M. Kaliske, J. Eberhardsteiner

EUROMECH Colloquium 556

Theoretical, Numerical, and Experimental Analyses in Wood Mechanics

Dresden, Germany, 27-29 May 2015

Dynamic shear modulus of old timber members

A. Cavalli, D. Cibecchini, M. Togni
GESAAF – Department of Agricultural, Food and Forestry Systems – Section Forestry, Environment, Wood, Landscape – University of Florence, Via San Bonaventura, 13 - 50145 – Florence (FI), Italy.
E-mail: alberto.cavalli@unifi.it

1 Introduction

Waste reduction and ecological/environmental advantages promoted, during the last years, the interest in re-using old timber for structural purposes, flooring and furniture making. For the structural re-use of old timber the knowledge of the mechanical properties is mandatory. Many researches investigated the effect of the time on the bending strength and stiffness (MOE). In this research another basic property of the material is investigated: the shear modulus (G). G is important for short timber members or for parts subjected to torsional action. The calculation of the G and MOE/G ratio is based on transverse vibration technique.

2 Materials and methods

2.1 The timber

84 timber beams were rescued from historical buildings after a long structural use. All the beams were tested and visually graded: 17 of them were made of Spruce (*Picea abies* Karst.) and the other ones of Silver Fir (*Abies alba* Mill.). The average cross section of the beams was between 14x14 and 28x22 cm^2.

2.2 Dynamic test

All the specimens were tested using the transverse vibration technique and the frequency of vibration identified using a self-developed software. In this research the *Bordonné's* solution to the *Timoshenko's* model is used [1]: the solution allows to calculate a regression curve and to deduce G and MOE/G values. Only the regression curve with a r^2 higher than 0.9 were used, so only 81 beams were considered in the study (lower r^2 values indicate biased results).

3 Results and discussion

The main physical and mechanical properties of the tested beams are reported in table 1.

	ρ [kg/m³]	MOE [MPa]	G [MPa]	MOE/G
average	422	8626	398	21
min	335	2795	201	7
max	570	15575	613	36
CV (%)	11	30	28	33

Tab. 1 Descriptive statistic for density (ρ), modulus of elasticity (MOE), shear modulus (G) and MOE/G ratio.

In literature the G value is usually calculated as a ratio of the MOE in a range between 16 and 20. The average MOE/G ratio for the tested beams results 21. This value is close to the ones, obtained using dynamic tests, as reported in literature: Chui [2] and other researchers reported

a value of the MOE/G ratio of about 20. There was no correspondence between lower MOE/G ratio and lower MOE values, nor between higher MOE/G ratio and higher MOE values. This fact confirms that MOE and G are affected by wood defects in different ways, as reported in [2]. Additionally MOE and G were not related at all ($r^2 = 0.07$). In agreement to [3] the knots dimensions seemed to have an effect on G (fig. 1) although the coefficient of determination remains low but with high significance level ($r^2 = 0.11$). No relation were found between G and other characteristics such as density, slope of grain, average ring width, presence of ring shake and their extension or presence and extension of wane.

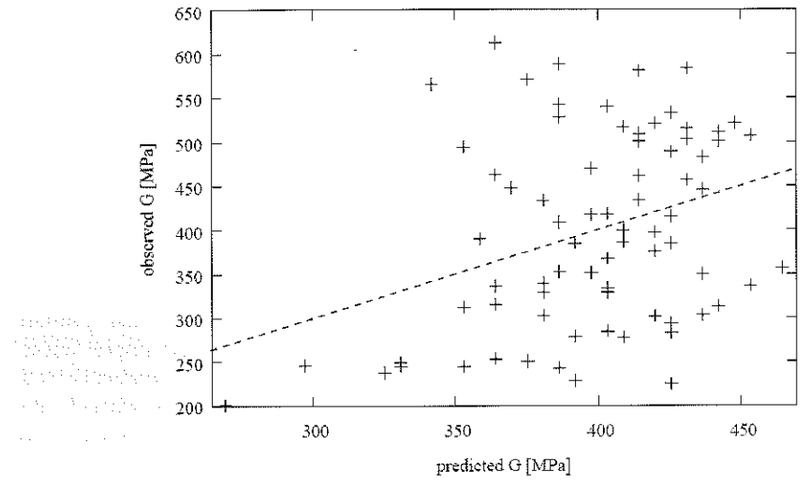

Fig. 1 Predicted versus observed G (predicted G = 492.4-577.8k, k= knots, calculated according to the standard DIN 4074 [4]).

4 Conclusions

84 old timber beams were dynamically tested and the G and MOE/G ratio were calculated basing on the *Bordonné's* solution. The average MOE/G was around 20, according to the results reported by many researchers for new solid timber, confirming that for the G, the passage of time doesn't have a significant effect, if the wood is preserved form decay.

References

[1] P. Bordonné, *Module dynamique et frottement intérieur dans le bois: Mesures sur poutres flottantes en vibrations naturelles*. 1989. Ph.D. thesis, INP Lorraine, Nancy, 154 p.

[2] Y. H. Chui, *Simultaneous evaluation of bending and shear moduli of wood and the influence of knots on these parameters. Wood Sci. Technol., vol. 25, pp. 125–134, 1991.*

[3] R. Gupta, C. Basta, and S. M. Kent, *Effect of Knots on Longitudinal Shear Strenth of douglas-Fir Using Shear Blocks. For. Prod. J., vol. 54, no. 11, pp. 77–83, 2004.*

[4] DIN 4074-1:2004-01-19 *Strength grading of wood* – Part 1: Coniferous sawn timber.