STUDY OF PHYSICAL AND MECHANICAL PROPERTIES OF ORIENTED BOARD DEPENDING ON MOISTURE CONTENT

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ABSTRACT

The goal of this study was to analyze the moisture content of the oriented strand board (Durélis/Populair and OSB 3) representing moisture resistant boards for load-bearing applications in humid conditions. The studied properties are modulus of rupture (MOR), modulus of elasticity (MOE), static hardness, thickness swelling and absorption of water. The moisture content of specimens was altered by soaking during different periods of time (6h, 12h, 18h, 24h, 36h) while one series (24h) was dried out in a climate chamber. An analytical equation was used for approximation of the change of the physical and mechanical properties of the specimens depending on their moisture content. The sensitivity of the measured data has been studied and the expanded uncertainties of the computed mean values are presented. The study reveals that although the boards are moisture resistant, there are some significant differences from the physical and mechanical properties set by the standard, which are caused by their different manufacturing technologies and differences in their structure.

Key words: particleboard, modulus of rupture, modulus of elasticity, static hardness, thickness swelling

INTRODUCTION

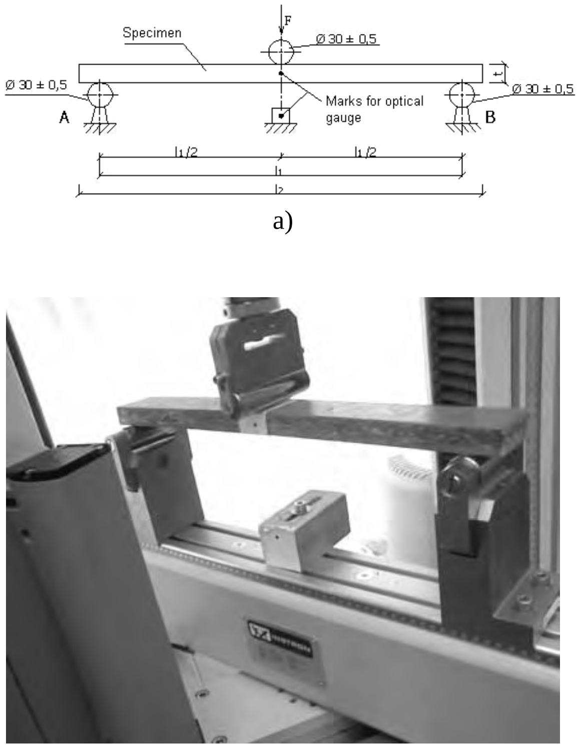
Oriented strand board should be moisture resistant in accordance with the standard EVS EN 300 Grade OSB 3. The mechanical properties of OSB generally surpass those of particleboard but it has higher thickness swelling and poorer surface smoothness. Particleboards are used for cladding walls and ceilings indoors or outdoors, as floor decking material and wind barrier. This kind of material is also used in load bearing structures as rigidity material (e.g., OSB 4). The Durélis/Populair and the OSB 3 panel as wood-based sheets are hygroscopic materials and the mechanical and their physical properties are dependent on their moisture content and surrounding temperature.

The goal of this research was to study the changes in the modulus of rapture (MOR), modulus of elasticity (MOE) in bending, static hardness and thickness swelling at different moisture contents.

The main method is to soak specimens in water for a certain period of time or to dry them in a climate chamber; further, to measure the moisture content and to test them with the universal test machine INSTRON 3369. After these procedures they are analyzed.

EXPERIMENTAL PROCEDURE AND METHOD

The MOR and the MOE in bending are found by three-point bending using the test machine INSTRON 3369 (Fig. 1). Deflection for calculating the modulus of elasticity was measured by an optical gauge (Advanced Video Extensometer 2663-821). The experiments were made with three series (the minimum number of specimens in series is eight). The specimens were cut in different directions from a board: one in the longitudinal direction (lengthwise) of the board and another in the transversal direction (crosswise).



a)

b)

Figure 1. Three-point bending and points of deflection measurement: a) scheme b) photo

Figure 2 presents the MOE obtained by the bending testing and by the approximation of the load-deflection curve with the straight line (Fig. 2).

