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OPTIMIZATION OF THE PHYSICAL AND MECHANICAL PROPERTIES OF ORIENTED STRAND BOARD (OSB) FROM LOW QUALITY OF TIMBER IN ENVIRONMENTAL SUSTAINABILITY

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ABSTRACT

Oriented Strand Board (OSB) is a product panel made of individual strands, bound with Phenol-Formaldehyde (PF) and hot-pressed at 170oC. To optimize the physical and mechanical properties of OSB, to obtain maximum benefits, steaming is used. From the sample test, the results of the steaming time weru considered significant on the physical and mechanical properties of OSB. The value of moisture content, thickness development and OSB water absorption is decreasing. The value of MOE, MOR, internal bond strength and screw holding increases. The optimal value is obtained at 2 hours steaming time, while the increase in thickness and water absorption, get maximum results at the measurement time of 8 hours. The physical and mechanical properties of OSB produced after going through the steaming process have met the particleboard product standards (SNI 03-2105, 2006), JAS for Structural Plywood 1983 and JIS A Standard 5908: 2003 (Japanese Industrial Standards). Using, OSB is very appropriate to be used as a lightweight construction material and furniture as well as plywood, which will reduce the use of solid wood in nature for environmental sustainability.

Keywords: *oriented strand board, physical and mechanical properties, environmental sustainability*.

INTRODUCTION

As the population increases, the need for wood as a construction material and furniture raw material is increasing. On the other hand wood production from natural forests has declined due to deforestation and degradation of natural forests, both due to forest fires, illegal logging or the conversion of areas (Forest Watch Indonesia, 2015). In overcoming the shortage of raw materials and minimizing the rate of deforestation, processed wood is the right choice. Currently processed wood is victorious. Processed wood has become a mandatory element. Almost every house today uses processed wood as interior filler, both in kitchen cabinets, TV panels, building floors, ships, containers and partition walls or as an exterior. (Koran Sindo, 2014).

Processed wood that is excellent in light construction is plywood, but the plywood industry is a threat and an enemy for environmental activists. The plywood industry requires quality wood raw materials, to get quality results as well. While forest degradation is increasing from year to year. which will affect the issue of global warming, climate change and the greenhouse effect. One example of an alternative substitute for plywood is OSB. No less superior to solid wood, OSB as processed wood is ready to shift the popularity of natural

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wood in the building construction arena because wood is always interesting to be applied into a dwelling. The emergence of OSB as processed wood is expected to reduce the use of solid wood, considering the supply of quality wood in natural forests is decreasing and scarce. Besides the strength of OSB which is almost equal to the strength of plywood, the raw material can be of any type of wood, such as low-quality wood, wood waste, bamboo, or even can use raw materials from water hyacinth weeds (Febrianto, 2013 and Hilal, 2012). Enabling this product can be used as one of the prospective efforts in tackling the water hyacinth weed that is starting to unsettle the community. OSB also has a high aesthetic value if used for light construction, both interior and exterior. However, for OSB to be better, to support lightweight construction products, it is necessary to optimize the properties of OSB, both physical and mechanical with the support of polishing the strands used. This steaming treatment is expected to improve the physical and mechanical properties of OSB, thereby increasing OSB as a substitute for solid wood to be more maximized to increase and minimize forest damage in an environmental sustainability effort.

METHODS

This research was carried out at the Pusat Penelitian dan Pengembangan Fisika Appliedan (P3FT), Serpong Puspitek Tangerang. The research material is low-quality wood, i.e type of Applied wood (Artocarpus elastics) and Weru wood (Albizia procera), which have a diameter of 20-25 cm. The equipment used is a disk flaker, callipers, dryer, ovens, scales, goblets, stirrers, pipettes, drills, screws, steaming, heaters, blenders, sprayers. tool press, cutting saw and the universal machine that functions to measure the internal bond, screw holding strength, modulus of elasticity and modulus of rupture.

Making OSB

The OSB test sample was made from **applied** wood, we and a mixture of **applied** and weru (75:25) with a size of 25 x 25 x 0.8 cm and a target density of about 0.68 g/cm^3. Strands are bonded using a phenol-formaldehyde (pf) adhesive with a level of 6% based on the weight of the oven-dry strands.

