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Determination of quality parameters of spruce structural timber by prediction models

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Abstract: *Determination of quality parameters of spruce structural timber by prediction models*. 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. Quality parameters - bending modulus of elasticity, modulus of rupture and wood density- were predicted for structural spruce wood (Slovakia, n = 154) which are abasis for the prediction models. They represent reliable indicators in quality evaluation of structural wood.

Keywords: structural spruce timber, wood density, modulus of elasticity, bending strength, indication, prediction

INTRODUCTION

The spruce timber (*Picea abies, Karst.*) of structural dimensions is commonly used in a building construction. High variability of properties, partially influenced by user environment (climatic conditions, character of loading), is considered to be its typical characteristic. Sawn timber built in construction is characterized by natural structure of wood and presence of defects (knots, splits). Timber quality represented by strength classes seems to be an important mean for differentiation and assessment of individual characteristics (***Glos 1999, Deublein et al. 2010***). These are defined in EN 338. Methods and process of strength class determination are identical in all countries.

The structural timber used in building construction is subjected to a strength grading. Grading requirements and methods are defined in European Standards, obligatory for each country where the structural timber is used. The destructive bending tests are applied during the strength grading process in order to acquire bending strength ($f_{m,384}$), modulus of elasticity in bending ($E_{m,g,384}$) and wood density (ρ_{384}). These characteristics represent a basis for prediction models specifying structural timber quality individually for each country. Destructive bending tests according to EN 408 followed by result evaluation according to EN 384 have to be performed in order to determine these values (Fig.1).

The system of strength classes based on bending strength, elastic properties in bending and density seems to be the most appropriate because bending is considered to be the most important type of load in timber structures. Hence, the bending strength is a critical strength property.

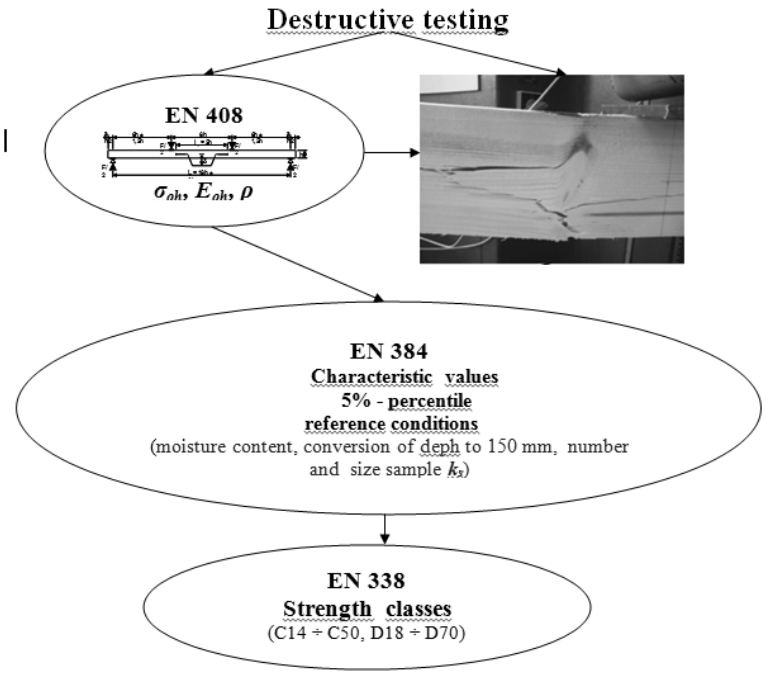

Fig. 1 Process of establishing characteristics values for strength classes

MATERIAL AND METHODS

The spruce timber (*Picea abies*, Karst.) was chosen from three Slovak forestry regions: West, North and Central SK. Specimens with dimensions of 50×120 (100) × 2360 (1900) mm were prepared from rough sawn timber of dimensions 55×200×5000 (4000) mm. The number of specimens was n = 154 pieces. Average moisture content of specimens was approximately 12%, measured in laboratory conditions. Moisture content was monitored and controlled using dielectric capacity moisture meter Hydromette HT 85 T.

The following properties of specimens were determined for creation of prediction models: bending strength, modulus of elasticity in bending – global and wood density.

Prediction models – methods and standards:

- Destructive bending test: $E_{m,g,408}$, $f_{m,408}$ and ρ_{408} according to EN 408, reduction: $E_{m,g,408}$, $f_{m,408}$ and ρ_{408} to $E_{m,g,384}$, $f_{m,384}$ and ρ_{384}.
- Determination of bending strength – $f_{m,408}$, reduction $f_{m,384}$.
- Determination of wood density - ρ_{384}.

RESULTS AND DISCUSSION

The basic statistical characteristics of three properties (wood density, modulus of elasticity and bending strength) represent the characteristics of spruce structural timber grown in Slovakia (3 regions). These characteristics create a basis for prediction models. Tab. 1 lists the parameters of prediction models in selected countries and the results are compared with Slovakia.

