Some Importance Properties of Bamboo-Wood Strand Board

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Abstract

Bamboo has gained increasing attention as an alternative raw material for use in the manufacture of composite boards. Three layered boards were made from bamboo strand and wood particle to evaluate the effects of resin content and layer structure on the properties of bamboo-wood strand board. Bamboo strand was used as face/back layers, and wood particle was used as core layer. The boards were fabricated using urea formaldehyde resin with three dosage levels ranging from 3 to 9 percent for bamboo strand and 6 percent resin content for wood particle. The mechanical properties and dimensional stability of bamboo-wood strand board were evaluated, and the results were summarized as follows. The bending properties, internal bond (IB) strength and dimensional stability of the board increased with increasing of resin content. Using bamboo strand as face/back layered, slightly increase bending properties of bamboo-wood strand board. However, the modulus constant and IB strengths after boiling test could not be observed. It indicates that urea formaldehyde was not suitable for bamboo-wood strand board.

Key words: bamboo, resin content, strand board, urea formaldehyde, wood particle

Introduction

Bamboos as composite material have been studying by many researchers. Chen (1985) reported that bamboo can be used as raw material for plywood. New product from bamboo was developed by Nugroho (2000) as *zhyper-board, particle board and fiber board* (Zhang *et al.* 1997, Sakuno and Han 2003). However, only a few publications regarding utilization of bamboo as structural composite are available. Zhang (2001) made bamboo-wafer board and Lee (1996) bamboo oriented strand board. Utilization bamboo as strand board improves physical and mechanical properties of panel. It is resulted by bamboo properties it self especially in longitudinal direction compared with some wood species (Lee 1996, Han 2003, Sumardi 2006, 2007).

The objective of this study was to determinate the effect of resin content and layer structure on the physical and mechanical properties of bamboo-wood strand board.

Materials and Methods

Strands were prepared from betung bamboo (*Dendrocalamus asper* (Schult. f) Becker ex Heyne) that was collected from a bamboo forest in Sumedang city, West Java, Indonesia. The length of bamboo pole was approximately 8 m. Prior to be stranded, bamboo was boiled at temperature of 70°C for 48 h in water bath. Bamboo was stranded using hand tool in a laboratory. The target sizes of the strand were 50 mm in length, 0.7 mm thickness, and 5 to 20 mm in width. Wood particles of mangium (*Acacia mangium* Willd) wood were collected from planer waste. Both bamboo strand and wood particle were screened on a 10-mesh sieve. The wood particles were then dried in a rotary oven at a temperature 60°C to reach the moisture content (MC) of 3% (Fig.1). One hundred pieces of bamboo strands were randomly chosen to determine their actual dimensions.

Strand boards were bonded using commercial liquid urea formaldehyde (UF) resin with 46% resin solid content. The board size was (400 x 400 x 12) mm^3. No waxes or other additives were added. Hand-formed mat were pressed for 10 min at temperature of 120°C. The maximum pressure applied was 8 MPa. The target density of board was 0.7 g cm^{-3}. No surface sanding was performed. Three resin contents were applied for panel manufacture i.e., 3, 6, and 9%. (Table 1) using a pressurized spray gun in a rotary-type blender.

Three types of board were fabricated i.e., a three-layered bamboo-wood strand board with face/back made from bamboo strand and core layer made from wood particle. The face/core/back ratio was 25:50:25 based on oven-dried weight. Bamboo random homogeneous strand board and particle homogeneous board were also prepared. Three boards were made for each combination.

Table 1 Layer structure combination of board manufactured

Board type	Layer structure	Resin content (%)	Replication
Three layered boards	F/C/B	3/6/3	3
		6/6/6	3
		9/6/9	3
Homogeneous board	Bamboo	6	6
	wood	6	6

F/C/B: Face/Core/Back

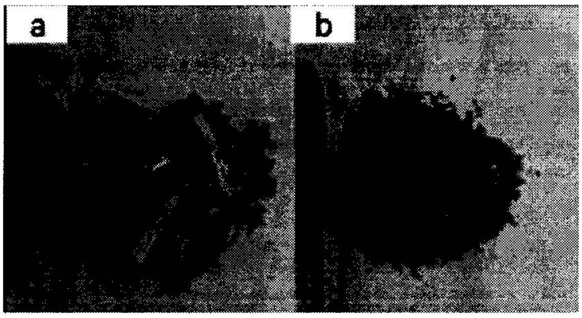


Figure 1 Bamboo strand (a) and wood particle (b)