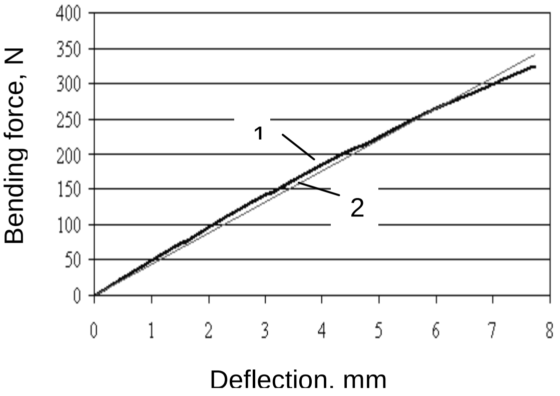


Figure 2. Dependence of deflection on bending force: 1 – real curve; 2 – approximation line.

The MOE was determined by the following formula (see the standard EVS-EN 310:2002)

$$E_m = \frac{l_1^3 (F_2 - F_1)}{4bt^3 (a_2 - a_1)}, \tag{1}$$

where
l_1 is the length between the supports, (240mm);
b is the width of a specimen, (50±1mm);
t is the thickness of a specimen, (12mm);
F_1 and F_2 are 10% and 40% from the maximum bending force, respectively;
a_1, a_2 are deflections according to the loads F_1, F_2.

The MOR was calculated by the following formula (see the standard EVS-EN 310:2002)

$$f_m = \frac{3F_{\max} l_1}{2bt^2}, \tag{2}$$

where F_{max}, is the maximum load, N.

Static hardness was determined by the Janka hardness test on the test machine INSTRON 3369 using 50×50 mm specimens.
The following analytical expression was used to approximate the experimental data for the investigated parameters depending on their moisture content

$$Y(x) \equiv Y_0 \times e^{-(cx)^2}, \tag{3}$$

where Y_0 is the value of the investigated properties (x = 0), c is a dimensionless parameter.

The purpose was to find unknown constants so that the measured properties can be approximated in the best way. This problem was solved using the mathematical program *Mathcad 2001i Professional* regression function *genfit* (vx, vy, F) (Kir'yanov, 2001).

MEASUREMENT UNCERTAINTIES

In general, the result of a measurement is only an approximation or an estimate of the value of a specific quantity subject to the measurement, and thus the result is complete only when accompanied by a quantitative statement of this uncertainty. This is the amount of doubt in a reported result of a measurement. It is usually described by a parameter that defines the range within which the true value of the quantity to be measured is estimated to fall within a given confidence range – usually 95%.
Standard uncertainty can be calculated by the following formula (Laaneots, Mathiesen, 2006).

$$s_{w,j} = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left(x_{i,j} - \bar{x}_i\right)^2}, \tag{4}$$

where n is the amount of specimens, $\bar{x}_i$ is the mean of the input estimates $x_{i,j}$.

$$\bar{x}_i = \frac{1}{n}\sum_{j=1}^{n} x_{i,j}. \tag{5}$$

Calculation of uncertainty of the measurements is carried out according to the standard EVS-EN 326-1:2002.
The lower confidence level at the significant level 5%

$$L^q{}_{5\%} = \bar{x} - t_n s_{w,j}, \tag{6}$$

where
t_n is the coverage coefficient.

The upper limit confidence level at the 5% significance

$$U^q{}_{5\%} = \bar{x} + t_n s_{w,j}. \tag{7}$$

RESULTS AND DISCUSSION

The investigated OSBs are manufactured: Durelis/Populair, Spano Group NV, Belgium; OSB 3, Bolderaja Ltd, Latvija; and Kronopol, Poland, according to the European Union standard EN 312.
The water absorption of the test specimens of the investigated materials, depending on the soaking time, is presented in Fig. 3.
The absorption of water in the OSB 3 panels is noticeably higher than in Durelis/Populair. MOR, MOE and static hardness were approximated by the presented logarithm function. The proposed formula approximated the experimental data satisfactorily. Here we present only MOR (see Fig. 4).

