17th International Conference
ENGINEERING MECHANICS 2011
Svratka, Czech Republic, 9 – 12 May 2011

CONTRIBUTION TO THE PROBABILISTIC APPROACH OF THE IMPACT STRENGTH OF WOOD

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Abstract: *The content of this paper relates to the impact bending strength determination of selected types of coniferous and broadleaved wood boards by means of destructive testing on the Charpy hammer, creating of histograms with obtained values and determination of impact bending strength statistical quantities for various sampling sets.*

Keywords: ***Impact bending strength, Charpy hammer.***

1. Introduction

Wood is a natural renewable resource which is abundant in most European countries; therefore, it is often used in civil construction. Besides its common usage in structures, wood is traditionally used in highway construction, for construction of footbridges and wooden bridges, and, currently and most recently, for the manufacture of wooden-steel crash barriers. The latter started to be produced, for example, in Switzerland for roads with lower speed limits and in areas of tourist concentration, where higher requirements for crash barrier appearance are imposed. It is supposed that their usage will spread into other European countries.

All these elements (crash barriers, railings of bridges and footbridges) must meet the specified level of restraint which is related to the wood impact strength.

2. Impact bending strength

The impact strength is the ability of wood to absorb work done by an impact bend and it characterizes the ability of material to withstand impact loads. The impact strength is expressed by the consumed energy for breaking of wood with defined dimensions.

A measure of the energy absorbed by a timber can be obtained from a simple experiment involving observation of the initial and final velocities of a mass which impacts the timber. A mass *m* travelling at velocity v_0 will slow to velocity v_1 after impact. The energy or work absorbed by the timber is the difference in kinetic energy of the mass before and after impact (Bodig & Jayne, 1993):

$$W = -(U_{K0} - U_{K1}) \tag{1}$$

U_{K0} ... is kinetic energy of the mass before impact;

U_{K1} ... kinetic energy of the mass after impact;

Instituted to well-known equation:

$$U_K = \frac{1}{2} m v^2 \tag{2}$$

The equation of work is following:

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$$W = -(\frac{1}{2}mv_0^2 - \frac{1}{2}mv_1^2) = -\frac{1}{2}m(v_0^2 - v_1^2) \quad (3)$$

where: m … is the mass;

v_0 … velocity before impact;

v_1 … velocity after impact;

3. Laboratory testing

Sets of more than 40 samples of spruce, beech and oak boards were created for impact bending strength tests. The Charpy hammer PSd 50H by WPM Leipzig Machines was used for impact bending strength of the selected sets.

The Charpy hammer PSd50H (Figs. 1, 2) by WPM Leipzig Testing Machines with the following parameters was used for impact bending strength of the selected sets.

- working capacity of the hammer 50 J;
- fall angle 160°,
- hammer impact velocity 3.8 m.s^{-1},
- pendulum impact testing machine weight 6.917 ± 0.035 kg,
- hammer face radius of curvature 15 mm,
- pendulum length 380 mm,
- resolution 0.01 J.

Figs. 1, 2: The Charpy hammer PSd 50H.

Test specimens had the shape of right-angle prisms with a base of 20 × 20 mm and a length in the direction of the grain of 300 m. One side of the test specimen was in the radial plane, whereas the other one was in the tangential plane.

The test specimen was symmetrically laid on supports and disturbed by one hammer impact on the radial surface (tangential bend). The work absorbed by the test specimen was measured with the accuracy of 0.01 J.

4. Laboratory testing results

Impact bending strength A_W with humidity at the moment of testing was determined from the formula according to ČSN 49 0117:

$$A_W = \frac{Q}{b.h} \tag{4}$$

where: Q ... is work exercised for sample disturbance;

b, h … dimensions of test specimen in the radial and tangential directions.

