Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

LAYER COMPOSITING EFFECT IN THE PROPERTIES OF DIFFERENT WOOD PANELS TYPE (FLAKEBOARD, OSB AND OSL)

Lygia Maria Napoli[1*], Ezaquel Bednarczuk[2], Luiz Henrique Natalli[3], Everton Hillig[4], Fabiane Salles Ferro[5].

[1*]Colégio Estadual Cívico Frei Doroteu de Pádua, Ponta Grossa, PR, Brasil – lygia.napoli@hotmail.com
[2]Universidade Estadual do Centro-Oeste, Doutorando, Pós-Graduação em Ciências Florestais, Irati, PR, Brasil -ziquebednarczuk@yahoo.com.br
[3]Universidade Estadual do Centro-Oeste, Doutorando, Pós-Graduação em Ciências Florestais, Irati, PR, Brasil – natalli.luiz@gmail.com*
[4]Universidade Estadual do Centro-Oeste, Professor Dpto. Enga. Florestal, Irati, PR, Brasil – ehillig@unicentro.br
[5]Universidade de São Paulo, São Carlos, SP, Brasil – fabi.salles.ferro@gmail.com

Received for publication: 06 / 07 / 2022 – Accepted for publication: 10 / 08 / 2023

Resumo

Efeito da Composição de camadas nas propriedades dos diferentes tipos de painéis de madeira (Flakeboard, OSB e OSL. O objetivo foi avaliar o efeito da composição de camadas nas propriedades de painéis produzidos com particulas de madeira de *Pinus taeda* tipo flake, resina fenol-formaldeído, densidade nominal de 0,65 g/cm³ e sete tipos de composição das camadas dos painéis. Os testes foram realizados de acordo com a série de normas europeias para painéis à base de madeira. Os resultados mostraram que o painel tipo P6 (composição 20/60S/20), com camada central de distribuição aleatória, apresentou maior estabilidade dimensional. O painel P4 (30/40/30) apresentou melhores resultados para propriedades de flexão estática na direção paralela, enquanto o painel P2 (10/80/10) na direção perpendicular. O painel P3 (20/60/20) apresentou um melhor equilíbrio das propriedades de flexão em ambas as direções. O OSL apresentou propriedades físicas semelhantes às do OSB e melhores resultados de MOR e MOE na direção paralela, independente da composição da camada. A regressão quadrática em função da proporção da camada externa paralela permitiu estimar as perdas e ganhos de MOR e MOE, paralelo e perpendicular.
Palavras-chave: Orientação de partículas, propriedades físico-mecânicas, estabilidade dimensional.

Abstract

The objective was to evaluate the effect of layered composition on the properties of panels manufactured using *Pinus taeda* wood flakes particles, phenol-formaldehyde resin, a nominal density of 0.65 g/cm³ and seven types of the panel layers compositions. The tests were carried out according to the series of European standards for wood-based panels. The results showed that the P6 panel type (20/60S/20 composition), with a randomly distributed central layer, exhibited greater dimensional stability. The panel P4 (30/40/30) showed better results for static bending properties in the parallel direction, whereas the P2 panel (10/80/10) did so in the perpendicular direction. The P3 Panel (20/60/20), showed a better balance of bending properties in both directions. The OSL displayed physical properties similar to OSB and better results for MOR and MOE results in the parallel direction, regardless of the layer composition. The quadratic regression based on the proportion of the parallel external layer enabled the estimation of parallel and perpendicular MOR and MOE losses and gains.
Keywords: Particle orientation, physical-mechanical properties, dimensional stability.

INTRODUCTION

According to Araújo *et al*. (2019), due to wood's significant versatility, many products have been developed to meet the demands of the furniture and construction sectors. Among these products are wood panels, which have been designed with optimal raw material utilization i in mind. Wood-based panels are produced using wood components and synthetic resins, serving as a binding agents and are chosen according to the desired uses. The panels can be categorized into three main groups, Laminates: Multilaminate plywood, Sawn veneer and Laminated Veneer Lumber (LVL); Particles: Medium Density Particleboard (MDP), Flakeboard, Oriented Strand Board (OSB), Oriented Strand Lumber (OSL) and Laminated Strand Lumber (LSL); Fibers: Wood Fiber, Insulating Fiber, Hardboard and Medium Density Fiberboard (MDF).

In the mid-1970s, the development process of OSB-type structural flat panels began. These panels use almost all logs, as they add thin, crooked logs, twigs, and in some cases, the bark. The only disregarded parts of trees are the leaves and the root (BARBIRATO *et al*. 2022).

