested experimentally. 52 pieces of sawn timber were prepared for destructive testing and 3 nondestructive testing methods based on various principles (40x185x2360 mm). In addition, the density of wood was determined gravimetrically at three places along each specimen.

Testing methods

The following methods were used to determine timber parameters:

a) 3 non – destructive methods:

- bending CB - flat wise, 3-point bending. Loading and reading parameters were designed according with EN 14 081-4, tab.1-2 - Cook Bolinder,
- vibration – measurement was realized by MTG Timber Grader device,
- acoustic - measurement was realized by SYLVATEST Duo device.

b) destructive bending test according with EN 408 (4-point bending).

Selection of parameters and testing methods:

Non – destructive - measured parameters:

- *bending CB* : modulus of elasticity in bending (E_{CB}), wood density (ρ_{CB}),
- *vibration:* dynamic modulus of elasticity ($E_{dyn,MTG}$), wood density (ρ_{MTG}), natural frequency (f_{MTG}),
- *ultrasound:* dynamic modulus of elasticity ($E_{dyn,\ sylv}$), speed of sound (c_{sylv}).

Destructive: *bending test* - measured parameters: modulus of elasticity in bending ($E_{m,g,408}$), bending strength ($f_{m,408}$), wood density (ρ_{408}) and moisture content.

All the parameters were recalculated to the standard conditions MC = 12%.

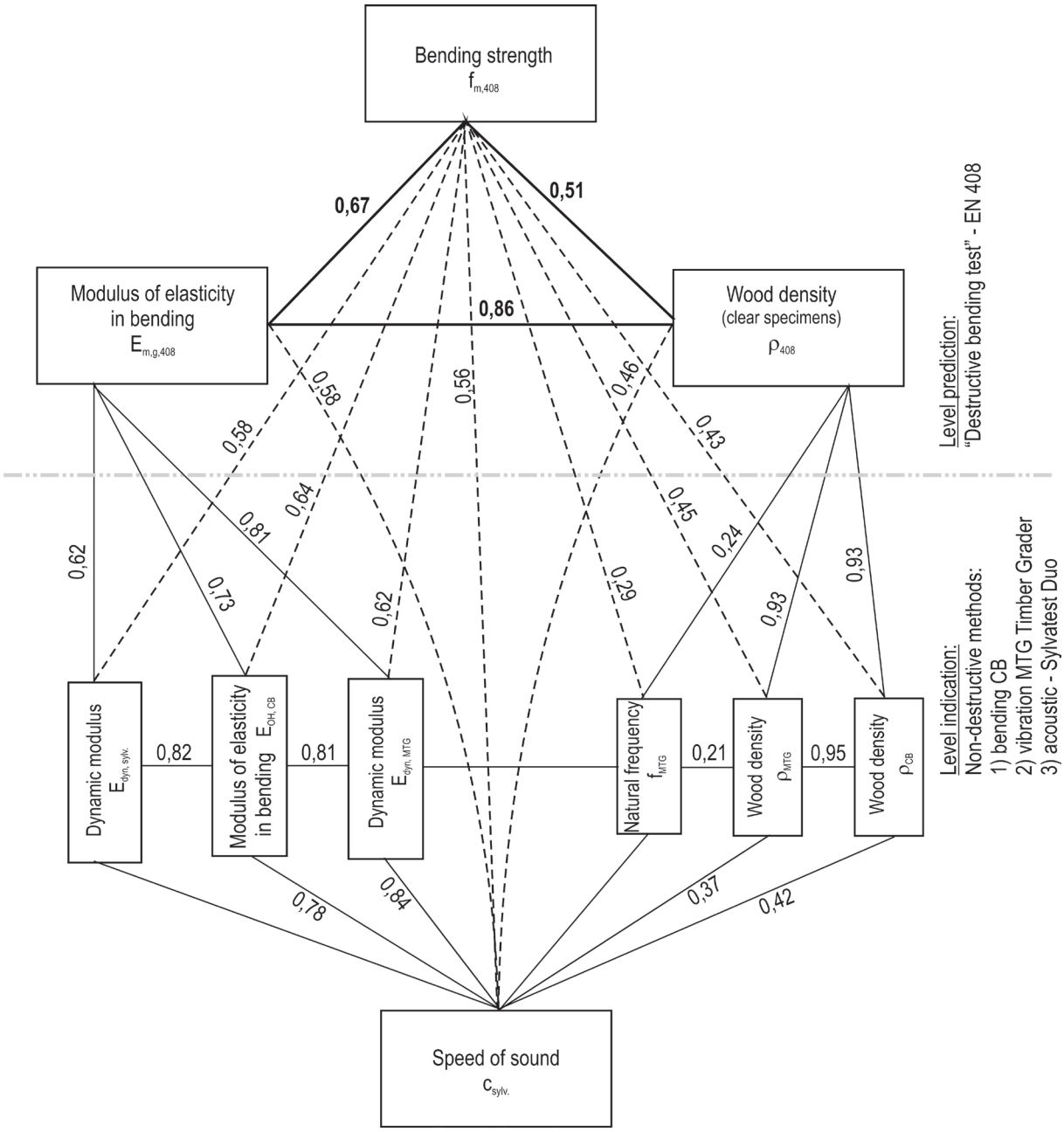
Statistical methods and result analysis

Values obtained from destructive bending test and non – destructive methods of determining the strength classes were analyzed in programs Statistica 7, Excel 2007.

RESEARCH RESULTS

Figures 1 illustrate the correlations of testing specimen grading by above mentioned methods for measuring parameters.

Fig. 1 Model correlations quality parameters structural spruce wood (n = 52)



The ***best*** correlation to bending strength is achieved with bending methods:
$E_{m,g,408,} \sim f_{m,408}$: r = 0,67, $E_{oh,CB} \sim f_{m,408}$: r = 0,64 and $E_{m,g,408} \sim \rho_{408}$: r = 0,86.
Lower values of correlation dependency were determined for acoustic methods
$E_{dyn,sylv} \sim f_{m,408}$: r = 0,58, $E_{dyn,MTG} \sim f_{m,408}$ r = 0,62.

CONCLUSION

The harmonization of knowledge in structural timber quality field enables to implement and unify progressive grading methods in accordance with EN in individual countries.

Prediction models and their correlations are applied to identify structural timber quality; they represent an integral part of research and application outputs. Knowledge in individual

grading methods of spruce wood (harvested in Slovakia) proved significance of parameters such as modulus of elasticity and bending strength. The complexity of this issue requires the analysis of more indicating parameters in regression and correlation dependencies.

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Streszczenie: *Korelacja parametrów jakościowych świerkowej tarcicy konstrukcyjnej*. Jakość świerkowego drewna konstrukcyjnego opisano za pomocą parametrów: wytrzymałości, modułu sprężystości i gęstości. Wszystkie parametry mierzono zgodnie z normą EN 408. Zauważono dominującą relację pomiędzy wytrzymałością oraz wskaźnikami opisującymi jakość tarcicy. Opisano korelację pomiędzy wynikami nadań nieniszczących i niszczących, wszystkie zależności okazały się istotne statystycznie. Powyższe zależności zostały użyte w dwustopniowej metodzie przewidywania wytrzymałości drewna na bazie wyników badań nieniszczących.

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