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Experimental Stress Analysis

Variability of Strength for Beams from the Glued Laminated Timber

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Abstract: This paper is focused on the specification of strength of each lamella segment in the twenty real beams from the glued laminated timber. Determination of strengths is based on the four measures of timber density, in each segment, each lamella and each beam. From the determined density is possible define desired strength. These strengths were inserted into the FEM models of the twenty real beams and compared to the damages of beams during the bending tests. Stresses on the fields of damage during tests are determined in FEM models.

Keywords: Variability of Strength, Beams from the Glued Laminated Timber

1. Introduction

The knowledge of strengths distribution is very important for design of beams from glued laminated timber. When we compare calculated strengths and stresses in places of damage in each beam, we can make design of our beams better and economical.

In our laboratory were tested twenty beams from the glued laminated timber. The increase of loading was realized in steps (4 kN each from two forces). The finis of each test was the destruction of beam. Second set of measurements were four values of timber density in each segment, each lamella and each from twenty beams. From the density of timber were computed average values of strengths, for each segment and each lamella. These average values reduce file with 1448 values to the file with 362 values. We make certain mistakes in average values of strengths in segments, but these mistakes are not very serious, because we can't measure absolutely precisely. We can make models of twenty beams precisely according to twenty real beams from the fixed values of strengths in segments. For each beam we compare the stress on the damage level with the strength of each part of each beam. The stress on the damage level (on the place of damage) is computed in the FEM models of twenty real beams. These beams we made in our previously works with the accent of accuracy modulus of elasticity in the fibres direction. Loading of beams is in the FEM models the force on the maximal level before the beam collapse.

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As part of these work is statistical approach to the file of 362 values of strengths in each segment as constant. In the conclusion of this work is confronted theoretical design of the beam from the glued laminated timber with the real beams.

2. Method and results

The method for measurement the timber density from the reference [3] is here use. We have four values of timber density on the each segment each lamella and each beam. We obtain the file of 1448 values and we use average value in each segment for the next computation it is 362 values of timber density. For the calculation of strengths from the timber densities we use the equation from the reference [1].

$$f = -36{,}13 + 0{,}156743 * \rho \tag{1}$$

Where ρ is the density of timber in kg/m^3 and f is the strength of timber in MPa. We obtain two files of strengths from two files of densities (Fig.1). For the FEM models we use strengths as one value in each segment. The damage is anticipated on the place of strength minimum in the segment where is stress on the same level. We have a problem with the density measurement, because measurement in each point of beam is impossible. The precision of minimum value determination is as perfect as is in this case possible.

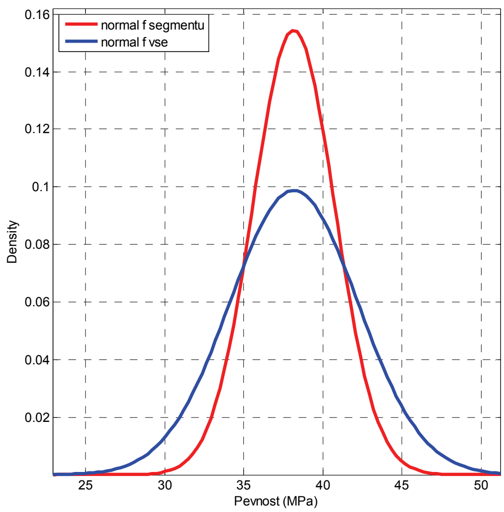

Fig. 1. The probability density functions for all 1448 values of densities and 362 values of timber densities as average value from each segment. Normal distribution is here used.

On the next three pictures are compared three quantities in three beams: the normal stress in the beam on the maximal loading level before collapse, the strength distribution and the damage distribution in the same beam. It is possible detected from these data the place of first damage of beam and way of collapse.

