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CHARACTERISTICS OF COMMERCIAL ORIENTED STRAND BOARDS (OSB) PRESENT ON THE MARKET

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ABSTRACT

The paper analyzes the properties of oriented strand boards (OSB) present on the market in our country. In the past years there has been an increased interest for construction of wooden buildings, where the wood-based panels are one of the basic materials for structural and non-structural use. In such buildings different types of OSB can be used as load-bearing members or as general purpose boards, as well as in dry or humid conditions, depending on the place of incorporation in the building.
It is important to take an overview of the characteristics of these panels that are present on the market in our country, which will contribute to better understanding of the proper use of OSB according to their physical and mechanical properties.

Commercially produced OSB panels taken from one company from wood-based panel market were tested. Evaluation of the quality of the panels was made on the basis of the results obtained for the physical and mechanical properties of the panels. Properties of OSB panels were tested according to the national MKC standards and European norms.

Tested OSB panels taken from the market are not fully in accordance with the technical specifications given by the manufacturer of these boards, and the requirements of the standards for OSB panels for use as structural load-bearing panels. There are some deviations found in the quality of the panels in different panels' direction regarding the values obtained for some of the properties tested.

Key words: wood-based panels, oriented strand boards (OSB), physical properties, mechanical properties, construction

1. INTRODUCTION

Oriented strand boards (OSB) are engineered wood-based panels made from large wood strands bonded together with an adhesive on the base of a synthetic resin. The wood strands used in OSB production have a length at least twice their width and they are orientated in predetermined directions in each layer to simulate some of the characteristics of plywood (TRADA, 2012). OSB is usually composed of three layers, with the strands of the outer two layers orientated in a particular direction. In OSB panels with oriented layers, it is often hard to see the orientation because there is quite a large degree of variability in this orientation among adjacent strands in the panels from each and every production line, as well as between panels from different producers (Panel Guide V4).
A typical production process involves reducing wood down to strands that are cut parallel to the grain and dried in a rotary drier. After drying, these strands are generally sprayed with a synthetic resin binder and wax. The three main adhesives used in the production of OSB are phenol-formaldehyde (PF), isocyanates (MDI or PMDI) and melamine-urea-formaldehyde (MUF). These are either used on their own, or the core and the surface layers may use two different types of adhesive. The resinated strands are then formed into a mat (forming the board in layers), where the strands for the surface

layers are oriented predominantly in one direction, while the strands for the core layer are either randomly orientated or orientated at right angles to those in the surface layers. The resinated mat is pressed to a required density and thickness, usually in a multi-daylight press or a continuous press (Wood Panel Industries Federation).

Typical densities of OSB panels range between 600 and 680 kg/m^3 (Wood Panel Industries Federation).

OSB panels produced in the European market are specified and classified according to the requirements defined in the EN 300. According to that classification, the requirements for the following types of OSB are specified in the standard:

- OSB/1 - General purpose, non-load-bearing panels, and panels for interior fitments for use in dry conditions;
- OSB/2 - Load-bearing panels for use in dry conditions;
- OSB/3 - Load-bearing panels for use in humid conditions;
- OSB/4 - Heavy duty load-bearing panels for use in humid conditions.

According to the European Panel Federation data (2017), the OSB panels suitable for structural and non-structural use in dry conditions accounted for 10% in 2016 (European Panel Federation, 2017). The load-bearing panel, suitable for structural use in humid conditions (OSB/3) is the major OSB type, which accounted for approximately 85% of the whole European output. The Heavy duty load-bearing OSB panels (OSB/4) accounted for 5% of the European OSB production (Mantanis *et al.*, 2017).

OSB panels should generally be kept away from direct contact with water. OSB panels suitable for use in humid conditions are to a certain extent resistant to short-term wetting and high humidity, but are not intended for exposure to prolonged wetting (Wood Panel Industries Federation, 2014).

Because of its composition and characteristics, OSB is primarily used in construction where it is widely used for flooring, flat roof decking, roof sarking and wall sheathing. OSB panels are also used for packaging and in furniture production. OSB panels with a surface coating are available for non-structural applications, such as site hoarding.