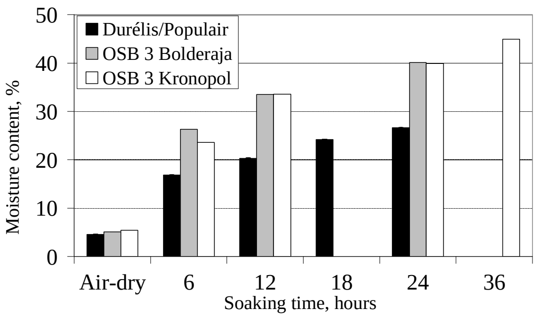
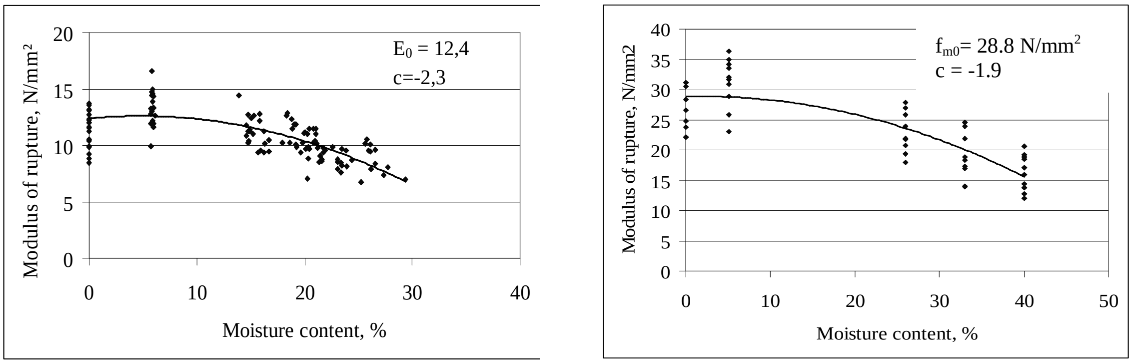


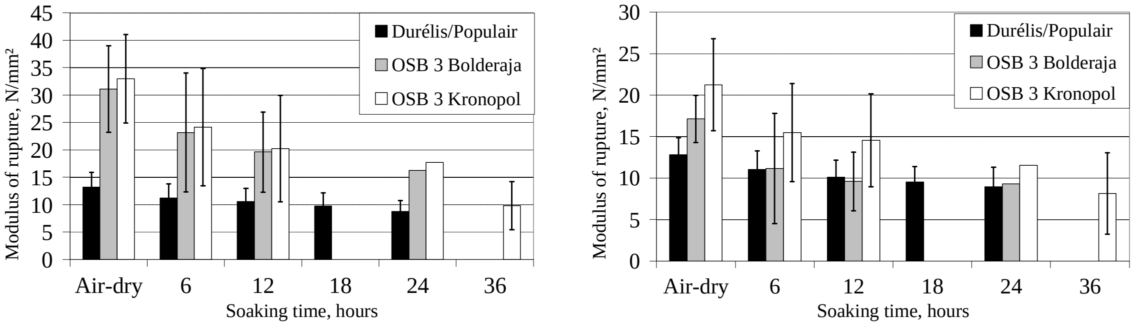
Figure 3. Moisture content depending on soaking time

The decrease in the values of the studied properties (about two times or more) is the largest at the moisture content from air-dry to 40%. For all values of the calculated properties the dimensionless parameter $c \approx -2$ (in the limits of measurement uncertainty). Thus, so we can determine to a certain extent the mechanical and physical properties if the moisture content is known. We can see that the MOR and the MOE are considerably higher for OSB 3 panels than for Durélis/Populair, which are cut lengthwise. The values of these parameters are more similar for the specimens cut crosswise.



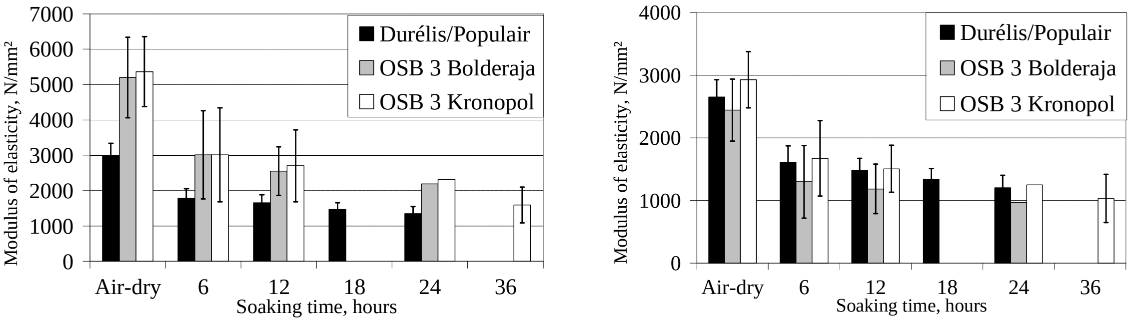
a) b)

Figure 4. Dependence of modulus of rapture on moisture content (lengthwise):
a) Durélis/Populair; b) OSB 3 panel (Bolderaja)



a) b)

Figure 5. Dependence of modulus of rupture on moisture content:
a) lengthwise, b) crosswise



a) b)

Figure 6. Dependence of modulus of elasticity on moisture content:
a) lengthwise, b) crosswise.