The making of OSB begins with the making of strands, steaming strands, drying, storing, mixing strands with adhesives, shaping and pressing. Strands are made from applied wood and weru with a moisture content of around 79.3%. Using a flaker disk, strands are made with a length of about 60-70 mm, width 15-25 mm and a thickness of 0.6 mm. Steaming is carried out in a device made of aluminium, then flowed with hot steam at a temperature of 75^o-80^{o}C. Variation of steaming time 0, 2, 4, 6, and 8 hours. Excessive steaming time according to Hunt and Garrat (1986), can cause damage to wood. Steamed strands are dried in stages to avoid deformation due to drying. Dry strands are placed in a tightly closed plastic bag, to avoid the influence of the surrounding air humidity, then sorted based on the uniformity of sizes and specified requirements. The weight of strands needed to make a test sample is 330.4 grams, with a core layer of 165.4 grams and a surface layer (back and face) of 165.2 grams. The orientation of the core layer strands perpendicular to the surface layer, because the orientation of the core layer which is perpendicular, will produce better strength

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than parallel or random core layers (Nat *et al*, 1992). The strands that have been provided are mixed with PF adhesive with 40% solid content from 6% solid adhesive. The use of the right adhesive composition is very important and will continue to play a role in the efficient use of wood resources (Firhart, 2015). To accelerate the adhesive maturation reaction used NH4Cl 1% catalyst. The last process is hot pressing using a maximum pressure of 35 kg/cm^2.

Testing physical and mechanical properties

Testing physical and mechanical properties, referring to the Indonesian National Standard for particleboard products (SNI 03-2105, 2006) and JAS For Structural Plywood 1983 for tests of moisture content, density, modulus of elasticity and modulus of rupture. Whereas JIS A Standard 5908: 2003 (Japanese Industrial Standard) is used to test internal bond strength, the screw holding strength, thickness development and water absorption Febrianto, 2013).

Data from OSB's physical and mechanical properties weru analyzed statistically using a factorial completely randomized design, experiment design with two treatment factors: factor A was the type of wood consisting of applied wood, weru wood, and a mixture of applied and well. Factor B is steaming time consisting of 0, 2, 4, 6, and 8 hours. Each treatment consisted of three replications and five steaming times, so it was called factorial 3x5.

RESULTS AND DISCUSSION

Physical and Mechanical Properties of Oriented Strandboard (OSB)

Density

The desired target density is 0.68 g / cm2. While the density of research results has not met the target. This is suspected because it is caused by the quality of strands and the use of compressive pressure that is not maximum. The size of the OSB density is influenced by the density of the original wood/strands quality, pressure press and the adhesive content used. The higher the adhesive content, the higher the density of the OSB (Ridwan, 1997). Pressure presses also determine the yield density, the maximum pressure will produce the maximum density. The pressure used in the study was 35 kg / cm2, the same for all types of treatments. So it can be concluded that to achieve the target density can not use constant pressure but must be adjusted to the type of raw material used. Based on SNI 03-2105, 2006, the density of research results is classified as moderate, i.e 0.59-0.74 g / cm3. The density according to JAS For Structural Plywood1983 is 0.5-0.9 g / cm3 and meets these standards.

Moisture Content

The average water content of the research results is presented in Fig 1. From figure 1 it can be seen that the steaming treatment with time variations of 0, 2, 4, 6 and 8 hours, tends to reduce the water content. The longer the steaming time, the moisture content decreases. The average moisture content of weru is higher than other types. This is due to differences in wood specific gravity (BJ). The specific gravity of wood is influenced by cell

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walls, wood species, extractive substances and moisture content (Haygreen and Bowyer, 2003). Wood plantations with higher specific gravity than applied wood, have thicker cell walls, meaning that the moisture content bound in the cell (Bound water) is also higher and this will affect the final moisture content of OSB (Haygreen and Bowyer, 2003). To find out the effect of steaming on OSB, diversity analysis was carried out and it was known that the diversity of wood species and the steaming time had a very significant effect on water content at 5% and 1% levels. Thus the diversity of treatments affect the value of the resulting OSB moisture content.