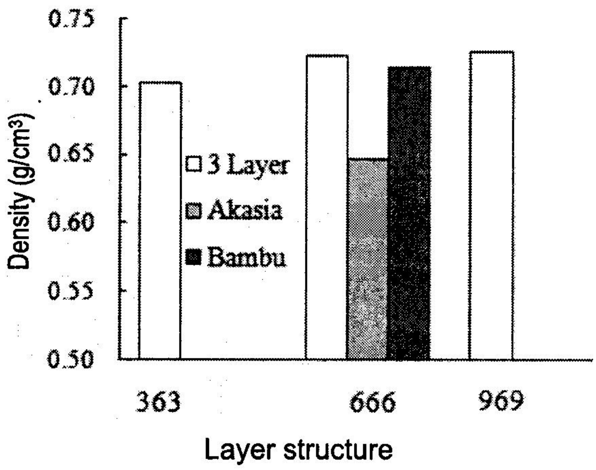
Evaluation of physical and mechanical properties

Prior to testing, the boards were conditioned in a room with a relative humidity (RH) of 65 % and temperature of 25°C. Bending and internal bond (IB) strength tests were conducted according to Japanese Industrial Standard (JIS) for particle board (JIS 1994). Five replication samples for modulus of elasticity (MOE) and modulus of rupture (MOR with dimension of (12 x 50 x 300) mm^3, and seven replications for samples for IB strength with dimension of (12 x 50 x 50) mm^3 were determined under air-dried conditions. The wet-B test was also conducted for MOE, MOR and IB parameters. Prior to be tested in wet conditioned, the samples were boiled in water for 2 h and following 1 h immersed in cold water (JIS 1994). The samples were then oven dried at temperature of 50°C for 48 h. The dimension of dimensional stability parameter i.e., thickness swelling (TS) and water absorption (WA) samples were (12 x 50 x 50) mm^3. The samples were immersed in cold water for 2 and 24 h. Eight (8) replications were performed for measuring TS and WA parameters.

Results and Discussion

Board characteristics

The mean values of board density were presented in Fig. 2. The board density varied in the range of 0.65 to 0.73 g cm^{-3}. The lowest and the highest values of board density were obtained by mangium particleboard and strand board with layer structure of 363, respectively.



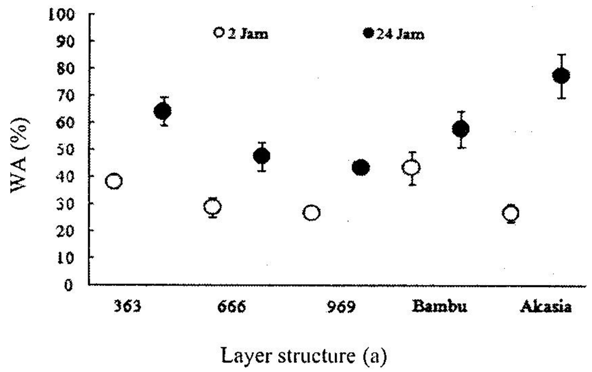
363 : Layer Structure Bamboo-Acacia-Bamboo, RC : 3%-6%-3%
666 : Layer Structure Bamboo-Acacia-Bamboo, RC : 6%-6%-6%
969 : Layer Structure Bamboo-Acacia-Bamboo, RC : 9%-6%-9%
Bamboo : Bamboo, RC: 6%
Acacia : Acacia, RC 6%

Figure 2 Board density of bamboo-wood strandboard

Dimensional stability

Fig. 3a and 3b showed effect of resin contents and layer structure on dimensional stability (TS and WA) after immersed in cold water for 2 and 24 h. The results showed that TS decrease with increasing resin content. Higher resin content improve bond quality among strand arrangement and resulted in decreasing TS value (Sumardi 2006). Increasing trend of TS value between immersing in cold water for 2 and 24 h water immersion was similar. However deflection TS between board of 363-666 and 666-969 was different about 10% and 3%, respectively. It indicates that 6% resin content for all layers is enough to reduce the value of TS although it is a fairly good performance for bamboo-wood strand board.

