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Jurnal Ilmu dan Teknologi Kayu Tropis adalah Jurnal resmi Masyarakat Peneliti Kayu Indonesia (MAPEKI) yang terbit sejak tahun 2003. Jurnal ini mempublikasikan artikel asli baik penelitian dasar maupun terapan di bidang ilmu pengetahuan dan teknologi kayu, bahan berlignoselulosa bukan kayu, serta hasil hutan lainnya. Selain itu, jurnal ini juga mempublikasikan artikel ulas balik (*review*) dengan tema yang ditentukan oleh redaksi. Setiap artikel yang diterbitkan dalam jurnal ini telah ditelaah oleh mitra bestari yang dicantumkan pada nomor paling akhir dari setiap volume. Penerbitan jurnal 2 kali dalam setahun (Januari dan Juli). Harga langganan jurnal (*hardcopy*) sebesar Rp 100.000/tahun. Jurnal juga dapat diakses secara *online* di http://www.mapeki.org. Jurnal ini telah terakreditasi A oleh LIPI dengan Nomor 185/AU1/P2MBI/08/2009

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Physical, Mechanical, and Durability Properties of OSB Prepared from CCB Treated Fast Growing Tree Species Strands

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Abstract

The objective of this research was to evaluate the effect of preservative treatment of strands on the properties of oriented strand board (OSB) made from *Paraserianthes falcataria*, *Maesopsis eminii* and *Acacia mangium* strands. Prior to OSB manufacturing, strands were treated with chromium copper boron (CCB) soaking with concentration of 2% for 6 h. Three (3) layers OSB bonded with 7% of methylene diphenyl isocyanate (MDI) resin were produced with the core layer orientation perpendicular to the face and back layers. The results indicated that soaking strand with CCB significantly decreased the water absorption (WA) and thickness swelling (TS) values of OSB after immersed in water for 24 hours. Preservative treatment significantly decreased the mechanical properties of OSB (modulus of rupture/MOR parallel, modulus of elasticity/MOE parallel and internal bond/IB). Almost all board met the requirement of CSA 0437.0 standard for grade O-1 OSB panels, except board made from *P. falcataria* treated with preservative which did not achieve the requirement of TS, MOE in parallel direction, and IB. Preservative treatment strongly affected the durability of OSB. Soaking strand with CCB increased the resistance of OSB against termites attack 13.0 times higher than control board.

Key words: chromium copper boron, fast growing tree species, methylene diphenyl isocyanate, oriented strand board

Introduction

The utilization of fast growing tree species in Indonesia has increased due to the decrease of logging area available nowadays for supplying big diameter logs. Some of the most planted and utilized fast growing tree species in Indonesia are *Paraserianthes falcataria*, *Maesopsis eminii* and *Acacia mangium*. In general, fast growing tree species has relatively lower quality compared to wood supplied from natural forest. Johnson and Jayawickrama (2002) reported that the tendency occurred because wood density will decrease when trees stimulated to grow ten times faster. Bowyer *et al.* (2003) added that fast growth of trees can increase juvenile wood proportion, longitudinal shrinkage, wood knots, and decrease wood durability. Structural lumber containing juvenile wood has significantly lower stiffness and it may not meet safety design specifications. These effects raise the concern that the fast growing tree species may not be optimal for use in traditional products.

One of industrial products that can adapt the weakness problems of the fast growing tree species is oriented strand board (OSB). OSB is a structural engineered wood composite panel that is made from long, thin and narrow wood strands that are aligned purposefully with each other, formed under heat and pressure by pressing mats that are formed using gravity and flake orientation of wood strands (Youngquist 1999). Many studies reported that OSB has successfully utilized juvenile wood and low density timber from fast growing tree species with excellent properties to be used as structural panels (Hidayat *et al*. 2011, Nurhaida *et al*, 2008, Okino *et al*. 2004, Papadopoulos 2002. Cloutier *et al*. (2007) suggested juvenile wood could be used for the OSB manufacture up to a proportion of 70% of the oven-dry wood weight without significant losses of the physical and mechanical properties if the juvenile wood strands are located in the surface layers.