Beside plywood as wood-based material, OSB panels are the most commonly used wood-based panels in construction sector in our country. These panels are imported from other countries. For proper use of OSB panels it is essential for the designers of wooden buildings, constructors and users to be familiar with the properties of these panels.

Also, in the course of the past years there has been an increased interest for construction of wooden buildings in our country where the wood-based panels are one of the basic materials for structural and non-structural use. In such buildings different types of OSB can be used as load-bearing members, or as general purpose boards, depend on the place of incorporation in the building. Very often buyers and users of wood-based panels are not familiar with the different types of OSB panels, their categorization and characteristics that are intended for different applications. That is why it is important to make an overview of the characteristics of these panels that are present on the market in our country, which will contribute to better understanding of the proper use of OSB according to their physical and mechanical properties.

For better understanding of OSB panels and their proper end use by constructors and designers, physical and mechanical properties of OSB panels present on the market have been tested.

2. MATERIALS AND METHODS

For realization of the research, oriented strand boards were taken by random choice from the storehouse of the company “Mikrotim” from Kumanovo and were transported to the Laboratory for wood-composite materials at the Faculty of Forestry in Skopje. The OSB panels were product of the company „Kronospan Bulgaria EOOD-Burgas“ from Bulgaria. The product dimensions of the panels were 1220×2440×18 mm.

Test specimens for determination of the physical and mechanical properties according to the national and European norms were cut from the panels. The following properties were tested: density (MKS D.C8.114), moisture content (MKS D.C8.103), thickness swelling and water absorption (MKS D.C8.104), modulus of rupture (MOR-bending strength) and modulus of elasticity in bending-MOE

(MKS EN 310), internal bond-IB (MKS EN 319), compressive strength (MKS D.A1.110) and hardness according to Janka.

Thickness swelling and water absorption were tested after 24 hours immersion in water, which is a standard treatment, and after prolongation of the treatment up to 72 hours, in order to see the behavior of the OSB panels during their exposure to high humidity conditions and prolonged water impact.

The bending strength and modulus of elasticity in bending, as well as compressive strength, were tested in five directions, i.e. parallel and perpendicular to the length of the panel and at the angles of 22,5°; 45° and 67,5° to the panel's length. Tests in different directions of the OSB panels will provide data on the strength characteristics of the OSB panels in different directions related to the structure of OSB.

The data obtained was statistically analyzed. One way ANOVA was used to determine the significance of the effect of the direction of the force in bending and force of compression on the OSB bending strength and modulus of elasticity in bending, as well as on OSB compressive strength. Tukey's test was applied to evaluate the statistical significance between mean values for the properties in different panel direction.

Statistical software SPSS Statistic was used for statistical analysis of the data obtained.

3. RESULTS AND DISCUSSION

The results obtained for the physical and mechanical properties of OSB panels are shown in Table 1.

The mean value for thickness swelling after 24 hours immersion in water is above 20% (22,12%). The European norm EN 300 for OSB panels defines the maximal value for thickness swelling after 24 hours for different types of OSB as follows: for OSB/1 max 25%, for OSB/2 max 20%, for OSB/3 max 15% and for OSB/4 max 12%. According to these limitations, the tested OSB panels meet the requirements for general purpose OSB for non-load-bearing panels, and panels for interior fitments for use in dry conditions (OSB/1 The obtained mean value for this property is above the maximal allowed value of 20% for type OSB/2 (load-bearing panels for use in dry conditions), which is stated in the technical specification of the boards (Product technical specification, 2010).

The multiple layer mat structure of OSB has an influence on panel properties, notably on thickness swelling (Wang *et al.*, 2004). The thickness swelling is affected by many parameters that are related to mat structure, such as: number of layers, orientation, furnish quality, species, the ratio on a weight basis of face material to core materials, resin type, resin ratio, wax type, wax ratio etc. (Wang *et al.*, 2004).

Thickness swelling is one of the basic properties that determine whether the panel will be used in dry or humid conditions. That is why it is very important for constructors and designers to be aware of the climate conditions in which the OSB panels will be used.

The intensity of thickness swelling is highest in the first period of immersion in water (24 h). By prolonging the water treatment to 48 and 72 h, the thickness swelling increases, but with lower intensity.