The OSB panel is considered the 2nd generation of waferboard and flakeboard panels, with the main differences among them lying in the particle size, the formation of the mattress, and consequently, the physical-mechanical performance of these panels (MENDES *et al*. 2010).

In the waferboard, particles known as wafers are used, which are shorter and wider (approximately 40 x 40 mm) compared to the particles used in the manufacturing of flakeboard or OSB, referred to as (around 25 x 80-150 mm) (Zerbe *et al*. 2015). In the flakeboard, particles are not oriented and, are randomly distributed in a homogeneous layer. In OSB, particles are distributed in a layered oriented manner, with the particles in the outer layers aligned and arranged parallel to the length or width of the panel, while particles in the inner layers can be random or aligned, generally, perpendicular to those in the outer layers. These differences result in an enhanced and better balance in terms of mechanical strength and dimensional stability along the length and width directions of the OSB panel (SALDANHA and IWAKIRI, 2009).

A wide variety of wood species are being studied for producing high quality OSB and OSL panels, including pine, spruce, rubber and poplar, in order to meet the demand for structural wood products (TAGHIYARI *et al*, 2020).

OSB panels have the function of bracing the structure of walls, roofs, mezzanines, dry slabs, floors and ceilings, and are also utilized in packaging and furniture manufacturing. (CHIROMITO *et al*., 2016).

In the manufacturing process of OSB laminates, it is possible to control the dimensions, proportions and particles orientation in layers of the panel. This control in the OSB production process is crucial to achieving increased bending strength and stiffness of the panel, which are largely attributed to the parallel orientation of the flakes (SHMULSKY and JONES, 2011). According to Plenzler *et al.* (2013), the stiffness of the OSB panel is a function of both the orthotropic properties of the used wood, and the thickness of each layer.

The mattress formation process is important in the production of OSB panels, as the structural composition in crossed layers (face/core/face) has a strong influence on the static bending strength and dimensional stability of the panels. There are several studies that address the direct influence of this production parameter on the physical-mechanical properties, confirming its importance. This composition varies from 20/60/20 to 30/40/30, according to the percentage of the dry weight of glued particles, in Canadian and American industries (CLOUTIER, 1998).

Suzuki and Takeda (2000) found results in which the static bending properties can be equalized in the parallel and perpendicular directions with 25% outer layer (25:50:25).

Trianoski *et al*. (2016), observed improvement in bending properties in the perpendicular direction for the 20/60/20 composition and improvement in bending in the parallel direction for the 30/40/30 composition.

According to Hassami *et al*. (2019), OSL is a structural panel with consistent properties capable of handling large loads, produced by aligning long wood particles in parallel and joining them using adhesives, pressure and heat. It can be used in some residential construction applications, as well as industrial purposes such as furniture manufacturing.

In accordance with Stark *et al*. (2010), OSL panels are produced with wood particles that have a length-thickness ratio of approximately 75 times, resembling OSB in appearance, as both are manufactured from wood species and similar wood particles, however arranged parallel to the longitudinal axis of the panel.

Therefore, considering the composition of layers in the physical and mechanical properties of the OSB panels, the importance of studies evaluating these variables stands out. In this way, the present study aimed to create a foundation for the Brazilian wood panel industry through the production and evaluation of OSB panels with different compositions of oriented layers, in order to demonstrate the influence of this factor on the physical and mechanical properties of the panels and to compare them to flakeboard and OSL panels.

MATERIAL AND METHODS

Material

The panels were produced with wood flakes from *Pinus taeda* from planted forests. The material was supplied by an OSB panel industry in the Campos Gerais region of Paraná.

Panel manufacture

The panels were produced using phenol-formaldehyde adhesive and flake particles, oriented or no in different layer compositions, according to the experimental design (Table 1).

Table 1. Experimental model for the production of Panels.
Tabela 1. Modelo experimental para produção dos Painéis.

Panel type	Composition of layers (%)			Repetitions
	C1	C2	C3	
P1		OSL*		3
P2	10	80	10	3
P3	20	60	20	3
P4	30	40	30	3
P5	40	20	40	3
P6	20	60 Flakeboard*	20	3
P7		Flakeboard*		3
Total				21

Subtitle*: OSL: Parallel orientation flakes; Flakeboard: Random orientation flakes.

The nominal density of the panels was established at 0.65 g/cm³, with a thickness of 10 mm and three panels being produced per panel type. The particles were subjected to drying in a forced air circulation oven at 60 ± 5º C, until reaching humidity between 3 and 5%. After drying, they were placed in sealed plastic containers in order to maintain the moisture content.