As the strands in OSB are biodegradable materials, OSB is vulnerable to termites attack; hence the use of chromium copper boron (CCB) preservative can be a solution to improve its durability, especially durability against termites attack. It has been reported that CCB treatments prevent wood from termites and fungal attack effectively (Goroyias & Hale 2004, Selamat *et al.* 1992, Yalinkilic 1999). The aim of this study was to evaluate the effect of preservative treatment of strand on the physical, mechanical and durability of OSB.

Materials and Methods

Strand preparation

Strands were prepared from logs of *P. falcataria*, *M. eminii,* and *A. mangium* with trees ages range 7-15 years and the diameters range 15-25 cm. The wood densities were 0.36, 0.41 and 0.46 g cm^{-3} for *P. falcataria*, *M. eminii,* and *A. mangium*, respectively. The logs were converted into planks with dimensions of (2000x25) mm^2 in length and thickness by using band saw. Planks were then cut into small blocks with dimensions of (70x25) mm^2 in length and thickness by using circular saw. Strands were produced from the planks using a laboratory disk-flaker. Strands average dimensions determined from 100 sampels were 60-70 mm in length, 20-30 mm in width and 0.2-1.4 mm in thickness. Strands were screened and sorted by using a sieve before being treated. Sorted strands were treated with preservative (strands were soaked into CCB preservative with concentration of 2% for 6 h). After being treated, strands were oven-dried at 80 °C to a moisture content of less than 3%. For comparison, control strands (untreated strands) were also prepared.

Board manufacturing

Control strands and preservative treated strands were resinated with a pressurized spray gun in a box-type blender with a seven (7) percent of liquid methylene diphenyl isocyanate (MDI) resin. The resin, H3M type, was purchased from PT. Polychemie Asia Pasific Permai, Indonesia and had 98% solids content. Mats were hand-formed with core layer aligned perpendicularly to the face and back layers. Target board size and density were 30 by 30 by 1.0 cm^3 and 0.6 g cm^{-3}, respectively. Mats were pressed for 7 min at a temperature of 180 °C using a maximum pressure 25 kg cm^{-2}. Three kind of wood species and two types of strand treatments (i.e. preservative treated and control) OSB

panels were produced. The face-core-back ratio was 1:2:1). Three replications of each board were made, giving a total of 18 boards.

Evaluation of physical and mechanical properties of OSB

Prior to testing, all boards were fully conditioned at a relative humidity (RH) of 65% and a temperature of 25 ºC for 1 week. All boards were tested according to JIS A 5908-2003 (JAS 2003) for particleboards to determine its physical properties (i.e., density, moisture content (MC), water absorption (WA), and thickness swelling (TS)) and mechanical properties (i.e., modulus of rupture (MOR), modulus of elasticity (MOE), and internal bond (IB)). The physical and mechanical properties of strand board were compared to CSA 0437.0 standard for grade O-1 OSB panels.

The dimension of specimen for evaluation air-dry density and MC of board was 100 by 100 by 10 mm^3. The specimens were immediately weighed and dried in the oven at 103±2 °C until they reached constant weight. The dimension of specimen for WA and TS tests are (50x50x10) mm^3. The specimens were immediately weighed. Average thickness was determined by taking several measurements at specific locations. After 24 h of submersion, specimens were dripped and wiped cleaning of any surface water. The weight and thickness of specimens were measured. The strength of strand board was tested by using a Universal Testing Machine. Evaluation of MOE and MOR were performed both in their long dimension parallel and perpendicular to the major axis of panel using specimen with dimension of (200x50x10) mm^3. The three-point bending was applied over an effective span of 150 mm at the loading speed of 10 mm/min. IB was evaluated using specimen with dimension of (50x50x10) mm^3. Steel plates were bonded to each face of the specimen using epoxy resin adhesive for about 6 h to ensure a good glue bond. The maximum load at the point of delamination was determined for each specimen. The IB test was performed at the loading speed of 3 mm/min.

Evaluation of durability of OSB

Resistance of OSB against subterranean termites attack was determined through grave yard test using specimen with dimension of (200x50x10) mm^3. The specimens were dried in an oven dryer with temperature of 103±2 °C for 24 h, and weighed before buried into the ground. After three months, the specimens were taken from the ground, cleaned, oven-dried and then weighed. Weight loss percentages (WLP) and damages of specimens were observed.