The values for water absorption of OSB correspond to those of thickness swelling. The tested panel has high values for water absorption, which is most intense in the first period of immersion (after 24 h). After 48 and 72 h immersion in water, the values for this property increase but with lower intensity.

According to the value obtained for internal bond, the tested OSB meets the requirements for all types of OSB panels including type OSB/4 for heavy duty load-bearing panels for use in humid conditions. The standard EN 300 defines the following minimal values for internal bond for OSB with thickness from 18 to 25 mm: for OSB/1 min 0,26 N/mm^2; for OSB/2 and OSB/3 min 0,3 N/mm^2 and for OSB/4 min 0,4 N/mm^2.

The OSB hardness test is not mandatory, and there is no sufficient literature data to make comparison between the values obtained for hardness.

The statistical data for the bending strength and modulus of elasticity in bending of tested OSB are shown in Tables 2 and 3.

The analysis of variance of the obtained data for bending strength (ANOVA: F(4;51) = 35,016; p<<0,001) showed that the there are statistically significant differences in the mean values of MOR in different directions of the panel at 0,05 probability level. The highest value of MOR is achieved in direction parallel to the length of the OSB panel, while the lowest value is achieved in cross-length direction. The values of MOR at the angles of 22,5°; 45° and 67,5° are between the values at these two directions (parallel and perpendicular to the length), whereas by increasing the angle the value for bending strength is decreasing. Compared to the mean value of MOR parallel to the length of the panel, the mean value of MOR perpendicular to the length of the panel and at the angles of 22,5°; 45° and 67,5° to the panel's length is lower by 46,32%, 15,91%, 31,14% and 37,45%, respectively. The post-hoc Tukey's test showed that there are no statistically significant differences in the mean value of MOR perpendicular to the panel's length and at the angle of 67,5°, as well as between MOR at the angle of 45° and 67,5° to the panel's length.

The differences in the values for bending strength in different directions of OSB panel are a result of the orientation of the wood strands in panel structure. The orientation of the wood strands along the length of the panel in the face layers of the OSB panel has direct impact on achieving higher values for bending strength in this direction.

Table 1. *Statistical data for physical and mechanical properties of OSB panel*

Property	***N***	***Mean***	***Std. Deviation***	***Std. Error***	***95% Confidence Interval for Mean***		***Min***	***Max***
					Lower Bound	***Upper Bound***		
Density (kg/m^3)	12	599,91	22,51	6,50	585,60	614,21	554,80	634,67
Moisture content (%)	12	8,51	0,17	0,05	8,40	8,61	8,34	8,88
Thickness swelling after 24 h (%)	12	22,12	1,05	0,30	21,45	22,78	19,48	23,64
Thickness swelling after 48 h (%)	12	22,77	1,16	0,34	22,03	23,51	19,75	24,18
Thickness swelling after 72 h (%)	12	23,88	1,15	0,33	23,15	24,61	21,06	25,39
Water absorption after 24 h (%)	12	75,35	2,70	0,78	73,64	77,07	70,50	80,13
Water absorption after 48 h (%)	12	86,06	2,90	0,84	84,22	87,90	80,50	90,98
Water absorption after 72 h (%)	12	89,15	2,71	0,78	87,43	90,87	84,11	93,91
IB (N/mm^2)	10	0,40	0,05	0,02	0,36	0,44	0,32	0,50
Janka hardness (N/mm^2)	12	30,39	4,21	0,86	28,61	32,24	24,53	39,24

Table 2. *Statistical data for MOR in different directions of the panel*

Force direction	***N***	***Mean***	***Std. Deviation***	***Std. Error***	***95% Confidence Interval for Mean***		***Min***	***Max***
					Lower Bound	***Upper Bound***		
Parallel	10	19,17[a]	2,47	0,78	17,41	20,94	15,02	23,35
Perpendicular	12	10,28[b]	1,46	0,42	9,36	11,21	8,12	12,92
Angle 22,5°	11	16,12[c]	2,54	0,76	14,41	17,82	12,72	20,46
Angle 45°	11	13,20[d]	1,59	0,48	12,13	14,27	10,88	17,01
Angle 67,5°	12	12,00[b,d]	1,59	0,46	10,98	13,00	9,04	15,57