Tab. 1 Properties of structural timber (*Picea abies,* Karst.) and coefficients of variation in selected countries

Country of origin	Parameters of prediction models						
		Density of wood		Modulus of elasticity		Bending strength	
	N	ρ_{384} [kg.m^{-3}]	*COV* [%]	$E_{m,g,384}$ [MPa]	*COV* [%]	$f_{m,384}$ [MPa]	*COV* [%]
Slovenia	1126	445	10	11200	21	43	31
Poland	443	440	11	10800	20	39	31
Ukraine	204	389	10	9600	19	36	29
Switzerland	563	472	7	12200	17	46	25
Finland[1]	111	428	10	11138	19	43	29
Finland[2]	589	448	9	12252	19	41	29
Slovakia- this work	**154**	**434**	**9**	**12252**	**19**	**41**	**29**

The values listed in Tab. 1 for Slovenia, Poland and Ukraine were obtained from a project Gradewood (***Stapel – Denzler, 2010***). The results of spruce structural timber testing in Switzerland are listed by ***Arnold - Steiger* (*2007*)**. The quality of structural timber in Finland was studied by ***Hanhijärvi[1] et al.* (*2005*) and *Ranta-Maunus[2] et al.* (*2001*)**.

When considering the location of Slovakia in Europe (CNE), the properties of Slovakian spruce structural timber (Tab. 1) are in conformity with the presented countries.

Additionally, pine wood (*Pinus sylvestris* L.) is also used in building construction. Results of structural pine timber testing are listed by ***Krzosek et al.* (*2008*)**, ***Baltušiar-Mišeikyté* (*2011*)**, ***Stapel - Denzler* (*2011*)**, ***Hanhijärvi et al.* (*2005*)**, ***Ranta-Maunus et al.* (*2001*)**.

Distribution parameters

The normality of distribution of measured prediction model parameters was evaluated by three independent statistical tests (Kolmogorov – Smirnov, Lilliefors and Shapiro-Wilkov).

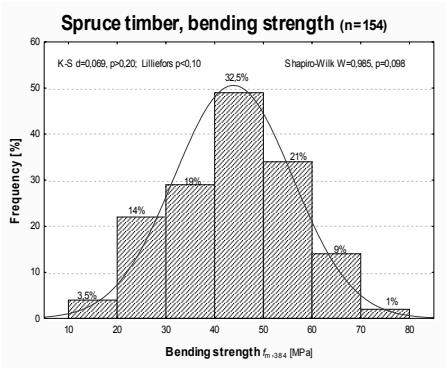

Fig. 2 Bending strength distribution

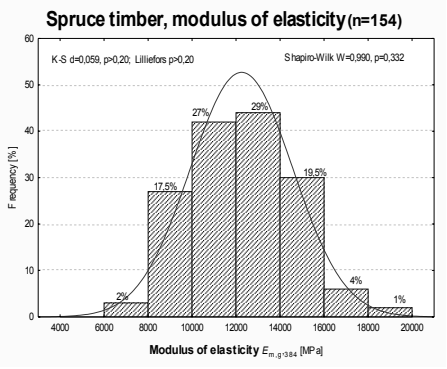

Fig. 3. Modulus of elasticity distribution

CONCLUSIONS

Prediction model parameters $E_{m,g,384}$ and ρ_{384} of structural timber (*Picea abies, Karst.*) from Slovakia have a normal distribution. Moduli of elasticity in bending and wood density are reliable indicators of structural timber strength.

The prediction of parameters of structural spruce timber from locality Slovakia presupposes a contribution for future development of timber property database for building construction. Commercial application of results consists in a definition of setting parameters for grading devices based on various principles (EN 14081-4).

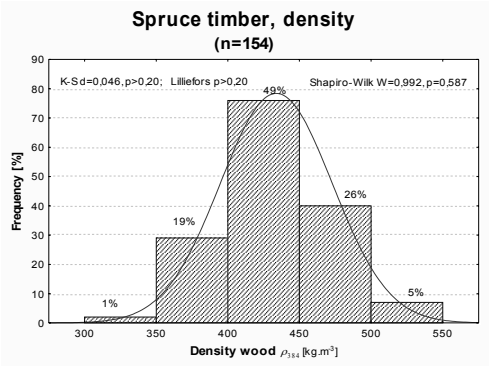

Fig. 4 Wood densities distribution

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Streszczenie: *Określenie parametrów jakościowych konstrukcyjnego drewna świerkowego z wykorzystaniem modeli predykcji.* Podczas projektowania i produkcji konstrukcji drewnianych, jakość drewna konstrukcyjnego jest ważnym atrybutem ich niezawodności. W artykule prognozowano parametry jakościowe drewna świerkowego: moduł sprężystości przy zginaniu, wytrzymałość na zginanie statyczne i gęstość drewna, z wykorzystaniem modeli predykcji. Modele te stanowią wiarygodne narzędzie oceny jakości drewna konstrukcyjnego.

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