Data analysis

The experimental design was a completely randomized factorial design. The results of the properties tested were submitted to an overall analysis of variance (ANOVA) using a SPSS 17 software package. The homogeneity of the means among combinations was tested using the Tukey's High Significant Different (using significance level of 0.05).

Results and Discussion

Physical properties of OSB

The physical properties of strand board were evaluated using density, MC, WA and TS after immersed in cold water for 24 h parameters. The data are summarised in Table 1. From this table, it can be seen that the values of density

of OSB ranged from 0.53 to 0.57 g cm^{-3}. The results revealed that strand treatment and wood species did not significantly affect density values.

The values of MC of OSB ranged from 6.15 to 8.89%. The highest value of MC was achieved by control board prepared from *P. falcataria*, while the lowest one was achieved by preservative treated board prepared from *A. mangium*. Statistical analysis revealed that overally preservative treatment significantly affected the MC parameter.

The values of WA of OSB after immersed in water for 24 h ranged from 14.00 to 29.81% From Table 1 it can be seen that soaking strand into CCB preservative resulted in decreased WA values of OSB from each wood strand species. The lowest WA values for 24 h tests were achieved by control board prepared from *A. mangium*, while the highest one was achieved by preservative treated board prepared from *P. falcataria*. Statistical analysis revealed that strand treatment factor significantly affected the WA values of OSB after immersed in water for 24 h.

The values of TS of OSB after immersed in water for 24 h ranged from 8.19 to 21.95%. The maximum TS value required by the CSA 0437.0 standard for grade O-1 OSB is 15%. Almost all board achieve this requirement, except the preservative treated board prepared from *P. falcataria* which achieved the highest TS value of 21.95%. The result of TS tests show similar trend with the result of WA tests. Statistical analysis revealed that soaking strand into CCB preservative significantly decrease the TS values of OSB after immersed in water for 24 h. The result is similar with the study by Zhou (2004).

The study manufactured OSB using MDI as a binder, and found out that CCB contributed adverse effect because it decreased the bond quality among the wood strand.

This result was consistent with the boards bonded with PF resin. Thickness swelling generally increased with the increase of borate levels in the treated OSB bonded with PF resin (Lee *et al.* 2001). Soaking strand into CCB preservative is suspected to change the wettability of strands which resulted in low adhesion between strands and adhesives; hence, the boards manufactured became more hygroscopic and the dimensional stability was decreased.

Mechanical properties of OSB

Table 2 showed the values of mechanical properties (i.e., MOR, MOE, and IB) of strand board prepared under various wood species and layer structures. The values of MOR in parallel direction ranged between 299-509 kg cm^{-2}. The highest value of MOR in parallel direction occured in control board of prepared from *P. falcataria* strand, while the lowest value occured in preservative treated board prepared from *P. falcataria*. The values of MOR in perpendicular direction ranged between 237-296 kg cm^{-2}. The values of MOR in perpendicular show similar trend as MOR in parallel direction. Statistical analysis for MOR values showed that MOR in parallel direction significantly affected by preservative treatment, while the effect on MOR in perpendicular direction was not significant. The values of MOR in both direction met the requirements of CSA 047.0 as standard for grade O-1 OSB panels.

Table 1 Physical properties of OSB prepared from various woods species and strands treatments

Treatments	Density (g cm^{-3})	Moisture content (%)	Water absorption 24 h (%)	Thickness swelling 24 h (%)
P. falcataria				
- Control	0.55[a] (0.03)	8.89[a] (0.45)	24.45[a] (1.24)	14.37[a] (2.65)
- Preservative	0.55[a] (0.04)	7.16[b] (0.46)	29.81[a] (3.89)	21.95[b] (3.73)
M. eminii				
- Control	0.54[a] (0.01)	6.42[a] (0.13)	16.95[a] (0.38)	8.19[a] (0.56)
- Preservative	0.53[a] (0.05)	7.38[b] (0.28)	22.05[b] (0.28)	14.59[b] (1.41)
A. mangium				
- Control	0.57[a] (0.01)	8.09[a] (0.33)	14.00[a] (0.51)	8.48[a] (1.36)
- Preservative	0.56[a] (0.08)	6.15[b] (0.02)	19.65[b] (1.40)	12.46[b] (1.41)
CSA 0437.0 Grade O-1 Requirements	N/A	N/A	N/A	≤15%

Notes: Means within a column of each species followed by different letter are significantly different at 5% significance level using Tukey's HSD test. Values in parenthesis are standard deviations. Means are average of 3 replications.