The mean values with the same letters are not significantly different at 0,05 probability level

Table 3. *Statistical data for MOE in different directions of the panel*

Force direction	***N***	***Mean***	***Std. Deviation***	***Std. Error***	***95% Confidence Interval for Mean***		***Min***	***Max***
					Lower Bound	***Upper Bound***		
Parallel	10	2636,25[a]	294,93	93,26	2425,27	2847,23	2080,06	3147,39
Perpendicular	12	1408,25[b]	175,22	50,58	1296,91	1519,58	1090,77	1628,90
Angle 22,5°	11	2183,51[c]	194,89	58,76	2052,58	2314,44	1876,27	2471,10
Angle 45°	11	1987,54[c]	196,51	59,25	1855,52	2119,56	1634,59	2254,00
Angle 67,5°	12	1597,05[b]	157,29	45,41	1497,11	1696,98	1335,80	1862,36

The mean values with the same letters are not significantly different at 0,05 probability level

The analysis of variance of the obtained data for modulus of elasticity in bending-MOE (ANOVA: $F(4;51) = 60{,}996$; $p<<0{,}001$) showed that there are statistically significant differences in the mean value for this property in different panel directions at 0,05 probability level. The post-hoc Tukey's test showed that MOE parallel to the panel's length statistically differs from the MOE in all other directions of the panel. There are no statistically significant differences in the mean value of MOE perpendicular to the panel's length and at the angle of 67,5°, as well as between MOE at the angle of 22,5° and 45° to the panel's length.

The anisotropy of the OSB panel also can be seen from the polar diagram of bending strength shown in Figure 1.

The values obtained for bending strength meet the requirements for load-bearing panels (type OSB/2 and OSB/3) defined in the standard EN 300.

EN 300 defines the minimal value of 3500 N/mm^2 for MOE parallel to the panel's length for load-bearing panels OSB/2 and OSB/3 and minimal value of 1400 N/mm^2 for MOE perpendicular to the length of the panel. The obtained value of MOE parallel to the length of the panel is lower than the minimal value given by the manufacturer of the tested OSB boards. The tested OSB panel does not meet the requirements of the standard EN 300 for load-bearing panels in relation to the MOE parallel to the panel's length. According to this value obtained and defined requirements by the standard, the tested OSB can be used only as general purpose, non-load-bearing panels, and panels for interior fitments for use in dry conditions (OSB/1).

By comparison of the obtained values of MOE with the values given in the panel guides and technical documents (Cai and Ross, 2010; EPF-European panel federation; Structural Board

Association, 2004; Stark *et al.*, 2010; Youngquist, 1999), one can come to a conclusion that this OSB can be used as a general purpose board in dry conditions, and it does not meet the requirements for structural load-bearing panels in wood structures.

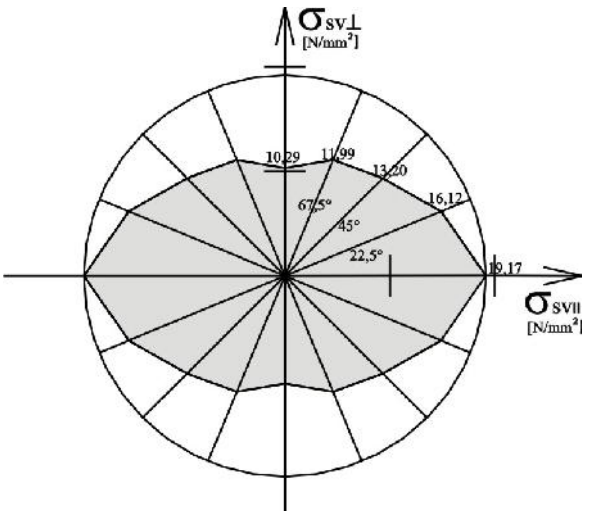

Figure 1. *Polar diagram of bending strength of OSB panel*

Figure 2. *Standard deformation of the test specimens when testing the bending strength*

The statistical data for the compressive strength of tested OSB are shown in Table 4.

