Steaming Effect on Natural Durability of Bamboo Oriented Strand Board against Termites and Powder Post Beetle

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Abstract

The objective of this research was to evaluate the resistance of bamboo oriented strand board (BOSB) prepared from steamed and non-steamed strands of five (5) bamboo species against subterranean termite (*Coptotermes curvignathus*), dry wood termite (*Cryptotermes cynocephalus*), and powder post beetle. The five bamboo species were betung, andong, ampel, hitam, and tali. In steaming treatment, bamboo strands were steamed in autoclave at 126 °C and 1.4 kg cm^{-2} pressure for 1 h prior mixing with adhesive. Strands were bonded into BOSB by the use of commercial Phenol formaldehyde (PF) adhesive at 10% (w/w) of oven dried strands. The resistance of BOSB against termite was done based on SNI 01.7207-2006 procedures and requirement. The results indicated that the resistance of BOSB against termites was significantly affected by bamboo species and steam treatment. The resistance of BOSB prepared from steamed bamboo strands against *C. curvignathus* and *C. cynocephalus* was higher than that of non-steamed bamboo strands particularly that of ampel bamboo strands. The powder post beetle was identified as *Anobium* sp. Bamboo species and strands steaming did not significantly influence the resistance of BOSBs against *Anobium* sp.

Key words: bamboo, dry wood termite, oriented strand board, powder post beetles, subterranean termite

Introduction

Bamboo is abundant and a versatile important material for the rural community of Indonesia. It is used for housing components, construction products, ladder, fences, containers, furniture, musical instruments, and handicraft products. Recently, bamboo has obtained an increasing interest for wood alternative due to its fast growth rate, short rotation cycle, ease of cultivation and processing, excellent mechanical properties, medium to high density, and an established material for certain products. Furthermore, bamboo is a less damaging housing material compared to stones and mortar when subjected to earthquakes disasters (Febrianto *et al.* 2012). The increasing global interest of bamboo utilization at the present time is also due to the decreasing quantity and deteriorating quality of forest resources. However, many disadvantages are inherent in bamboo, as well. These include its small stem diameter and susceptibility to termites and borers attack.

Among the 143 species of bamboo naturally grown in Indonesia, only 32 species are used for specific purposes (Wijaya *et al.* 2004, Wijaya 2001). All bamboo species retains its individual characteristics that lead to numerous suitability of application (Nuryatin 2011).

Successful commercialization of bamboo plywood and flooring has stimulated researches on bamboo for structural applications products such as that for oriented strand board (OSB). OSB is suitable for a wide range of structural and industrial applications. An OSB is a matted panel of longitudinally sliced strands of the low to medium density of small diameters wood logs bonded with exterior-type binder under the application of heat and pressure (SBA 2005). Large number of studies on bamboo OSBs has been conducted, showing that they can be effectively manufactured at an industrial scale (Febrianto *et al*. 2012, Sumardi *et al*. 2008, Lee *et al*. 1996).

In our previous publication (Febrianto *et al.* 2012), it was found that betung bamboo (*Dendrocalamus asper*) was very promising raw material of OSBs because of its excellent physical and mechanical properties. Cold water extraction and partial acetylation pretreatments have also been proven capable of increasing the performance of the resulting OSB. Steam treatment is commonly used to facilitate the bending of bamboo into desired shapes. It can also improve bamboo resistance against insect (Liese 1987). During steam treatment, free sugars in woody materials can be converted into furan intermediates, which can be further converted into furan resins. This phenomenon has been understood to improve both the mechanical properties and the dimensional stabilization of the resulting boards (Iswanto *et al*. 2010, Rowell *et al.* 2002). In this study, the effect of bamboo species and pre-treatment of strands on the durability of bamboo oriented strand board (BOSB) were determined.

Materials and Methods

Materials

For the present study, 3 to 4 years-old andong (*Gigantochloa verticillata*), betung (*Dendrocalamus aspe*r), ampel (*Bambusa vulgaris*), tali (*Gigantochloa apus*) and hitam (*Gigantochloa atroviolaceae*) bamboos were collected from the district of Bogor, West Java, Indonesia. Their basic densities were found to be 0.60, 0.73, 0.55, 0.63 and 0.64 g cm^{-3}, respectively. The strands were manually produced using a sharp-knife. The target length, width, and thickness of the strands were 70, 20, and 0.80 mm, respectively. Phenol formaldehyde (PF) adhesive and paraffin were purchased from PT Polychemie Asia Pacific (Jakarta, Indonesia).