For the application of the adhesives, the particles were weighed in specific amounts and placed in an adapted glue machine. The adhesives and the paraffin emulsion were applied using a compressed air gun and the phenol-formaldehyde adhesive was applied in the proportion of 6% solids on the dry weight of the particles.

The formation of the particle mattress occurred manually, so as to distribute the particles in a forming box with final dimensions of 450 x 450 mm (figure 1). The particles were distributed randomly or in three layers, and, when necessary, the orientation of the particles was assisted by a laboratory advisor, coupled to the forming box.

After, cold pre-pressing was carried out for compaction and the mattress was submitted to a hydraulic plate press with electric heating together with the 10 mm thick limiting bars placed on opposite sides of the mattress, in order to delimit the panel thickness. The pressing parameters were a specific pressure of 3.92 MPa and temperature of 160º C for 10 minutes. The panels production process is illustrated in Figure 1.

Figure 1. Panel manufacturing process, where (a) Wood Aligner built for the laboratory; (b) oriented particle mattress; (c) pressing.
Figura 1. Processo de manufatura dos painéis, onde (a) orientador de partículas construído para laboratório; (b) colchão de partículas orientadas; (c) prensagem.

Determination of the physical-mechanical properties of the panels

After conditioning the panels, the specimens were cut and subjected to physical-mechanical tests. The tests followed the standards established by the EN 300:2006 standard series for particles/fibers panels and complementary standards. The design of the cut sections of the test specimens in the panels is illustrated in Figure 2**.**

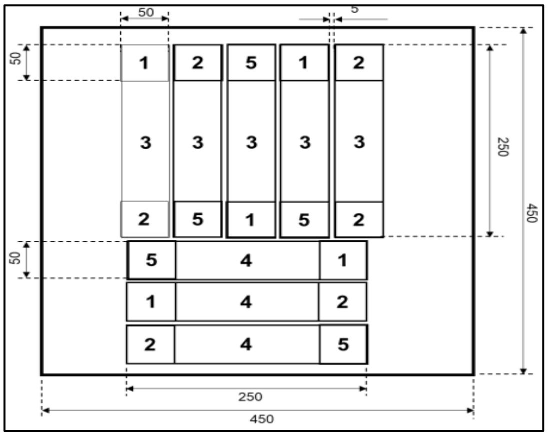

Figure 2. Sketch of specimens to evaluate properties with dimensions in mm. (1) Basic density at moisture content and equilibrium moisture content; (2) Tensile strength perpendicular to the panel faces; (3): Static bending in the parallel direction; (4): Static bending in the perpendicular direction; (5): Water absorption and thickness swelling.

Figura 2. Croqui dos corpos de prova para avaliação das propriedades com dimensões em mm. (1) Densidade básica ao teor de umidade e teor de umidade de equilíbrio; (2) Tração perpendicular às faces do painel; (3): Flexão estática no sentido paralelo; (4): Flexão estática no sentido perpendicular; (5): Absorção de água e inchamento em espessura.

The physical properties determined were the basic density at equilibrium moisture content, the moisture content, water absorption 2 and 24h and thickness swelling 2 and 24h. In the evaluation of the mechanical properties, static bending tests were carried out in the parallel and perpendicular directions to the particles of layer of the panel face (MOE and MOR) as well as Internal bond strength (tensile strength perpendicular to the surface of the panel).

Table 2. Physical-mechanical properties tests, symbols, and rules of the panels.
Tabela 2. Propriedades físico-mecânicas dos painéis.

Test	Symbol	Standard
Basic density*	Bd	EN 323
Moisture content	MS	EN 322
Water **A**bsorption after 2h immersion	WA 2h	EN 317
Water absorption after 24h immersion	WA 24h	EN 317
Thickness swelling after 2h immersion	TS 2h	EN 317
Thickness swelling after 24h immersion	TS 24h	EN 317
Static bending	MOR/MOE	EN 310
Internal bond strength	IB	EN 319

The experiment was carried out in a completely randomized design, consisting of seven types of panels. Once the prerequisites for homogeneity of variances and normal distribution were satisfied, ANOVA was applied with a 5% prerequisites of error prerequisites for the main factors and their interactions. If there were significant differences between the factors, a Tukey test was performed to compare the means. Also, for the elaboration of the graphs, data were transformed using the base 10 logarithm, to achieve homogeneity of variances.

RESULTS

Physical properties of the panels

The results for the physical properties of the panels (basic density at equilibrium moisture content, moisture content, water absorption 2h and 24h and thickness swelling 2h and 24h) are shown in table 3.