The values of MOE in parallel direction ranged between 39957-62724 kg cm^{-2}. Similar to MOR in both parallel and perpendicular direction, the lowest value of MOE in parallel direction occured in preservative treated board prepared from *P. falcataria.* Statistical analysis showed that preservative treatment significantly affects the values of MOE in parallel direction. The values of MOE in perpendicular direction ranged between 17986-25382 kg cm^{-2}. Statistical analysis for MOE in perpendicular direction showed that preservative treated board and control board has similar values of MOE. Almost all MOE values both in parallel and perpendicular direction met the requirements of CSA 047.0 standard for grade O-1 OSB panels, except MOE value of preservative treated board prepared from *P. falcataria* strands.

The values of IB ranged between 3.17-10.72 kg cm^{-2}. The highest values of IB occurred in control board prepared from *M. eminii* strands, while the lowest one occured in preservative treated board prepared from *P. falcataria*. Statistical analysis showed that preservative treatment affect the values of IB. All IB values of OSB met the requirements of CSA 047.0 standard for grade O-1 OSB panels, except IB value of preservative treated board prepared from *P. falcataria*.

The value of mechanical properties are in conformity with those obtained by other research (Goroyias & Hale 2004). The study noted significant deterioration of physical and mechanical properties of board when the preservative applied by spraying dry strands or by post-board-manufacture heat and cold quench.

The values of WLP ranged between 0.61-15.467%. The highest and the lowest values of WLP occurred in control board prepared from *M. eminii* strands, and in preservative treated board prepared from *A. mangium*, respectively. Strands treated with CCB increased durability of OSB against termites attack. Preservative substance could act as poison to termites.

Table 2 Mechanical properties of OSB prepared under various wood species and layer structures

Treatments	MOR (kg cm^{-2})		MOE (kg cm^{-2})		IB	WLP
	//	⊥	//	⊥	(kg cm^{-2})	(%)
P. falcataria						
- Control	509^{a} (58)	296^{a} (30)	57190^{a} (1516)	22580^{a} (3872)	7.85^{a} (1.66)	10.71^{a} (3.52)
- Preservative	299^{b} (54)	237^{a} (29)	39957^{b} (3580)	17986^{a} (1631)	3.17^{b} (0.93)	0.96^{b} (0.18)
M. eminii						
- Control	405^{a} (46)	248^{a} (34)	62724^{a} (2849)	20987^{a} (3082)	10.72^{a} (2.37)	15.46^{a} (2.97)
- Preservative	341^{a} (43)	237^{a} (22)	47678^{b} (3262)	20807^{a} (2057)	4.64^{b} (0.98)	1.47^{b} (0.44)
A. mangium						
- Control	500^{a} (46)	237^{a} (18)	58460^{a} (4137)	18444^{a} (1596)	9.30^{a} (2.33)	10.64^{a} (2.26)
- Preservative	360^{b} (53)	288^{a} (29)	60202^{a} (4114)	25382^{a} (2875)	6.03^{a} (1.47)	0.61^{b} (0.15)
CSA 0437.0 Grade O-1 Requirements	239	98	45887	13256	3.52	N/A

Note: //: Parallel to the grain direction; ⊥ = Perpendicular to the grain direction; Means within a column of each species followed by different letter are significantly different at 5% significance level using Tukey's HSD test; Values in parenthesis are standard deviations; Means are average of 3 replications

Goroyias and Hale (2004) studied the mechanical and physical properties of strand boards treated with boron preservatives. The study found out that vacuum treatment of dry strands and soaking of green strands before board manufacture with boron improved board resistance against termites with few adverse effects on physical and mechanical properties of the board.

Conclusion

Strand soaking in CCB with concentration of 2% for 6 h significantly decreased the physical and mechanical properties of OSB. However all board met the requirement of CSA 0437.0 standard for grade O-1 OSB panels, except board made from *P. falcataria* treated with preservative which did not achieve the requirement of TS, MOE parallel, and IB. In contrast to the physical and mechanical properties, preservative treatment increased the resistance of OSB against termites attack 13.0 times more than control board.

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