Table 4. *Statistical data for compressive strength in different directions of the panel*

Force direction	***N***	***Mean***	***Std. Deviation***	***Std. Error***	***95% Confidence Interval for Mean***		***Min***	***Max***
					Lower Bound	***Upper Bound***		
Parallel	12	12,20[a, c]	1,23	0,35	11,42	12,98	10,65	14,40
Perpendicular	10	8,95[b]	0,79	0,25	8,39	9,52	7,43	9,96
Angle 22,5°	11	12,98[c]	1,25	0,38	12,14	13,82	10,27	14,84
Angle 45°	12	11,48[a, d]	1,02	0,29	10,83	12,13	9,80	12,87
Angle 67,5°	12	10,38[d]	1,00	0,29	9,74	11,01	9,08	11,97

The mean values with the same letters are not significantly different at 0,05 probability level

The analysis of variance of the obtained data for compressive strength (ANOVA: $F(4;52) = 22,883$; $p<<0,001$) and post-hoc Tukey's test showed that the there are statistically significant differences in the mean values for compressive strength in different directions of the panel at 0,05 probability level. The highest value for this property is achieved when the direction of the force of compression is at the angle of 22,5° to the length of the OSB panel, while the lowest value is achieved when the compression force is perpendicular to the panels length. By increasing the angle between the direction of the force of compression and the length of the panel in the range between 22,5° and 90°, the value for compressive strength is decreasing.

The differences in the values for compressive strength in different directions of OSB panel are a result of the orientation of the wood strands in panel structure. The orientation of the wood strands along the length of the panel in the face layers of the OSB panel has direct impact on achieving higher values for compressive strength when the force of compression is parallel to the length of the panel and when it is at the angle of 22,5°.

The polar diagram of compressive strength is shown on Figure 3.

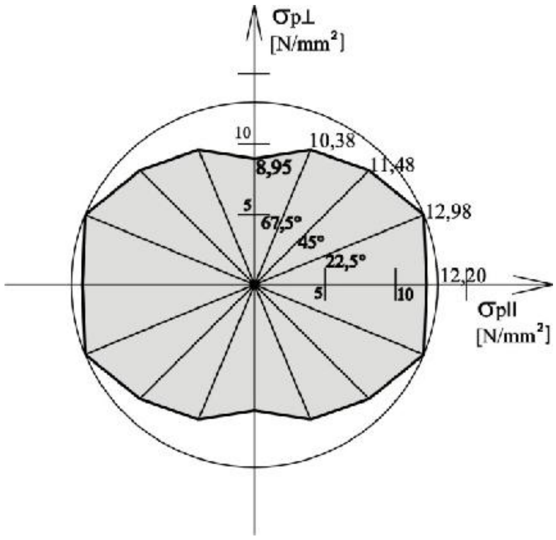

Figure 3. *Polar diagram of compressive strength of OSB panel*

Figure 4. *Standard deformation of the test specimens when testing the compressive strength*

4. CONCLUSIONS

Oriented strand boards are wood-based panels which are increasingly being used for construction due to their good physical and mechanical properties. Proper application of OSB requires understanding of the basic physical and mechanical properties of the panels, especially of those ones present on the market. Very often buyers and users of wood-based panels are not familiar with the different types of OSB panels, their categorization and characteristics that are intended for different applications.

There are deviations found in the quality of the panels regarding the values obtained from some of the tested properties in different directions of the panel. For some of the tested properties the OSB panels meet the requirements of the standard for load-bearing panels, but only in one direction of the panel (such was the case with the MOE in bending). The obtained high value for thickness swelling defines the tested OSB panels as general purpose boards for use in dry conditions, which does not correspond to the values obtained for some of the mechanical properties, according to which the OSB can be classified as a load-bearing panel.

Tested OSB panels taken from our market are not fully in accordance with the technical specifications given by the manufacturer of these boards and the requirements of the standards for OSB panels for use as structural load-bearing panels. Based on the specifications given by the manufacturers, the importers can introduce these panels as load-bearing panels for structural application, which does not correspond to the real quality of the boards. This is an issue that we must pay attention to.

The results obtained from this research can give directions for appropriate application of these panels according to their quality characteristics. At the same time, the importers of panels in the Republic of Macedonia can gain a better insight in the quality of the panels that they import.

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