Table 3. Average values for the physical properties of the panels.
Tabela 3. Valores médios para as propriedades físicas dos painéis.

Panel type	Composition of layers (%)			Bd (g/cm³)	MC (%)	WA (%)		TS (%)	
	C1	C2	C3			2H	24H	2H	24H
P1		OSL		0.68 a	7.7 a	68.0 ab	84.8 b	34.1 a	45.3 a
P2	10	80	10	0.67 a	7.6 a	72.4 b	86 b	36.5 a	44.2 a
P3	20	60	20	0.67 a	8.2 a	67.8 ab	83.3 ab	30.8 a	45.1 a
P4	30	40	30	0.69 a	8.3 a	59.3 a	76.4 ab	28 a	37.5 a
P5	40	20	40	0.69 a	8.3 a	63.5 ab	82 ab	32.2 a	43.9 a
P6	20	60 Flakeboard	20	0.68 a	8.0 a	60.6 ab	74.7 a	27.5 a	33.5 a
P7		Flakeboard		0.67 a	8.4 a	64 ab	76.3 ab	28.2 a	39 a
Average VC (%)				6.43	10.25	17.9	12.2	37.1	28.8

Subtitle: Bd: Basic density; MC: Moisture content; WA: Water absorption; TS: Thickness swelling; H: hours.

The results showed that for density and moisture content, no statistical difference was found between the panels.

The values for water absorption and thickness swelling presented statistically equivalent averages. In general, panels P4 and P6 displayed the best and highest nominal values for these properties.

Mechanical properties of the panels

The mechanical properties of the panels (internal bond strength (IB) and static bending in the parallel and perpendicular direction (MOE and MOR) are presented in table 4.

Table 4. Average values for the mechanical properties of the panels.
Tabela 4. Valores médios para as propriedades mecânicas dos painéis.

Panel type	Composition of layers (%)			I.B (MPa)	Bending // (MPa)		Bending ++ (MPa)	
	C1	C2	C3		**MOR**	**MOE**	**MOR**	**MOE**
P1		OSL		0.17 a	37.6 c	4551.5 c	13.1 ab	1550.8 b
P2	10	80	10	0.21 ab	16.4 a	2130.7 a	25.1 d	2560.7 d
P3	20	60	20	0.23 ab	25.3 bc	3301.5 bc	23.7 cd	2268.6 cd
P4	30	40	30	0.33 b	34.1 c	4284.6 c	17.4 bc	1712.5 bc
P5	40	20	40	0.30 b	29.2 bc	4044.2 c	12.0 a	1137.4 a
P6	20	60 Flakeboard	20	0.21 ab	31.0 bc	4151.5 c	21.4 cd	2133.5 cd
P7		Flakeboard		0.31 b	23.2 ab	2659.8 ab	23.2 cd	2546.4 d
Average VC (%)				46.2	12.1	13.2	4.4	4.8

Subtitle: //: parallel; ++: perpendicular; I.B: Internal bond strength; MOR: Modulus of elasticity; MOR: Modulus of rupture.

The average values observed for internal bonding showed an increase in OSL panels compared to OSB with a layer composition of 30/40/30, decreasing again in the 40/20/40 composition. The 20/60 Flakeboard/20 composition presented an intermediate average value and the100S was equivalent to the 30/40/30 and 40/20/40 compositions.

There was a high coefficient of variation in the values of internal bonding, which did not allow for the detection of statistical differences between the averages. This fact was due to the presence of bubbles that were observed in certain regions of each panel and that were caused by a concentration of moisture/adhesive in these areas. Therefore, the adhesive distribution did not reach the desired efficiency and, thus, the values of the internal bonding strength tests had variations from one specimen to another for the same panel.

The average values of modulus of rupture and modulus of elasticity, in both the parallel and perpendicular directions, showed a low coefficient of variation, demonstrating good homogeneity among the test specimens. There was also a statistical difference between some types of panels, indicating that there was an influence of the layers compositions on the values of modulus of rupture and modulus of elasticity in both directions, parallel and perpendicular.

The MOR and MOE in the parallel direction have a maximum value for panel P1 (OSL) followed by panel P4.

Panels P5 and P6 showed lower, but statistically equivalent values. The 20/60/20 (P3) and 30/40/30 (P4) compositions are the most commonly used industrially, suggesting that the results were consistent with those used commercially. The lowest values were recorded for panel P2, with an average lower than the minimum required to be classified as OSB/1 (20 MPa for parallel MOR and 2500 MPa for parallel MOE) according to the EN 300:2006 standard.