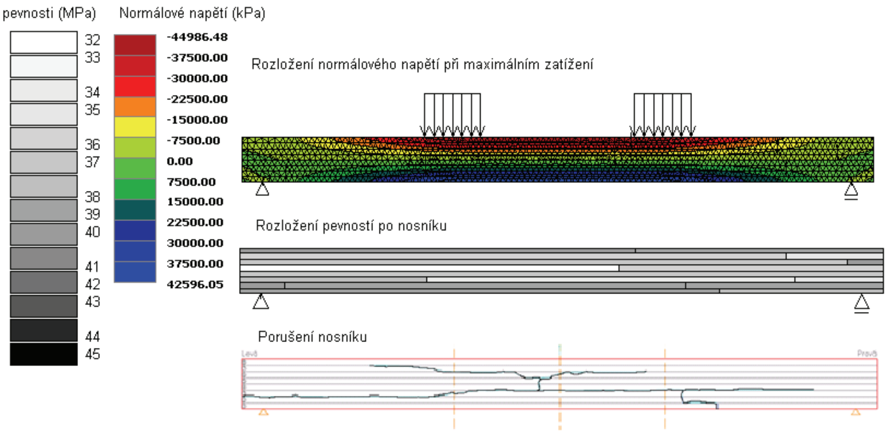

Fig. 2. The normal stress distribution in beam 1 on the maximal loading level before collapse, the strength distribution and the damage distribution in the same beam.

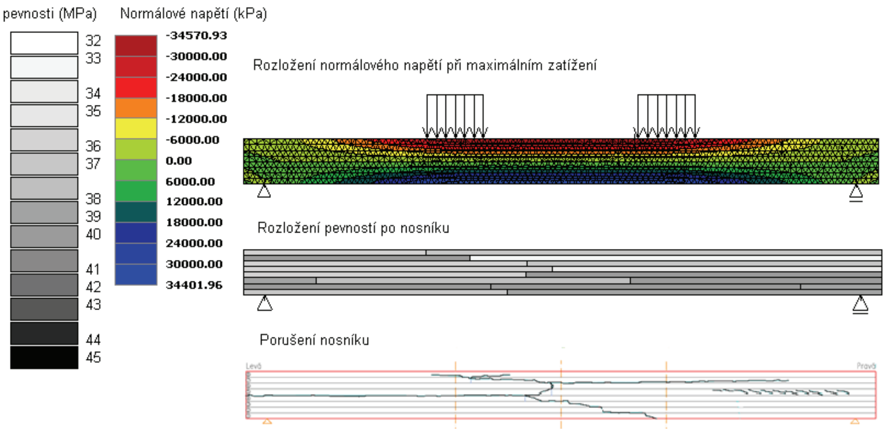

Fig. 3. The normal stress distribution in beam 7 on the maximal loading level before collapse, the strength distribution and the damage distribution in the same beam.

3. Conclusions

From determined strengths of lamellas and stresses in beams are possible define the damages during beam collapse.

From the same timber is possible construct better beam, if we place the lamella with high strength on the field with high stress in beam.

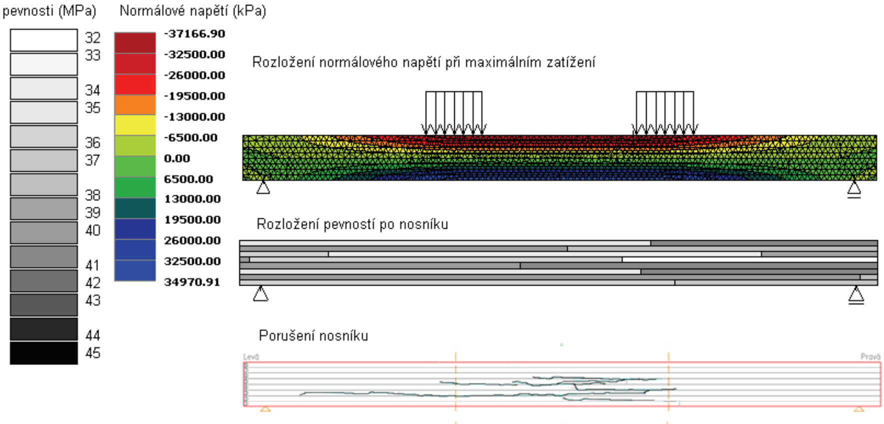

Fig. 4. The normal stress distribution in beam 20 on the maximal loading level before collapse, the strength distribution and the damage distribution in the same beam.

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