It is also clear that board comprises of 100% wood particles (particleboard) hat higher TS value compare to board comprise of 100% bamboo strands. TS value of bamboo strand board increase rapidly during the first 2 h. However, after immersed in cold water for 24 h, the TS value of bamboo strand board was lower than particleboard. It indicates that at initial stage bamboo strand board was much easier to absorb water compared to particleboard due to differences of particle dimension (Lehmann 1974). Similar trend with TS occurred on WA parameter (Fig. 3a). A higher resin dosage can reduce the WA of mat-formed panel products in three layer structure board. The value of WA for bamboo strand board and particleboard after immersing in cold water for 2 and 24 hours was 43.4%, 26.9%, and 77.6%, 57.9%, respectively.



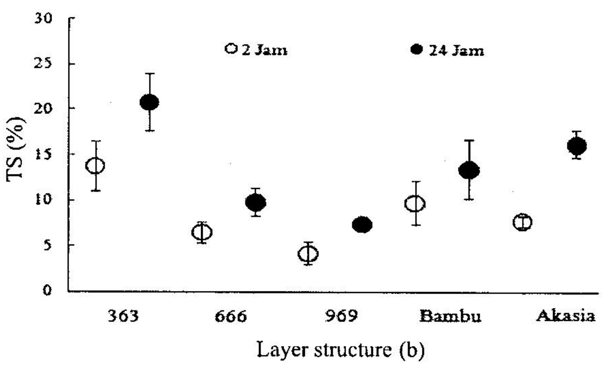


Figure 3 WA (a) and TS (b)

Effect of resin content on mechanical properties

Fig. 4 shows the relationships between resin content and bending properties (MOE and MOR). Both MOR and MOE values showed small increase with increasing resin content. The effects of resin content on bending properties were less prominent with the effect of layer structure. The higher mechanical properties of the longitudinal direction of bamboo strand may have allowed high bending performance, even with lower resin coverage of the available surface area.

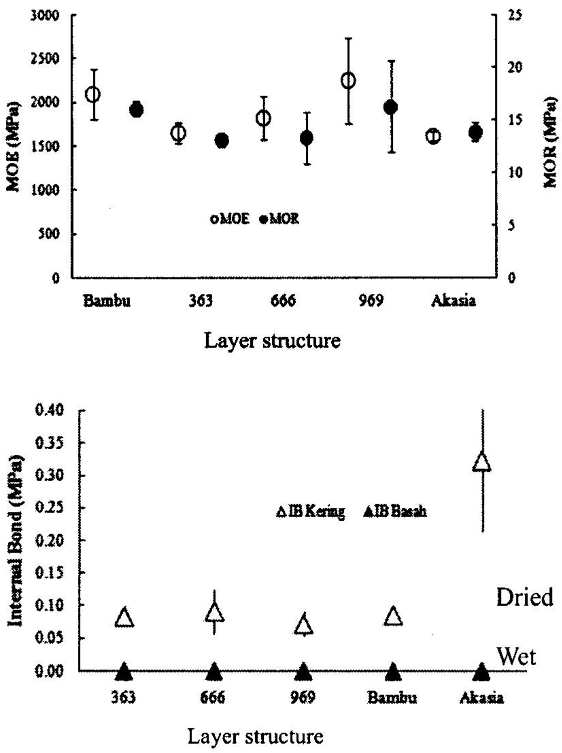
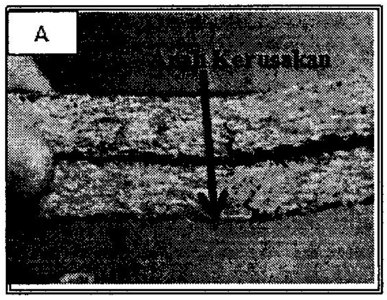