The average values of MOR and MOE in the perpendicular direction met the minimum requirements of the EN 300:2003 standard for OSB/1 panels. As expected, there was a tend of increasing averages of MOR and MOE in the perpendicular direction as the proportion of the external layers of the panels decreased.

For a more accurate verification of the influence of layer compositions on the properties of modulus of rupture and modulus of elasticity, regression analysis was performed. By adjusting the MOR and MOE values (parallel and perpendicular) through a quadratic regression model, the coefficients of determination (R^2) and the standard error of estimate (Sxy) for these properties were obtained.

The coefficients of determination found for MOR and MOE in the parallel direction were 0.60 with a standard error of estimate of 13.2% and 0.75 with an error of 10%, respectively.

In the perpendicular direction, for MOR and MOE, it was found that the coefficient of determination was 0.58 with an error of 10% for MOR and 0.68 with an error of 12.1% for MOE. A significant relationship between these properties and the percentage of the external layers compositions, arranged in both directions of the panel, was also observed.

Figure 3 displays the graphs of MOR and MOE in the parallel direction, both as a function of the percentage composition of the external layers, together with the line obtained by quadratic regression. For the elaboration of the graphs, data were transformed using the 10 logarithm, to obtain homogeneity of variances.

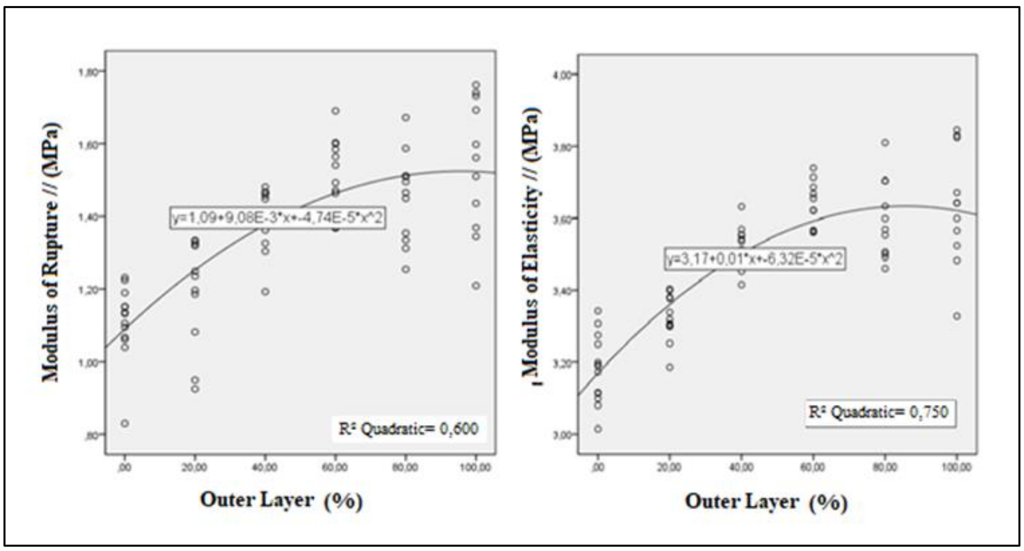

Figure 3. Parallel MOR and MOE as a function of the proportion of particles oriented parallel to the outer layers of the panels.

Figura 3. MOR e MOE paralelos em função da proporção de partículas orientadas paralelamente às camadas externas dos painéis.

It can be seen that there was an increase in the value of MOR and MOE in the parallel direction up to the proportion of 60% of oriented external layers, with trend of stabilization beyond that proportion. The 60% proportion of oriented layers corresponds to the 30/40/30 composition.

Thus, it was considered that the best layer composition to maximize MOR and MOE in the parallel direction of the panels was 30/40/30. With this composition, an increase in MOR of 31% was achieved in relation to the composition of random layers (Waferboard) and 8% in relation to the 20/60S/20 composition. Likewise, for MOE the increases were 37% and 3%, respectively.

Universidade Federal do Paraná
Setor de Ciências Agrárias
Pós-graduação em Engenharia Florestal
Revista Floresta

Figure 4 shows the MOR and MOE graphs in the perpendicular direction.