Steam treatment and OSB preparation

The strands were steamed at 126 °C and 0.14 MPa pressure for 1 h, and then air-dried and oven-dried at 75–80 ºC for several days to achieve a moisture content (MC) of 7 %. Three-layered OSBs with a size of (30×30×1.0) cm^3 were prepared. The strand compositions for the face, core, and back were 25, 50 and 25%, respectively. The average density target was 0.7 g cm^{-3}. Commercial PF adhesive was used to bond the strands to the OSBs and its spreading rates was at 10% on the basis of the oven-dry weight of the strands.

Paraffin at a concentration of 1% was added. A rotary drum blender was used for mixing the strands and the adhesive. The mat-form was hot-pressed at 160 ºC for 6 min at a pressure of 2.5 MPa to fabricate the OSBs. Succeeding the board formation, the OSBs was conditioned for several days in a room adjusted to a temperature in the range 25–30 ºC and 60–65% RH. The duration of the conditioning process was determined by regular weighing of the specimens until no further changes in the weights were detected. Three boards were prepared for each treatment.

The resistance of bamboo oriented strand board (BOSB) against subterranean termite (*Coptotermes curvignathus*)

The initial weight of the specimen was obtained by oven drying specimens with the dimension of (2.5x 2.5x1) cm^3 at 60 ± 2 ºC for 48 h. SNI 01.7207-2006 (BSN 2006) was referred in the evaluation of the BOSB resistance against subterranean termite. Weight loss and termite mortality were observed.

The resistance of BOSB against dry wood termite (*Cryptotermes cynocephalus*)

The initial weight of the specimen was obtained by oven drying specimens with the dimension of 5 cm x 2.5 cm x 1 cm at 60 ± 2 ºC for 48 h. SNI 01.7207-2006 (BSN 2006) was referred in the evaluation of the BOSB resistance against dry wood termite. Weight loss of wood and termite mortality were observed.

Resistance of BOSB against powder post beetle

Semi field test scale was performed to determine the resistance of BOSB against powder post beetle. The initial weight of the specimen was obtained by oven drying specimens with the dimension of (10x 10x1) cm^3 at 60±2 ºC for 48 h to obtain The resistance of the BOSB against powder post beetle was determined referring to Purwaningsih (2012). Weight loss of the specimen was observed and powder post beetle species was identified.

Data analysis

To assess physical and mechanical properties, all multiple comparisons were subjected to an analysis of variance (ANOVA). Highly significant ($\alpha \leq 0.01$) and significant ($\alpha \leq 0.05$) differences between the mean values of the untreated and treated specimens were determined using Duncan's multiple range tests.

Results and Discussion

The resistance of BOSB against subterranean termite (*C. curvignathus*)

The average weight loss of BOSB without steam treatment was in range of 3.22-8.53%. The highest and the lowest weight losses were obtained from ampel and andong BOSB, respectively. Based on SNI 01.7207-2006 requirement, andong BOSB belonged to the 1st class (very resistance), hitam, tali, and betung BOSB, belonged to the 2nd class (resistance), and ampel BOSB belonged to the 3rd class (moderate). The average values of BOSB weight loss with steam treatment were in the range of 2.63-4.35%. The highest and the lowest weight loss were obtained from betung and andong BOSB, respectively (Figure 1). Based on SNI 01.7207-2006 requrement, steam andong and ampel BOSB were classified as the 1st class (very resistance), while steam tali, hitam and betung BOSB prepared from were classified to the 2nd class (resistance).