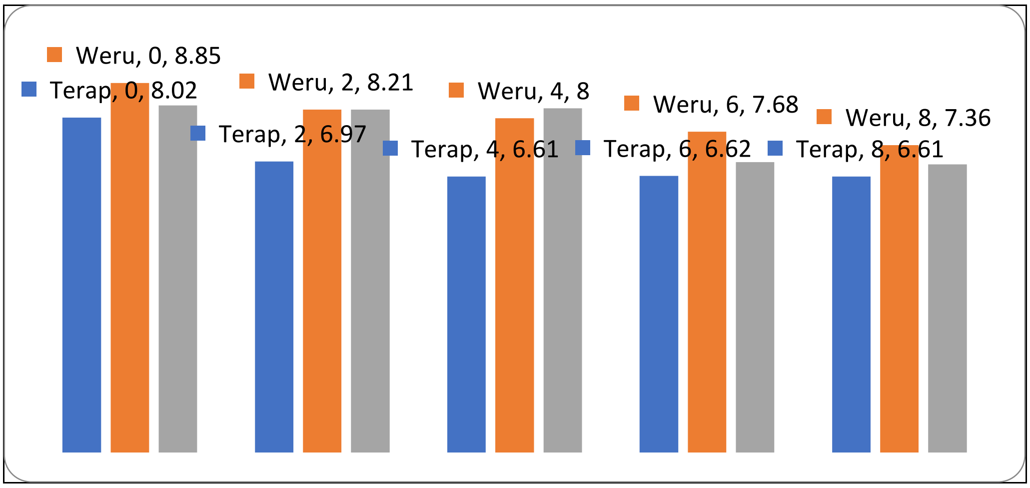

Fig 1. Percentage of Average moisture content value

To find out which treatment was significantly different, Duncan's test was performed. It turns out that the types of wood are significantly different from each other, meaning that the OSB water content can be influenced by the type of wood, where the minimum water content is in the applied wood and the maximum water content is in the weru wood. The steaming time is also very influential on the moisture content of the OSB produced.

In addition to diversity analysis, a regression analysis was also conducted, which showed that steaming time was negatively correlated with OSB moisture content. The longer the steaming time, the percentage of water content produced tends to decrease. Water content begins to decrease at the time of steaming 2 hours, and the smallest percentage of water content is at the time of steaming for 8 hours (7.134%). The values produced have met SNI standards 03-2105, 2006 and JAS For Structural Plywood 1983, which is 14%. Thus it was concluded that the steaming time of 2 hours is the optimum time that can be used in reducing OSB water content. Steaming strands cause the development of vessel channels. Extractive substances contained in the wood will be reduced, making it easier for the flow of adhesive to be absorbed by wood (Kubunsky and Itju, 1972). The adhesive will close the cell cavities in the wood and prevent water and water vapour from penetrating the cell wall.

Development of Thickness and Water Absorption

Measurement of the value of thickness development and water absorption aims to determine OSB resistance to liquids. From the measurement results, it can be seen that the steaming treatment will reduce the thickness development characteristics and OSB water

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absorption. Analysis of diversity shows that variations in steaming time and wood type significantly affect the value of thick development and water absorption at a level of 1%. While the Duncan test, the variation of time used (0, 2, 4, 6, and 8 hours) gave significantly different results.

The longer the steaming time, the thicker the nature of development and the smaller water absorption. The highest absorption value for the three types of wood is found in OSB which did not receive steaming treatment. Steaming strands will experience a decrease in extractive content, this will increase the penetration of the adhesive into the cell cavity so that the adhesive in the strands will cover free OH groups in wood, and cause a decrease in water absorption properties in OSB. The results of measurements of thickness development and water absorption properties can be seen in Fig 2 and 3.

