Variability of modulus of elasticity in glued laminated timber beams

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Abstract Twenty beams from the glued laminated timber were subjected to the bending tests. Displacements and some local modulus of elasticity were measured during loading. Local modulus of elasticity in the fibers direction was tested in the 1448 places. Precisely according to experiments are made 2D isotropic FEM models. The agreement between experiment and calculation is excellent. Values of local modulus of elasticity were statistic evaluated in lamellas. Three new beams were determined only on the base statistic inputs. First beam had extremely small *E* in the top and down lamellas. Second beam had in top and down lamellas average *E*. Third beam had in top and down lamellas high value of *E*. All beams had between top and down lamellas average *E*. Range of the displacements of these three beams was the same as in experiments. For displacement of beam is dominant modulus of elasticity in the fibers direction.

Keywords displacement, glued laminated timber, local modulus of elasticity, randomly properties

1. INTRODUCTION

On the Faculty of Civil Engineering in Prague were realized experiments on twenty beams from the glued laminated timber with dimensions of real structures. During experiments were obtained data from different sensors. The subject of this article is the evaluation the results of the tests, FEM modelling experimented beams and prediction of the properties of similar beams from the real statistic data obtained in the experiments.

2. METHODS AND RESULTS

2.1. Experiments-determination of local modulus of elasticity

Each beam from the glued laminated timber contains eight lamellas with high 4 cm, it is 32 cm high all beam. In length were lamellas jointed in randomly places. For independent set of experiment was detected as local modulus of elasticity in fibers direction. In each segment each lamella were measured four values of E_x. For twenty beams we obtain data file with 1448 values of local modulus of elasticity. The confrontation of values of local modulus of elasticity from the independent experiments

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and values E_x measured by strain gauges during loading tests is made. File of all values E_x is distributed according to normal distribution as demonstrates equation (1).

$$f(x) = \frac{1}{\sigma * \sqrt{2\pi}} * e^{\frac{-(x-\mu)^2}{2\sigma^2}} \quad (1)$$

Where $\mu = 12.0002$, $\sigma = 1.4385$ and variance = 2.06932.

2.2. Real FEM models

In our previously works is provided that in cause strain in one axis is possible wood structure modeled as isotropic material in 2D (Melzerová and Kuklík 2010). 3D FEM models were made as orthotropic too. Difference other material parameters with exception modulus of elasticity in fibers direction were practically negligible on the displacement of beam. This influence is much smaller than precision of measurement. Presented FEM models are 2D isotropic. Primary attention is put on distribution of modulus of elasticity in the fibers direction E in the beam. Influence of the joints on the beam displacement was detected too, in our previously works (Melzerová and Kuklík 2009).
Firstly were made FEM models twenty beams as really as possible. On the each segment on each lamella was used E as average value from the four measurements. All file of beams is derived into three groups, following displacement.

2.3. FEM models only from the statistic inputs

Here are three FEM models for extreme cases of distribution of modulus of elasticity only from the statistic inputs. Detected are displacements. First beam has top and down lamellas with modulus of elasticity on the level 0.05 cumulative probabilistic function. These value are $E = 9.63$ GPa for down lamella and $E = 9.01$ GPa for top lamella. Average six lamellas have average modulus of elasticity from these parts for twenty beams. It is $E = 11.9831$ GPa. The difference between first and second beams is only in top and down lamellas. These lamellas have average modulus of elasticity. For top lamella is $E = 11.8762$ GPa and for down lamella is $E = 12.2268$ GPa. Third beam have down and top lamellas from the modulus of elasticity on the level 0.95 cumulative probabilistic function. Top lamella have modulus of elasticity $E = 14.74$ GPa and down lamella $E = 14.82$ GPa.
From the calculated values is visible that precisely detection of modulus of elasticity is very important for displacement of beam. Results of FEM models from the statistic inputs show that contains all range of real beams.

3. CONCLUSIONS

Modulus of elasticity in the fibers direction is for the displacement of beams from the glued laminated timber fundamental. Agreement of experiments and real FEM models is excellent. FEM models can be 2D isotropic. FEM models only from the statistic inputs are excellent too, for displacement.

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REFERENCES

Melzerová, L., and Kuklík, P. (2010). “Statistical research of Mechanical properties of glued laminated timber beams.” *Metallurgy*, 49-2, 376-380.

Melzerová, L., and Kuklík, P. (2009). “Beams from the glued laminated timber experiment versus FEM model.” *World Academy of Science Engineering and Technology*, 55, 262-266.