Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 72, 2010: 220-224
(Ann. WULS-SGGW, For and Wood Technol. 72, 2010)

# Characteristic values of quality for spruce timber determined by MTG Timber Grader device

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**Abstract** *Characteristic values of quality for spruce timber determined by device MTG Timber Grader.* This contribution concerns the evaluation of spruce timber quality using the acoustic vibration method. The principle of this grading method is applied in the device MTG Timber Grader. MTG Timber Grader measures dynamic modulus of elasticity ***(MOE)*** and it determines the strength class ***C***. Within the experiments, the various parameters of quality were evaluated on timber of different lengths (long – 5 000 mm, short – 2 300 mm), such as: wood density, dynamic modulus of elasticity and strength class C. The grading methods were in accordance with European Standards.
The acoustic vibration method provides simple and fast measurement and evaluation of wood quality. However the results show the suitability of using the acoustic method for timber grading in accordance to European Standards also in condition of Slovakia, there is a need for more extensive analyses of timber quality evaluation in both theoretical and application field.

*Keywords:* spruce wood, timber quality, vibration method, dynamic modulus of elasticity, strength class

## INTRODUCTION

Wood and the assortement of some species are characteristic by its very good acoustic properties.

The sound is transmetted only trough a material medium (solid, liquid or gas). People are capable to perceive the sound waves with frequency range from 16 to 20 000 Hz. The sound waves propagate with velocity that depends on its frequency and wave length as follows:

$$c = \lambda \cdot f \quad [\mathrm{m.s^{-1}}],$$

where **c -** velocity of wave propagation [$\mathrm{m.s^{-1}}$],
**λ -** wave length [mm],
**f -** frequency [Hz].

The velocity of sound wave propagation in wood can be calculated as follows:

$$c = \sqrt{\frac{E}{\rho}} \quad [m \cdot s^{-1}]$$

where ***E*** - Young´s modulus of elasticity [MPa],
***ρ*** - wood density [$\mathrm{kg.m^{-3}}$].

These elastic properties of wood, such as modulus of elasticity and velocity of sound propagation in wood can be determined on the basis of vibrations provoked by proper force action. Amplitude of vibration depends on the frequency of applied force. The frequencies of certain wave length reacts in wood with the maximal amplitude of vibration and these frequencies are called resonant or own (natural) frequencies of wood.

Acoustic properties of wood are used as nondestructive methods for wood quality assessment. The vibration method is applied in MTG Timber Grader device.

***Timber Grader MTG -*** *principle*

Timber Grader MTG (Figure1) is patented manual portable device for nondestructive method of measuring the strength classes and the modulus of elasticity.

It works on the principle of sound waves emission and the following observation of natural frequency of wood. The obtained values are evaluated in software. It allows to perform measurements in timber of softwood and hardwood species.

***Input data***: - specification of wood species (in accordance with EN 14081- 4),
- moisture content of specimen [%],
- dimensions of specimen [mm],
- weight of specimen [kg].

***Output values*** from the measurement are:

- modulus of elasticity of wood ***MOE***,
- strength class ***C*** in accordance with EN 338. It determines 3 classes C18, C24 and C30.


Figure 1. MTG Timber Grader - application

MATERIAL AND METHODS

Samples used for the experimental testing were of structural dimensions (hereinafter timber) prepared from spruce wood (*Picea abies L.*). Preparation of experimental material consisted of:

I. testing of timber (long): 40x190-5 000 mm - 52 pcs.,
II. testing of timber (short): 40x120-2 360 mm - 52 pcs.

To determine the density of wood, three small specimen were sawn from each piece of long timber (from the end parts and from the middle part of length).
The registration sheet was assign to each sample, containing:

- number and dimensions of sample,
- moisture content and density of wood (determined by gravimetric method),
- wood quality determined by acoustic vibration method (***MOE, C*** class).

RESULTS AND THEIR ANALYSIS

The evaluation of statistical characteristics of experiments is summarised in table 1. The density of wood obtained from small specimens was corrected to standard density $\rho_{12}$ and it was applied for the evaluation of dependencies for both long and short sawn timber. The dependency of wood density from modulus of elasticity is illustrated in Figure 2. It is accompained by the dependency listed in EN 338, which shows lower values of modulus of elasticity with the same values of density measured by the MTG Timber Grader device. Both dependencies show high coefficient of correlation (long: $r_L$ = 0,75, short: $r_S$ = 0,82). The results also show the insignicicant influence of sawn timber length on quality parameter ***MOE.*** The analysis of parameter „strength class C is reduced only to three levels. Application of three classes (C18, C24 and C30) cause the undercutting of strength values mainly for the sawn timber with higher values of ***MOE*** (Figure 3). The results prove the need of strength classes „C" redifinition especially for higher values of ***MOE.***

