The Resistance of Laminated Bamboo Boards to Subterranean Termite (*Coptotermes curvignathus* Holmgren)

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Abstract

This study investigated the resistance of three-layer laminated bamboo boards (LBB's) to subterranean termites (*Coptotermes curvignathus* Holmgren) according to the Indonesian standard (SNI 01.7207-2006). Bamboo strips for LBB fabrication were prepared from *Gigantochloa pseudoarundinacea* and assigned into 4 groups by pre-treatment methods namely: untreated, cold soaking in 5% boron solution for 2 hours, bleached by 17.5% and 20% hydrogen peroxide solutions. The LBB was formed by tannin resorcinol formaldehyde (TRF). Wheat flour was used as extender with two different concentrations (i.e., 2.5% and 5%) based on TRF weight. The results indicated that the resistances of LBB's were much affected by pre-treatment methods. Applying different concentration of extender in TRF resin resulted in similar termite resistance of LBB's against *C. curvignathus* Holmgren. Pre-treated of bamboo strips with 5% boron solution and bleached by 17.5% and 20% hydrogen peroxide solutions prior to be LBB manufactured improved the termite reistance of LBB's against *C. curvignathus* Holmgren one level compared to untreated LBB. The termite-resistance of LBB made from untreated bamboo strips was categorized as class IV (poor) whereas those from boron- or hydrogen peroxide-treated bamboo strips belonged to class III (moderate).

Key words: boron solution, hydrogen peroxide, laminated bamboo board, subterranean termite, tannin resorcinol formaldehyde

Introduction

The total population of Indonesia in 2005 was 219.2 millions with the annual growth rate of 1.34% (SI 2006a). According to Supriana *et al*. (2003), the need for houses in Indonesia was about 2.9 millions units per year, and every unit of house consumes about 2.97 m^3 of wood on average. This means that approximately 8.613 millions m^3 of sawn timber is needed annually for house construction in Indonesia. Since the wood supply for housing industry has been decreasing considerably, the search for substitutes is urgent concern.

Bamboo has the potential to be an alternative to housing materials due to its ability to grow fast in various soils with desirable properties. Although there is a long history to use bamboo as construction materials, furniture, household utensils and handicrafts in Indonesian villages, the shape and dimension appear to limit the usage of bamboo. Due to its circular and hollow shape, bamboo must be converted into the flat and relatively thick materials as wood substitutes. It is fortunately possible to produce timber-like-materials with the desired dimensions from bamboo strips, so-called laminated bamboo board (LBB) by the aid of appropriate adhesives. LBB is a lumber-like product in dimensions, consisting of several layers of bamboo sheets bonded together with the grain in parallel direction, and may be formed into planks or beams. The production of LBB with longer service life is expected to contribute to a longer harvest cycle and environmental conservation as well. We should better understand LBB, not only its physical and mechanical properties but also its resistance to subterranean termites before the LBB is widely commercialized. This paper describes the results of an experiment to determine the resistance of three-layer LBB glued with tannin resorcinol formaldehyde (TRF) against subterranean termites (*Coptotermes curvignathus* Holmgren).

Materials and Methods

Materials

The andong bamboo **(***Gigantochloa pseudoarundinacea*) culms were harvested from private gardens in Bogor, West Java, Indonesia, to collect mature bamboo culms. The lower 60 cm parts were discarded so that the remaining 6 m long culms were cross cut into 90 cm long segments with more or less two internodes. The adhesive used was liquid TRF.

Preparation of bamboo strips

Each bamboo segment (90 cm in length) was manually processed by a bamboo splitter machine to obtain straight bamboo strips (5-7 strips) with the width of approximately 2 cm. The inner and outer parts of the selected straight bamboo strips were then scraped off and planed smoothly using a planner machine. The bamboo strips were stacked and then air-dried at room temperature for one week. The bamboo strips were assigned into 4 groups by pre-treatment methods: untreated, cold soaking in 5% boron solution for 2 hours, bleached by 17.5% and 20% hydrogen peroxide solutions. The bamboo strips were dried under the sunlight to 12% moisture content after pre-treatments.

LBB Preparation

LBBs were produced by laminating three layers of bamboo sheet, aligned parallel to the grain direction. Each layer (bamboo sheet) consisted of 7 bamboo strips. The bamboo sheets were glued with TRF, with wheat flour added at 2.5% or 5% of TRF. The glue mix was hand-spread over the surface of bamboo sheets using a metal spatula and the amount of glue spread rate was 170 g m^{-2} per a single glue line. The assembled LBBs were cold pressed by a wooden clamp for 4 hours. Since the clamp was not equipped with a pressure gauge, the time when approximately equal glue amount was squeezed out from the glue lines was taken as the indicator of proper amount of pressure applied to the LBBs (assembly of bamboo sheets). The assembled LBBs were then conditioned for about two weeks before the subsequent termite test.