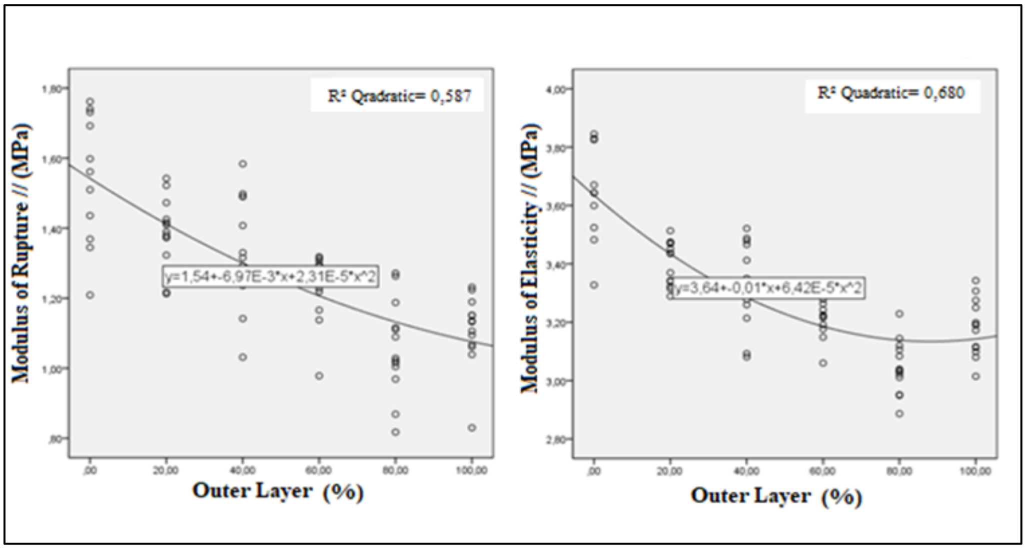

Figure 4. Perpendicular MOR and MOE as a function of the proportion of particles oriented parallel to the outer layers of the panels.

Figura 4. MOR e MOE perpendiculares em função da proporção de partículas orientadas paralelamente às camadas externas dos painéis.

As the proportion of the external layer increases, the values of the modulus of rupture and elasticity in the perpendicular direction decrease, that is, they have a negative correlation. It is also observed that only for MOE is there a point where these properties reach a minimum value and then start to rise again.

It can be observed that there was a decrease in perpendicular MOE up to the proportion of 80% of oriented external layers, with a trend of increase beyond that proportion. The 80% proportion of oriented layers corresponds to the 40/20/40 composition.

Thus, in addition to the OSL panels, it was considered that the best layer composition to maximize MOR and MOE in the perpendicular direction of the panels was 10/80/10. With this composition, an increase in MOR of 7% was achieved in relation to the composition of random layers (Flakeboard) and 14% in relation to the 20/60S/20 composition. Likewise, for MOE the increases were 0.5% and 16%, respectively.

As for the layer composition factor, the 30/40/30 proportion favored the static bending properties in the parallel direction, while the 10/80/10 proportion in the perpendicular direction. This behavior is mainly justified by the arrangement of relative to the plane of the panel and the respective testing plane.

Analyzing the static bending result in both directions, in order to obtain the best balance of the OSB, it is noticed that the panel without orientation (100S) presented the best balance of properties. This can be attributed to the orientation of the particles in both, the external and internal layers, which provide the panel with dimensional and bending stability. However, these properties did not show a statistically significant difference compared to the 20/60/20 composition, which had higher values. Thus, the 20/60/20 composition was considered the most appropriate to achieve a better balance between MOR and MOE.

DISCUSSIONS

Physical properties of the panels

The density values are above the nominal density established for production due to calculation that predicted a percentage of 8% of material loss, which did not occur in their entirety during the production process. According the results, the EN 300 (2006) standard establishes losses between 7 and 15%, which are within the established standards.

As for the moisture content, the average values were within the standards established by the EN 300 (2006) standards, which specify values in the range of 5 to 12%.

The EN 300 (2006) standard does not specify maximum values for of water absorption properties (2 and 24h) and thickness swelling after 2h of immersion in water.

Similar values were found by Gorski *et al*. (2015), who produced OSB panels with a mixture of *Pinus taeda* and *Pinus elliottii* using phenol-formaldehyde and a composition of 20/60/20 and found average values of 53.1% for WA2h, 88.7% for WA24h and 20.6 % for TS2h.

Looking at the average values for thickness swelling after 24 hours of water immersion, these are above what is established by the standard EN 300 (2006), which fixes maximum values of 25% (OSB/1). Similar results were found by Martarello *et al*. (2015), who observed high average values for 2-hour and 24-hour thickness swelling and did not reach the values established by the EN standard.