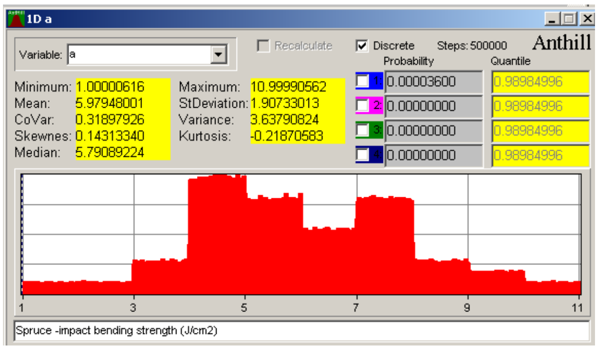
According to ČSN 49 0117 the impact bending strength was calculated for 12% humidity according to the formula:

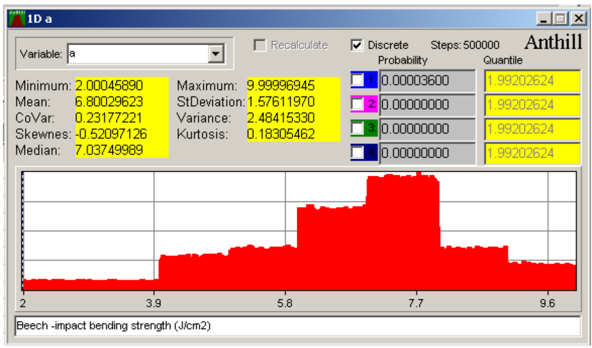
$$A_{12} = A_W \left(1 + \alpha \left(W - 12\right)\right) \tag{5}$$

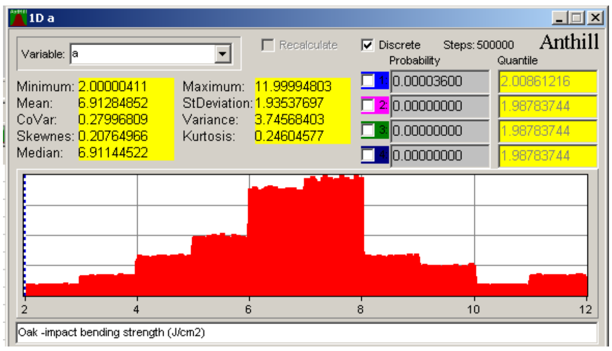
α … is a correction factor for humidity which is 0.02 for all wood species;

W … wood humidity at the moment of testing.

The values of statistical quantities (average value, standard deviation and 5% quantile) were set and arranged by means of the calculation programs PASW Statistics 18 and Anthill.







Figs. 3, 4, 5: Histogram of measured values and Gaussian distribution approximation for the impact bending strength of spruce beech and oak.

The typical disturbance of spruce samples during impact bending strength testing was the splitting of the samples along the grain (along its whole length) and creation of splintering in growth rings (Fig. 6).

Splitting without splintering along the grain (Fig. 7) is typical of beech and oak. Sometimes even clear “cutting” occurred (Fig. 8).

Figs. 6, 7, 8: Typical disturbance of spruce, beech and oak samples.

Tab. 1 shows brief summary of the values gained during the impact bending test by means of the Charpy hammer.

Tab. 1: Table with the resultant values of sample sets of individual board samples (Ø – average quantity value, σ - standard deviation, A_{05} - 5% quantile).

Impact bending strength [J.cm^{-2}]			
	ø	σ	A_{05}
Spruce	6.04	1.784	3.09
Oak	6.85	1.893	3.74
Beech	6.94	1.65	4.23

5. Conclusions

It is evident from table (1) that the highest impact bending strength is shown with beech (average value 6.94 J.cm^{-2}); whereas the lowest impact bending strength is shown with coniferous – spruce (average value 6.00 J.cm^{-2}). At 5% quantiles, the difference is much higher.

Impact bending strength was tested at an average humidity of 8% in the sample sets. As wood characteristics are dependent on humidity, it would be convenient to test wood strength for various humidity levels and to check humidity influence on wood strength because the elements of crash barriers and footbridge railings are exposed to various climatic conditions.

Acknowledgement

This outcome has been achieved with the financial support of the Ministry of Education, Youth and Sports of the Czech Republic, project No. 1M0579, within activities of the CIDEAS research centre**.**

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Anthill, computational program for PC.

PASW Statistics 18, computational program for PC.