Laboratory termite-resistance test

Five replicate specimens of each LBB type with a dimension of (2.5 x 2.5 x 2.5) cm^3 thickness were tested for their termite-resistance.

Table 1 Classification of wood resistance against subterranean termites attack (*C. curvignathus* Holmgren)

Class	Resistance criteria	Weight loss (%)
I	Very resistant	< 3.52
II	Resistant	3.52 - < 7.50
III	Moderate	7.50 - < 10.96
IV	Poor	10.96 - < 18.94
V	Very poor	18.94 - 31.89

The forced-feeding test was conducted according to SNI 01.7207-2006 (NSA 2006b). An individual specimen was buried in the soil of which the moisture content was adjusted at 7% under the water-holding capacity of the sand together with 200 sound workers of *C. curvignathus*. The assembled test bottle was kept in the dark for 4 weeks.

Mass loss percentage and termite mortality were determined for each specimen recovered after 4-week exposure to termite attack. These data were used to classify the resistance class of LBBs made from pre-treated bamboo strips based on the figures and criteria in Table 1. In addition, the infestation rate by termites was determined according to the classification described by Pablo and Garcia (1997).

Results and Discussion

Table 2 shows the results of termite-resistance test of LBBs. The LBBs made from untreated bamboo strips sustained mean mass loss of 14% for the extender content 5% and 15.4% for the extender content 2.5%. These figures fell in the resistance class IV (poor). Mean mass losses of the LBBs made from treated bamboo strips ranged from 7.6% to 10.5%, and belonged to the resistance class III (moderate). This meant that pre-treatments of bamboo strips increased the termite-resistance of LBB's.

Termite mortality of LBBs made from untreated bamboo strips were 89.8% and 97.9%, respectively for 2.5% and 5% of the extender content, whereas the mortality recorded with all LBBs treated was 100%. The findings may suggest the toxicity of tannin resorcinol formaldehyde in the LBB to termites. Since tannins are phenolic in nature (Pizzi 1994), phenolic compounds has a typical smell and produce strong antiseptic characteristics which may inhibit the activity of particular enzymes and can toxic to the insects as well (Woworoentoe *et al*. 1971). Jasni and Supriana (1992) stated that the tested preservative which produced over 55% of termite could be considered to be termiticidal.

The termite-resistance of LBBs can be also assessed from the value and severity of termite attack (infestation rate). As shown in Table 2, the infestation rate values of LBB's ranged from 1% to 16.5% and on all LBB samples can be categorized as slight attack based on the severity of attack.

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Conclusions

Laboratory evaluations demonstrated that the resistance of LBBs against subterranean termites attack was varied with pre-treatments of bamboo strips. The resistance class of three-layered LBBs made from untreated bamboo strips was IV, whereas those from treated was in class III. Although the pre-preatment of bamboo strips before LBB fabrication could slightly increase the termite-resistance, it seemed that further studies are needed to satisfy the performance requirements as construction materials.

Table 2 Termite-resistance of laminated bamboo boards

Pre-Treatment[1]	Extender content (%)	Mass loss (%)		Mortality (%)	Infestation rate	
		Mean	Resistance class	Mean	Value (%)	Severity of attack
A	2.5	15.4 (2.70)	IV	89.8 (13.77)	12.5	Slightly attacked
	5	14.0 (2.39)	IV	97.9 (3.68)	16.5	Slightly attacked
B	2.5	8.5 (0.31)	III	100 (0)	2.0	Slightly attacked
	5	7.6 (1.16)	III	100 (0)	1.9	Slightly attacked
C	2.5	10.2 (1.79)	III	100 (0)	1.5	Slightly attacked
	5	10.2 (2.06)	III	100 (0)	1.1	Slightly attacked
D	2.5	10.3 (0.23)	III	100 (0)	1.1	Slightly attacked
	5	10.5 (0.37)	III	100 (0)	1.0	Slightly attacked

[1] A = untreated; B = soaking 5% boron solution for two hours; C = bleaching with 17.5% H_2O_2 solution; D = bleaching with 20% H_2O_2 solution; Values in parentheses are standard deviation

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