Mechanical properties of the panels

According to Zeleniuc *et al*. (2020), in the production process, the panel's performance depends directly on layer formation and pressing conditions and must meet standard requirements to maintain OSB's position in the market. The most effective way to improve the product quality and on-site performance is to evaluate the physical and mechanical properties of boards made under industrial conditions.

Comparing the values with the standards established by EN 300 (2006), only panels P4, P5 (composition of layers of 30/40/30 and 40/20/40 respectively) and P7 (Flakeboard) reached the minimum requirement of 0.30 MPa for OSB/1 panels. A similar value was found in the study by Bufalino *et al*. (2015), who obtained an average value of 0.33 MPa for OSB produced with *Pinus oocarpa* wood, phenol-formaldehyde adhesive, density of 0.65 g/cm³ and composition of 25/50/25.

Chiromito et al. (2016) also observed higher MOR and MOE values for OSL panels when compared to OSB, being 7,012 and 5,775 MPa respectively.

The MOR and MOE results found in the present study corroborate the values found by Trianoski *et al*. (2016) who produced OSB panels with *Cryptomeria japonica* wood. The authors found for the compositions of the 20/60/20 layers average values of 26.76 MPa for MOR and 4387 MPa for MOE in the parallel direction, and in the composition 30/40/30 found mean values of 31.69 MPa for MOR and 4560 MPa for MOE.

Saldanha and Iwakiri (2009), in the manufacture of OSB with *Pinus taeda* wood, phenol-formaldehyde adhesive, density of 0.65 g/cm³ and composition of 25/50/25, obtained mean values for MOR and MOE of 43.6 MPa and 5127.8 MPa, respectively.

Bufalino *et al*. (2015), obtained average values of MOR and MOE in the parallel direction of 34 MPa and 4882.3 MPa, respectively, producing OSB with wood of *Pinus oocarpa*, phenol-formaldehyde adhesive, density of 0.65 g/cm³ in the composition of 25/50/25.

Mendes (2010), in the production of OSB with *Pinus oocarpa* wood, using phenol-formaldehyde adhesive with an average density of 0.70 g/cm³ and composition 25/50/25, obtained values for MOR and MOE in the perpendicular direction of 20.82 MPa and 2022.3 MPa, respectively.

Martarello *et al*. (2015) for MOE and MOR found a statistical difference between the values only in the perpendicular direction, since the results were improved as an internal chamber perpendicular to the external one with 50 and 60% of particles was included.

Mendes *et al*. (2003) add that this fact occurs because the increase in the thickness of the internal layer favors the behavior of the MOE in the perpendicular direction, as the particles of the internal layer are also in that direction.

Similarly, Iwakiri *et al*. (2003) found a better balance of static bending properties between the parallel and perpendicular tests directions in panels with the 20/60/20 composition.

CONCLUSIONS

- Regarding the physical properties of the panels, the density values were above the established nominal density.
- The moisture content value was within the standards established by the OSB standard.
- For the properties of water absorption and thickness swelling, in a general context, the 20/60S/20 composition panel showed the best results, indicating better dimensional stability.
- Regarding the mechanical properties of the panels, it was observed that the proportion 30/40/30 provided an increase in static bending proprieties in the parallel direction, the 10/80/10 proportion resulted an increase in values in the perpendicular direction, and the 20/60/20 proportion exhibited better balance of properties values in parallel and perpendicular directions.
- The OSL panels exhibited similar physical properties to OSB panels, and superior static bending results (MOR and MOE) in parallel direction.

- The quadratic regression as a function of the parallel outer layer proportion allowed estimating the losses and gains of MOR and MOE, parallel and perpendicular.

REFERENCES

ARAÚJO, C. K. C., SALVADOR, R., PIEKARSKI, C. M., SOKULSKI, C. C., FRANCISCO, A. C., CAMARGO, S. K. C. A. Circular Economy Practices on Wood Panels: A Bibliographic Analysis. **Sustainability,** nc, v. 11, n.4, p.1057, dez/feb. 2019.

BARBIRATO, G., JUNIOR, W., MARTINS, R., SORIANO, J., FIORELLI, J. Experimental evaluation and numerical modeling of the mechanical performance of OSB sandwich panels manufactured with trapezoidal core. **Construction & Building Materials,** Amsterdam, v. 326, p. 1-12, 2022.

BUFALINO, L., CORRÊA, A. A. R., DE SÁ, V. A., MENDES, L. M., ALMEIDA, N. A., PIZZOL, V. D. Alternative compositions of oriented strand boards (OSB) made with commercial woods produced in Brazil. **Maderas. Ciencia y tecnologia**, Concepción-Chile, v.17, n.1, pp. 105-116, jan. 2015.