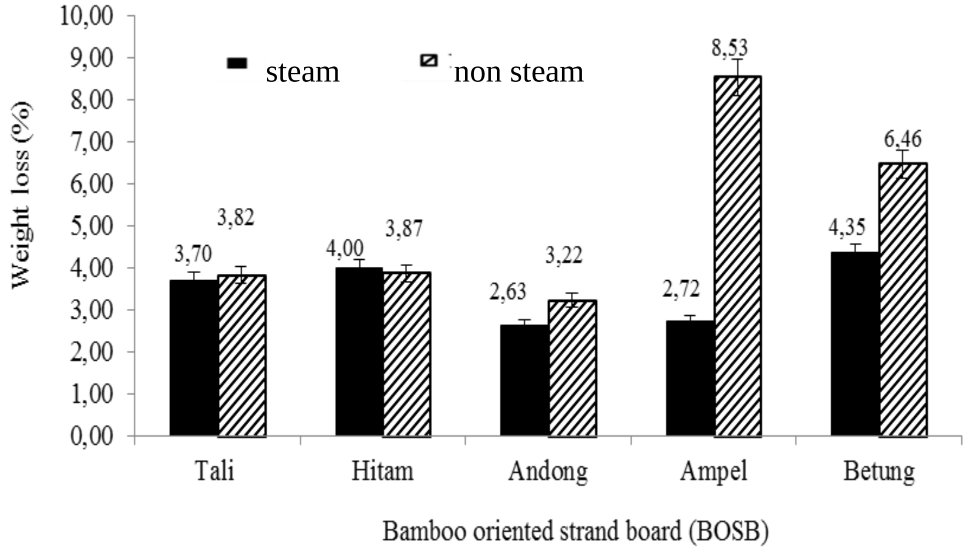

Figure 1 Weight loss of BOSB prepared from steamed and non-steamed strands after baiting to *C. curvignathus*.

Figure 2 showed that the average mortality of *C. curvignathus* at the end of testing was varied from 96.38 to 100%. The value of termite mortality was not affected by steam treatment and bamboo species. It is clear that the weight loss of steamed bamboo strands based BOSB was lower than that of BOSB based on non-steamed bamboo strands.

Statistical analysis supported these findings. The weight loss parameter was much affected by treatment and interaction between treatments and bamboo species. It was informed in the previous report that natural durability of betung, hitam and tali solid bamboos against *C. curvignathus* were belonged to the 2nd (resistance) class, while that of ampel and andong solid bamboos were classified into the 4th class (poor) (Purnamasari 2013).

Natural durability of BOSB, particulary those from ampel and andong bamboos, significantly improved compared to those of its origin. The role of PF resin as binder to bond bamboo strands was very dominant in non-durable bamboo strands. In BOSB, PF resin covered the surface of strand and phenol component in the PF resin is toxic to termites.

Steam treatment to strands also played dominant role in ampel and betung BOSB. Steam treatment facilitated resin penetration into bamboo strands resulted in a better bonding quality (Apriani 2012, Angin 2012, Rahayu 2012, Santoso 2012). During steam treatment, free sugars in woody materials can be converted into furan intermediates, which can be further converted into furan resins (Iswanto *et al.* 2010, Rowell *et al.* 2002).

It is more difficult for termites to digest specimen prepared from steamed bamboo strands compared to that of non-steamed bamboo strands. Thus, BOSB's prepared from steamed bamboo strands were much resistance against *C. curvignathus* compared to non-steamed bamboo.

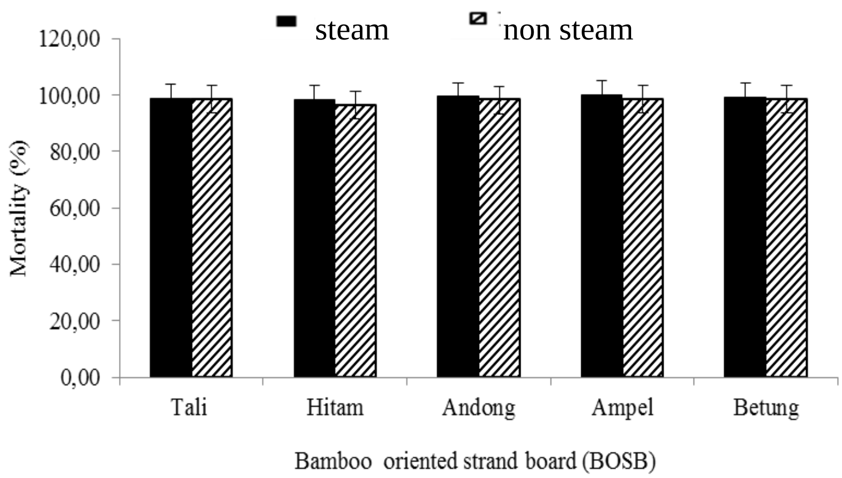

Figure 2 Termite mortality after BOSB baiting to C. *curvignathus*.