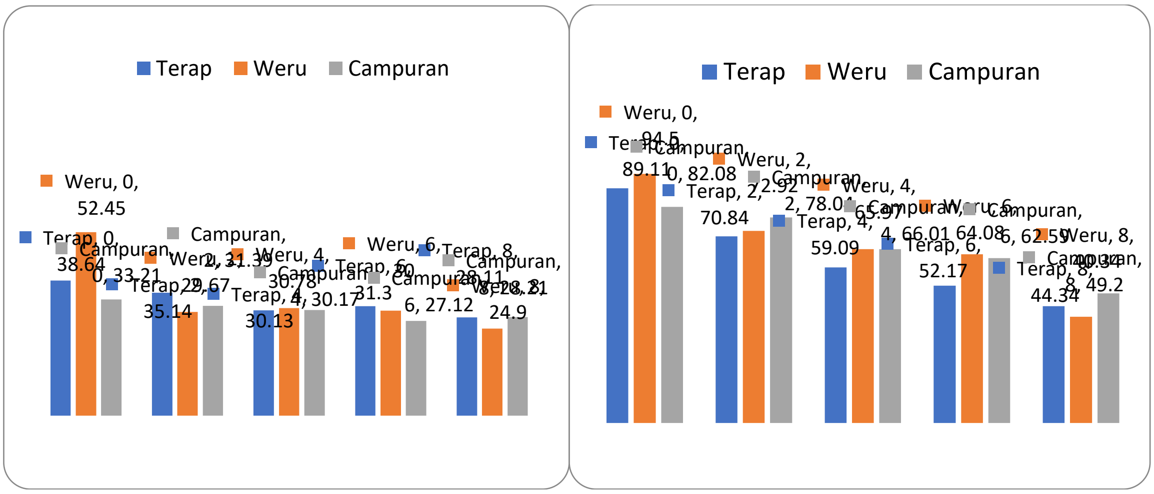

Fig 2. Average Thickness Development Value

Modulus of Elasticity (MOE)

Modulus of Elasticity (MOE) testing is conducted in two directions i.e MOE parallel and perpendicular to the longitudinal direction of the panel. The measurement results show that the administration of steaming treatment can increase the MOE value both parallel and perpendicular. The optimum MOE value for all three types of wood is found in OSB with strands for 2 hours. From the diversity analysis, it can be seen that the wood type factor and the steaming time variation significantly influence the level of 1% on the MOE value, both parallel and perpendicular.

The Duncan test shows that variations in wood species differ significantly from one another to the parallel MOE, but the type of planthopper and mixture are not significantly different to the MOE perpendicular to the elongated panel OSB. The variation of steaming time is also significantly different from one another, that is, steaming treatment has a positive influence on the value of the MOE produced, both parallel and perpendicular. The steaming time of 2 hours is the optimum time that can be used to increase the MOE value, both parallel and perpendicular. In a relatively short time can produce relatively higher MOE values. At the same conditions and steaming time, MOE in a direction is greater than perpendicular MOE.

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MOE value is influenced by strands direction. This is reinforced by Koch (1985) that several factors affect the value of the MOE i.e density, type of wood, the orientation of strands, quality of strands and moisture content. Strands in the core layer are arranged perpendicular to the surface (back and face). The surface layer is the weakest point when tested, so its orientation is very influential on MOE testing. The highest MOE is in the type of weru wood because the quality of the strands is better than that of applied wood.

The surface of the strands is smoother and flat, while the surface of the applied wood is rather rough to coarse. So that when mixing the adhesive the distribution is more evenly distributed. MOE OSB quality requirements are parallel and perpendicular according to SNI 03-2105 (2006), and JIS A 5908: 2003 (Japanese Industrial Standard (JIS), 2003) for 24 particleboard successively not less than 40,800 kgf/cm^2 and 13,260 kgf/cm^2. and according to JAS For Structural Plywood 1983, MOE is parallel and perpendicular to 6500 kgf / cm^2 and 25000 kgf/cm^2, so that the MOE of the results of the research as in tables 1 and 2 have fulfilled the standard.

Modulus of Rupture (MOR)

Modulus of Rupture testing (MOR) is also carried out in two directions i.e parallel and perpendicular to the elongated OSB direction. The test results can be seen in Tables 3 and 4. Tables 3 and 4 explained that the MOR value tends to increase due to steaming treatment, both parallel and perpendicular. The optimum MOR value is found in the panel that has been steamed for 2 hours.