CHIROMITO, E. M. S., CAMPOS, C. I., FERREIRA, B. S., CHRISTOFORO, A. L., LAHR, F. A. R. Propriedades mecânicas de painéis produzidos com lascas de madeira em três diferentes comprimentos. **Scientia Forestalis**, Piracicaba, v. 44, n. 109, p. 175-180, mar. 2016.

CLOUTIER, A. Oriented strand board (OSB): raw material, manufacturing process, properties of wood-base fiber and particle materials. **In: International seminar on solid wood products of high technology,** Belo Horizonte, BH. p. 173-185, 1988.

EUROPEAN COMMITTEE FOR STANDARDIZATION. **EN 300**: Oriented strand boards (OSB). Definitions, classification and specifications, European Committee for Standardization, Brussels, Belgium, 2006.

GORSKI, L.; CUNHA, A. B.; RIOS, P. D'.; TRIANOSKI, R.; FRANÇA, M. C.; ALMEIDA, C. C. F.; LONGO, B. L. Utilização da madeira de *Eucalyptus benthamii* na produção de painéis de partículas orientadas (OSB). F**loresta**, Curitiba, PR, v. 45, n. 4, p. 865 - 874, out/dez. 2015.

HASSAMI, V., TAGHIYARI H. R., SCHMIDT, O., MALEKI, S., PAPADOPOULOS, A. N. Mechanical and Physical Properties of Oriented Strand Lumber (OSL): The effect of fortification level of nano wollastonite on UF resin. **Polymers,** v.11, n. 1884, nc, nov. 2019.

MARTARELLO, L. P., DA CUNHA, A. B., RIOS, P. D'A., BRAND, M. A., GORSKI, L. Influência do arranjo das camadas do colchão nas propriedades tecnológicas de painéis de partículas orientadas (OSB) de *Eucalyptus benthamii*. **Scientia Forestalis,** Piracicaba, v. 43, n. 107, p. 503-510, set. 2015.

MENDES, R. F., MENDES, L. M., ABRANCHES, R. A. S., SANTOS, R. C., GUIMARÃES, J. B., JR. Painéis produzidos com bagaço de cana em associação com a madeira de eucalipto. **Scientia Forestalis.** Piracicaba, v.38, n86, p. 285-295, jun. 2010.

PLENZLER, R., NIEWIADOMSKA, L., MIELCAREK, P. Shear and bending properties of structural oriented strand boards OSB/4. **Wood Research,** nc, v. 48, n.2, p.285-294, 2013.

SALDANHA, L. K., IWAKIRI. S. Influência da densidade e do tipo de resina nas propriedades tecnológicas de painéis OSB de *Pinus taeda* L. **Floresta,** Curitiba, PR, v. 39, n. 3, p. 571-576, jul/set. 2009.

SHMULSKY, R., JONES, P. D. Forest products and wood science: an introduction. ***Hoboken,*** Wiley-Blackwell, NJ, USA, 2011.

SUZUKI, S., TAKEDA, K. Production and properties of Japanese oriented strand board I: effect of strand length and orientation on strength properties of oriented strand board. **Journal of wood science,** nc, v. 46, n. 4, p. 289-295, Jun/ago. 2000.

STARK, N. M., CAI, Z., CARLL, C. **Wood handbook—Wood as an engineering material**. Forest products laboratory. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. p.508, 2010.

TAGHIYARI, H. R., SOLTANI, A., ESMAILPOUR, A., HASSAMI, V., GHOLIPOUR, H., PAPADOPOULOS, A. N. Improving thermal conductivity coefficient in oriented strand lumber (OSL) using sepiolite. **Nanomaterials,** Basel, v. 10, v. 599, mar. 2020.

TRIANOSKI, R., IWAKIRI, S., CHIES, D. Utilização da madeira de *Cryptomeria japônica* para produção de painéis de partículas orientadas (OSB). **Scientia Forestalis,** Piracicaba, v. 44, n. 110, p. 487-496, jun. 2016.

ZELENIUC, O., DUMITRASCU, A., CIOBANU, V. D. Properties evaluation thickness and type of oriented strand boards manufactured in continuous press line. **Bio resources,** Raleigh, v. 15. n. 3, p. 5829-5842, 2020.

ZERBE, J. I., CAI, Z., HARPOLE, G. B. Na **Evolutionary History of Oriented Strandboard (OSB).** General Technical Report FPL-GTR-236. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. 6 p, 2015.