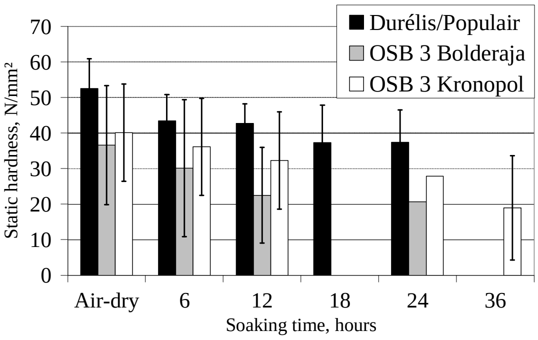


Figure 7. Dependence of static hardness on moisture content.

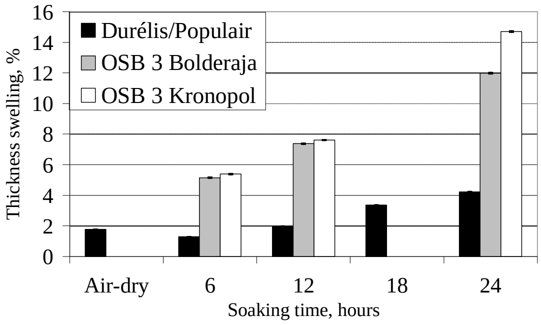


Figure 8. Dependence of thickness swelling on moisture content.

Long-term exposure to high levels of moisture causes reduction in the strength and stiffness.

The static hardness of Durélis/Populair panels is higher than that of OSB 3 panels but this property is less affected by the moisture content. The thickness swelling was determined in the middle of the specimens with the dimensions 50× 50 mm.

The thickness swelling of OSB 3 panels is more than two times larger than that of Durélis/Populair.

The uncertainties of the determined properties are lower for Durélis/Populair than for OSB 3 panels. The results of the study showe that there are some significant differences from the physical and mechanical properties set by the standard, which are caused by different manufacturing technologies and differences in their structure.

CONCLUSIONS

The investigated properties are affected by the soaking time: 12 hours for OSB 3 (moisture content 33%), 24 hours for Durélis/Populair (moisture content 27%) or higher. In the case of a higher moisture content the values of the properties decrease significantly (about two times) particularly, the values MOE, when the specimens were cut lengthwise from the test board.

The results of this study showed that the MOR and the MOE were lower for the specimens that were cut crosswise from the test boards compared with the specimens that were cut lengthwise, at all measured moisture contents.

The specimens cut from OSB 3 (Kronopol) panels after a soaking time of 24 hours were dried out in a climate chamber and they lost about 41% to 47% for MOR and MOE, 20% for the static hardness of their values of the investigated properties obtained at air-dry moisture.

The presented analysis is limited to the data obtained from the above described experiments.

A logarithmic function is proposed for approximation of the experimental data.

REFERENCES

Bolderaja Ltd. Products, OSB chipboard. [http://www.bolderaja.lv/index.php?act=page&id=12] (03.05.2011).

EVS-EN 300:2000: *Oriented Strand Boards* (OSB) - *Definitions, classification and specifications*. Tallinn. Eesti Standardikeskus.

EVS-EN 317:2000: *Particleboards and fibreboards - Determination of swelling in thickness after immersion in water.* Tallinn. Eesti Standardikeskus.

EVS-EN 310:2002. *Wood-based panels - Determination of modulus of elasticity in bending and bending strength.* Tallinn: Eesti Standardikeskus.

Kir'yanov, D. (2001) *Mathcad 2001. Manual for self-tuition,* Sankt-Petersburg: BHV-Petersburg.

Kronopol. Products, Construction products, Kronopol OSB 3. [http://en.mdb.kronopol.pl/OSB-boards/Programme] (03.05.2011)

Laaneots R. , Mathiesen O. (2006) *An Introduction to Metrology*. Tallinn: TUT Press. 206 p.

Paabo, P. (2008) *Study and comparison of oriented strand board (OSB) mechanical and physical values.* M.Eng. Thesis. Tartu: Estonian University of Life Sciences. 113 p.

Siim, K. (2010) *Study of physical and mechanical properties of Durélis/Populair particleboards depending on moisture content*. M. Eng. Thesis. Tartu: Estonian University of Life Sciences. 87 p.

Sillaste, K. (2011) *Study and comparison of oriented strand board (OSB) mechanical and physical values*. M. Eng.Thesis. Tartu: Estonian University of Life Sciences. 74 p.

SpanoGroup – Wood Based Solutions. Durélis/Populair. [http://www.spano.be/productdetails.aspx?con=238] (19.04.2010).