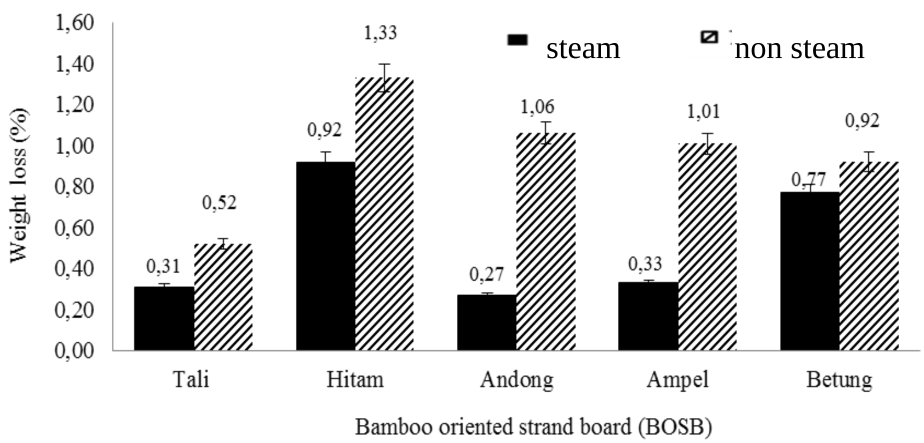

Figure 2 Weight loss of BOSB prepared from steamed and non-steamed strands after baited to *C. cynocephalus*.

The resistance of BOSB against dry wood termite (*C. cynocephalus*)

The average weight loss of non-steamed strands of BOSB was in the range of 0.52-1.33%. BOSB prepared from hitam and tali bamboos retained the highest and the lowest weight loss, respectively. All of the BOSB prepared from non-steamed strands of the present works were classified to the 1st class (very resistance) based on the SNI 01.7207-2006 requirements. The average weight loss of BOSB prepared from steamed bamboo strands were in the range of 0.27-0.92%. The highest and the lowest weight loss were found for BOSB prepared from hitam and ampel bamboos, respectively. All BOSB prepared from steamed bamboo strands were classified to the 1st class (very resistance). Although BOSB prepared from steamed and non-steamed bamboo strands retained the same resistance class, the weight loss of BOSB prepared from steamed strands were much lower compared to those of non-steamed bamboo strands.

Figure 4 shows the mortality of *C. cynocephalus* at the end of testing. The average mortality of *C. cynocephalus* was varied from 84.50-99.00%. The termite mortality was not affected by bamboo species and steam treatment.

Upon baiting to *C cynocephalus*, the weight loss of BOSB prepared both from steamed and non-steamed bamboo strands were much lower than that of solid bamboo (Purnamasari 2013). It was also clear that the weight loss of BOSB prepared from steamed bamboo strands considerably lower than that of non-steamed bamboo strands. Statistical analysis supported these findings. The weight loss parameter was significantly affected by bamboo species and treatment. Similar explanation to *C. curvignathus* can be applied to *C. cynocephalus* in this experiment. PF resin used for BOSB formation coated the surface of strands and inhibited termite damaging capability on the BOSB. Furthermore, the presence of phenolic component in the PF resin brought about the adhesive toxic to termites. Steam treatment helped resin penetration into the strands better than that into non-steamed bamboo strands resulted in a better bonding quality obtained for the BOSB prepared from steamed bamboo strands (Apriani 2012, Angin 2012, Rahayu 2012, Santoso 2012). During steaming treatment, free sugars in woody materials can be converted into furan intermediates, which can be further converted into furan resins (Iswanto *et al.* 2010, Rowell *et al.* 2002), and thus improve the resistance of BOSB against *C. cynocephalus.*

The resistance of BOSB against powder post beetle

The resistance of BOSB produced from steamed and non-steamed strands against post beetle was done in semi field test for 30 weeks. Observation of powder post beetle infection was done every week. The weight losses of sample and attacking powder post beetle species were determined at the end of testing. The attacking powder post beetle species was identified as *Anobium* sp. (Fam. Anobidae) and its morphology is shown in Figure 5.

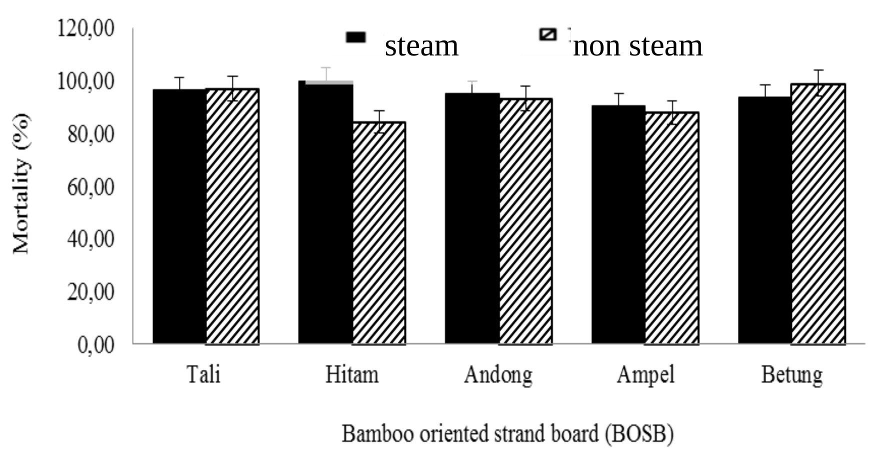

Figure 4 *C. cynocephalus* mortality after BOSB baiting.