Tabel 1. MOE is parallel to the OSB Longitudinal Direction

Wood Type	Steaming Time				
	0	2	4	6	8
Applied	67784	100204	87593	78360	78425
Weru	73764	106267	96885	95923	78906
Campuran	64746	105055	95422	82693	89388

Tabel 2. MOE is Perpendicular to the OSB Longitudinal Direction

Wood Type	Steaming Time				
	0	2	4	6	8
Applied	26057	40159	35120	29834	32867
Weru	26676	31398	28750	28051	27745
Campuran	26036	30826	27369	28717	29988

Tabel 3. MOR is parallel to the OSB Longitudinal Direction

Wood Type	Steaming Time				
	0	2	4	6	8
Applied	377	590	496	452	424
Weru	372	770	588	627	716
Campuran	371	645	562	526	608

Tabel 4. MOR is perpendicular to the OSB Longitudinal Direction

Wood Type	Steaming Time				
	0	2	4	6	8
Applied	236	329	309	288	282
Weru	265	335	310	272	301
Campuran	286	669	420	330	412

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Thus steaming for 2 hours is the optimal time that can be used to increase the MOR value. From the diversity analysis, it can be seen that the wood type factor and the steaming time variation significantly influence the MOR value at the level of 1%. While Duncan's different test explains that the MOR between the types of wood is significantly different from one another. This means that the MOR value is influenced by the type of wood. To see the correlation between steaming time variations with parallel or perpendicular MORs, a regression analysis was performed. The results of the regression analysis showed a positive relationship between steaming time with MOR in the parallel and perpendicular direction. This can be seen from the resulting correlation coefficient. MOR value in the parallel direction is higher than the perpendicular direction, like MOE, this is caused by the orientation of the strands used. So that increasing the value of MOE will also increase the value of MOR. The higher the MOE value, the stiffness of the OSB to change the shape due to the loading will be smaller. The higher the MOR value, the OSB's ability to withstand the load until it reaches a critical point will also be higher (Wangaard 1950, in Mardikanto, 1979).

Quality requirements according to SNI 03-2105 (2006) for particleboard type 24, JIS A 5908: 2003 (Japanese Industrial Standard, 2003) have been fulfilled, because the value is not less than 245 kgf/cm^2. Based on JAS for Structural Plywood 1983, MOR quality requirements for plywood are at least 320 kgf/cm^2 for parallel directions and 160 kgf / cm^2 for perpendicular directions. The results of this study also meet these standards.

Internal Bonds (IB)

Internal bond testing results can be seen in the following Fig 3 below.

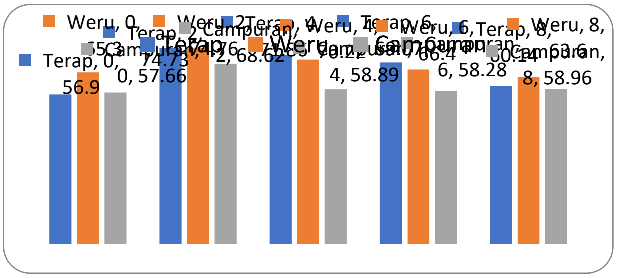

Fig 3. Internal Bond OSB

From the results of internal bond testing (IB), the maximum results obtained for the three types of wood are on the OSB which experienced steaming for 2 hours. To see the effect of wood species and variations in steaming time on IB values, diversity analysis was carried out. The results of the diversity analysis showed that the factors of wood type and steaming time had a very significant effect on the level of 1% on the strength of internal bonds. While Duncan's different test, it is known that each type of wood gives significantly different results from each other. This means that the type of wood is very influential on the value of IB OSB and the optimum value is found in weru wood which is 7.83%. While steaming time for 2 hours is significantly different from other times. The time of 4 hours is not significantly different from the time of 6 hours.

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According to Koch (1985), factors that influence the value of MOE and MOR, also affect internal ties. Lei and Wilson (1980) in Koch (1985), explain that internal bonding can be increased through a more even distribution of adhesives on strands. The steaming treatment is an effort to increase the distribution more evenly and increase the adhesive penetration to the strands. The value of internal ties results of the study already meets the standards of JIS A 5908: 2003 (Japanese Industrial Standard, 2003) which is ≥ 3.

Screw Holding Strength

The results of the measurement of screw holding strength can be seen in Fig 5. Fig 5 follow explained that the value of screw holding strength of the three types of wood meets JIS A 5908: 2003 standards (Japanese Industrial Standard, 2003). From the diversity analysis, it can be seen that the wood type factor and the variation of steaming time have a very significant effect on the value of the screw holding strength at 1% level. The maximum value of screw holding strength is found in the type of weru wood with a steaming time of 2 hours. Because OSB from the type of wood was has a high-density value, so to pull out the screw requires greater strength than other types.