Table 1. Basic mathematic-statistical characteristics of wood density at w = 12%, vibration method (***w*** *- wood moisture,* ***MOE*** *- dynamic modulus of elasticity)*

| Samples -timber- Basic mathematic-statistical characteristics | | Wood density $\rho_{12}$ [kg.m$^{-3}$] (small specimens) | Type of timber | | | |
|---|---|---|---|---|---|---|
| | | | ***Short timber*** 40/120-2360 mm | | ***Long timber*** 40/120-5000 mm | |
| | | | ***w*** [%] | ***MOE*** [MPa] | ***w*** [%] | ***MOE*** [MPa] |
| MTG Timber Grader | n | 52 | 52 | 52 | 52 | 52 |
| | $\bar{x}$ | 413 | 15,3 | 11303 | 16,25 | 11625 |
| | $x_{min}$ | 347 | 11,7 | 8047 | 13,7 | 8233 |
| | $x_{max}$ | 494 | 18,3 | 15584 | 19,3 | 16036 |
| | V [%] | 8,2 | 7,82 | 16 | 6,64 | 15,13 |

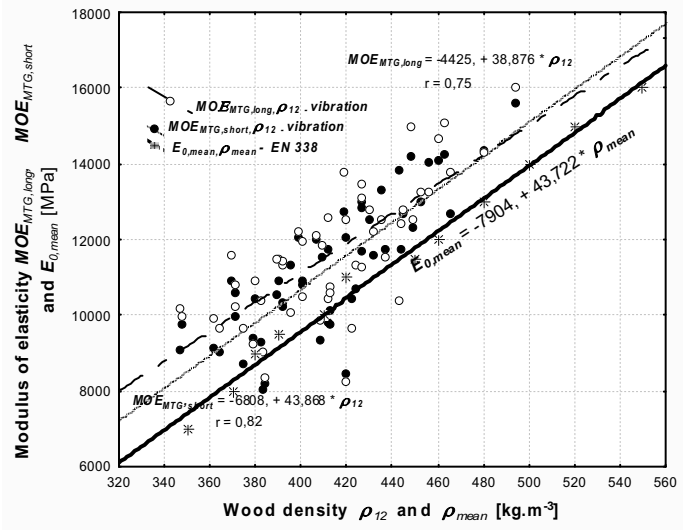


*Fig.2* Modulus of elasticity, $MOE_{MTG,long}$, $MOE_{MTG,short}$ and $E_{0,mean}$ related to measured density $\rho_{12}$ and $\rho_{mean}$

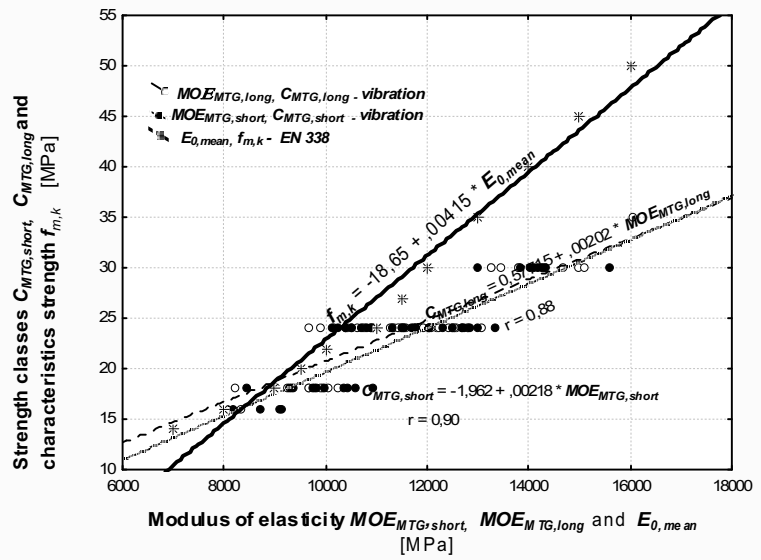


*Fig. 3. Change of strength class dependent from modulus of elasticity of spruce wood determined on timber (short, long) using MTG Timber Grader device and compared to EN 338- $f_{m,k}$.*

## CONCLUSION

The requirement of wood quality assesment based on various principles is justified and still actual. It has its important share in static, structural and economic assesment of wood for building construction.

Within the experiments, the quality of wood (MOE, C class, density of wood) was determined on spruce sawn timber (long, short) and the experimental results were compared to values listed in EN 338. The results show the insignificant influence of timber length on quality parameter MOE. Determination of strength classes „C“ using the MTG Timber Grader device undervalues the characteristic strength for higher values of modulus of elasticity MOE. The results proved the need of redifinition of number of strength classes „C“ espacially for higher values of MOE.

This study was supported by project under the contract No.VEGA 1/0549/08 „Quality of wood for building structures and its experimental analysis and verification *in situ*“.

## REFERENCES

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**Streszczenie:** *Jakość tarcicy świerkowej mierzona urządzeniem MTG Timber Grader.* Praca dotyczy wyznaczania jakości tarcicy świerkowej metodą wibroakustyczną. Metoda ta jest stosowana w urządzeniu MTG Timber Grader. Urządzenie to mierz dynamiczny modułsprężystości (MOE) oraz wyznacza klasę jakości C. W ramach eksperymentu mierzono różne parametry jakościowe w tarcicy o róznych długościach (deje potrzeba bardziej szczegółowej analizy tarcicy zarówno w aspektach teoretycznych jak i zastosowania praktycznego.

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