Figure 4 MOE, MOR, and IB

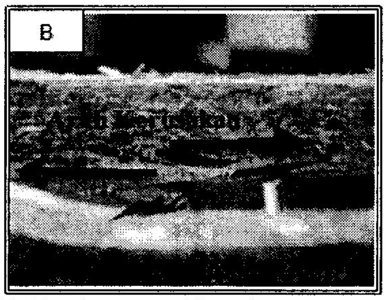
In contrast, IB strength was similar for board of 636, 666 and 969. IB value of 636, 666, 969 and bamboo strand board were more less than 0.1 MPa. This was lower compared JIS standard for particle board (0.3 MPa). However, IB strength of wood particle board fulfilled the requirement of JIS standard with value of 0.35 MPa. The small value of bonding strength between bamboo and wood particle is due to compression, compaction ratio and particle dimension.

Effect of layer structure on mechanical properties

Mechanical properties of strand board were affected by layer structure, as shown in Fig. 4. The elastic constant of homogenous bamboo strand board was higher than three layer of bamboo-wood strand board (666) and particle board. When wood particle was used as core layer, the elastic constant of bamboo-wood strand board slightly decrease. Dimension of wood particle which was smaller than bamboo strand were suggested influence the elastic constant of board (Fig. 1).



A. Wood particleboard



B. Bamboo strand board

Figure 5 Failed of structure in bending strength

Differences of bonding strength obtained in particleboard and bamboo strand board due to the different of structure failure. In general, elastic strength failure occurs in the middle of board length because of the centre load. The failure in particleboard used in this study also exhibited failure in the middle of board length. However, the failure of structure in bamboo strand board and bamboo-wood strand board was horizontal (Fig. 5). The type of failure of structure indicates strength of board. Horizontal failure of structure indicates higher strength than vertical. This phenomenon indicates that bamboo strength was higher than bonding strength itself. However, for particleboard, the bonding strength was greater than wood particle itself. This statement was supported by the value of IB of particleboard which was higher than bamboo strand board.

Properties retention after aging

The wet bending strength obtained from the JIS-B Wet-Bending test under wet condition was listed in Table 2. From twenty five sample tests, only eleven sample tests can be tested. Fig. 6 showed the sample test after boiling. The bending strength of three layer bamboo-wood strand board and bamboo strand board were very low. The strength retention increases with increasing resin content. Strength retention after aging treatment was about 2-3%. This is due to using UF resin and adhesion among bamboo is lower than wood.

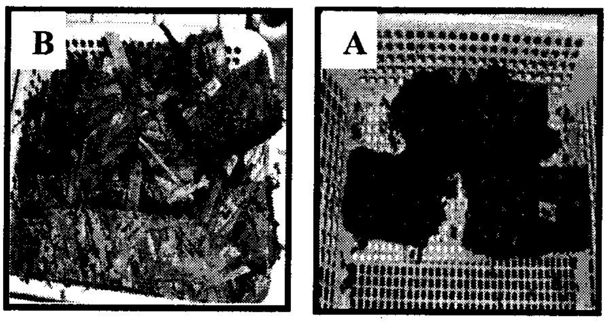


Figure 6 Samples after boilling treatment (B: bamboo, strandboard 3 layer, A: mangium, particleboard)

Tabel 2 Strength retention after aging treatment (%)

Layer structure	Dried condition (MPA)		Wet (MPa)		Retention (%)	
	MOE	MOR	MOE	MOR	MOE	MOR
Strand board 3 layer 363	1653	13.00	24.80	0.24	1.50	1.83
Strand board 3 layer 666	1820	13.30	26.30	0.29	1.44	2.18
Strand board 3 layer 969	2249	16.30	27.60	0.30	1.23	1.83
Bamboo	2099	16.10	26.50	0.29	1.26	1.80
Mangium**	1615	13.80	0	0	0	0

**Value of MOE/MOR wet Acacia = 0

Conclusions

In general using bamboo strand for face/back in board manufacture can improve bending and thickness swelling properties but did not appear to affect IB strength. Wood particle in core layer slightly reduce the strength properties. The value of strength retention after aging treatment was very low and those values are comparable to or lower than values for commercial boards. Urea formaldehyde resin was not recommendable for bamboo-wood strand board.

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