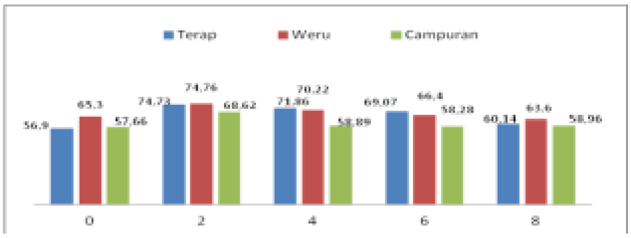

Fig 4. Screw Holding Strength

Comparison of Physical and Mechanical Properties of OSB

To see the effectiveness of strands steaming treatment in enhancing physical and mechanical properties of OSB, it is necessary to compare with other equivalent products, with different treatments. Table 4 shows that steaming strands very effectively used to increase the OSB. Improved physical and mechanical properties of OSB are expected to shift the use of solid wood from natural forests, environmental sustainability is maintained. Hot water immersion is also effective, but its weakness will produce a relatively high particle water content after immersion, so it takes a long time for the drying process. Per cent change in particleboard and OSB properties for each treatment can be seen as follows.

Tabel 5. Comparison of the properties of wood panels with multiple treatments

Properties of OSB Panel	Cold soaking [1])	Hot soaking [1])	Particle steaming[2])	Strands steaming*
Water Absdorption	-24	-28	-24	-134
Thickness Development	-31	-38	-35	-111
Modulus of Elasticity (MOE)	15	16	7	107
Modulus of Rupture (MOR)	65	58	22	44
Internal Bond				71

Keterangan : 1) Jaenudin (1988); 2) Priyatna (1988)
*) OSB leafhopper wood with a steaming time of 2 hours
+ Enhancement
- Drop

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Comparison of Physical and Mechanical Properties of OSB with Test Standards

From the results of data analysis, it was found that in general, the weru wood with a steaming time of 2 hours gave the best results on the physical and mechanical properties of OSB. Comparison with JAS For Structural Plywood 1983 and JIS A 5908-2003 standards is presented in Table 6 below.

Tabel 6. Physical and Mechanical Properties of OSB from Applied and Weru Wood compared to Standards *JAS For Structural Plywood 1983 and JIS A 5908-2003*

Properties of OSB Panel	*OSB Wood Applied*)*	*OSB Wood Weru*)*	*Standard JAS For Structural Plywood 1983*	*Standard JIS A 5908-2003*	*OSB**)*
Density (kg/cm^3)	0,68	0,68	0,5-0.9	-	0,65
Moisture content (%)	6,17	7,36	<14	-	9,26
MOE Parallel (Kgf/cm^2)	100204	106267	65000	-	77883
MOE Perpendicularly (Kgf/cm^2)	40159	31398	25000	-	25029
MOR Parallel (Kgf/cm^2)	590	770	320	-	302
MOR Perpendicular (Kgf/cm^2)	329	335	160	-	216
Thickness Development (%)	28,11	24,90	-	<12	15,68
Water Absorption (%)	44,34	40,30	-	-	27,26
Internal Bond (Kgf/cm^2)	7,14	7,83	-	>3	3,64
Screw Holding Strength (Kgf/cm^2)	74,73	74,76	-	>50	70

Keterangan :
*) OSB Wood applied dan Wood weru dengan perlakuan pengukusan selama 2 jam
**) OSB hasil penelitian Ridwan 1997 tanpa perlakuan

CONCLUSION

From the results of the study, it can be concluded that the administration of steaming treatment can improve the physical and mechanical properties of OSB. The longer the steaming time, the value of water content, thickness development and water absorption tends to decrease. While the MOE, MOR, internal ties and screw grip strength tend to increase. The optimal nature of OSB is obtained from steamed strands for 2 hours. The best type of wood is the type of weru wood. For the value of the thickness development properties and the best water absorption is found in OSB which has steamed for 8 hours. In general, the nature of the resulting OSB panel has met the standards of JAS For Structural Plywood 1983 and JIS A 5908-2003. But this is not the case with the nature of thick development and water absorption, although the value tends to decrease, the value is still below the test standard. Therefore further research is needed to find the most effective way to reduce the nature of thick development and water absorption, for example by giving paraffin or steaming with higher temperatures. So that the use of OSB panels as one of the processed wood products, can be used as an alternative to the use of solid wood, which will save the forest for environmental sustainability.

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