(a) (b) (c)

Figure 5 Morphology of *Anobium* sp.: lateral side (a), medial side (b), dorsal side (c).

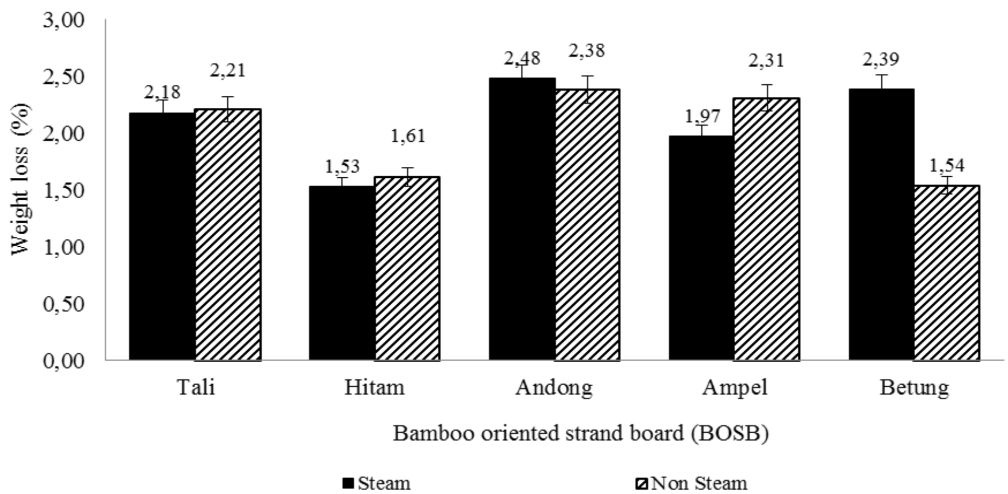

Figure 6 Weight loss of BOSB produced from steamed and non-steamed strands and solid bamboo after baited to powder post beetle.

The resistance of BOSB produced from both steamed and non-steamed strands against *Anobium* sp. was significantly higher than that of its original bamboos. . The resistance of solid bamboo against *Anobium* sp. was varied among bamboo species. The weight loss of solid bamboos (i.e tali, hitam, andong, ampel and betung) were in the range of 2.12-25.36%. Ampel solid bamboo was the less resistance against *Anobium* sp. (Purnamasari 2013). The weight losses of all BOSBs were statistically the same.

Anobium sp. attacked bamboo both for shelter and food (particularly starchy substances). It was reported that starch content of ampel bamboo was higher than that of betung, hitam and tali bamboos (Kusumaningsih 1997 *in* Munuhuwa & Laiwatu 2006).

The weight losses of BOSBs from both steamed and non-steamed strands were very low. It was presumably due to the presence of PF resin in the BOSBs. PF resin spread over the surface of strands and inhibited the damaging capability of *Anobium* sp. on the BOSBs. As mentioned before, the presence of phenolic compound in the PF resin brought about the adhesive toxic to the damaging agents such as *Anobium* sp. During steaming process, furan intermediates from free sugar that further converted into furan adhesive was also thought to increase the resistance of BOSBs against *Anobium* sp.

Conclusion

The resistance of BOSBs against *C. curvignathus* prepared from both steamed and non-steamed bamboo strands was considerably higher than that of its solid bamboos. The resistance of BOSBs prepared from steamed bamboo strands was higher than that of non-steamed bamboo strands. BOSBs prepared from non-steamed andong bamboo strands was categorized to the 1st class (very resistance), BOSBs prepared from non-steamed strands of hitam, tali and betung bamboo were categorized to the 2nd class (resistance), and BOSBs prepared from non-steamed ampel bamboo strands belonged to the 3rd class (moderate). BOSBs prepared from steamed andong and ampel bamboo strands were classified to the 1st class (very resistance), while BOSBs prepared from steamed tali, hitam and betung bamboo strands were classified to the 2nd class (resistance). The weight loss of BOSB prepared from steamed strands against *C. cynocephalus* was significantly lower than that of non-steamed bamboo strands. All steamed and non-steamed strands of the 5 bamboo species resulted in BOSBs of the 1st class (very resistance) against *Anobium* sp.

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