Durability of fiber boards made of jabon and andong bamboo with additional activated carbon additives against dry wood termites and subterranean termites

D R Trisatya, E R Satiti, D A Indrawan, R M Tampubolon

Forest Product Research and Development Center, Ministry of Environment and Forestry, Bogor, 16610, Indonesia

E-mail: drtrisatya@gmail.com

Abstract. Utilization of wood waste as material to produce medium density fiber-board (MDF) will help to reduce the rate of deforestation. Jabon waste (Anthocephalus cadamba Miq.) combined with andong (Gigantochloa pseudoarundinacea (Steudel) Widjaja) bamboo waste with 50%:50% ratio were made into MDF with the size of 30 cm x 30 cm x 1.2 cm and density 0.45 kg/m$^3$ and 0.55 kg/m$^3$. Activated carbon additive 4% were then added in the process. MDF durability test towards attack from Cryptotermes cynocephalus Light dry wood termite and Coptotermes curvignathus Holmgrem subterranean termites were done according to SNI 01-7207-2014. Result shows that the addition of activated carbon powder increased the MDF’s dry wood termites-durability level from IV (not-durable) to III (moderately durable). Meanwhile, adding activated carbon powder additive in MDF had not increase its durability to subterranean termites attack. The MDF durability level against soil termite stood at the same level of IV (not-durable). Improvement needs to be done for MDF made of jabon and andong bamboo mix using preservatives to increase the MDF durability level.

1. Introduction

Wood-based composites/WBC is increasingly used to substitute solid wood for structural and non-structural applications in the construction industry for the past few decades [1]. Fiberboard is a composite product which can be produced using wood waste. Currently, Indonesian fiberboard imports value tend to be higher than the export, which value is respectively 195.8-249.7 thousand tons and 68.4-116.2 thousand tons [2]. By utilizing wood waste as raw material in fiberboard production, the effort is expected to contribute in reducing deforestation rate.

At present, jabon (Anthocephalus cadamba Miq.) is widely cultivated due to its fast growing characteristics. Jabon is easily found in Indonesia, the Philippines, Papua New Guinea and Solomon Islands. Jabon also fulfills the requirements for pulp, paper, plywood, boards and matches [3, 4, 5]. Judging from its durability and strength, jabon is included in class V of durable (extremely non durable) and less strong (III-IV) [6] thus, it is not appropriate for wood working materials. Although jabon is a non durable and less robust wood, its cultivation is still carried out for two main reasons, namely because it has fast incremental growth (10 cm per annum) and planting can be done independently by the community thus the cultivation contribute to people's income [7].

Reducing the rate of deforestation can also be done by providing wood substitution materials. One of the substitutes is bamboo which is grouped into construction materials, household products, food,
activated carbon, pulp and paper, composite boards [8]. Numerous utilization of bamboo has been done, however in the making process a lot of waste is produced. For example, in the production of laminated-bamboo, only the large-sized, thick diameter and straight stems can be used, the bamboos then need to be shaved and the process generate a lot of waste [9]. Andong bamboo (Gigantochloa pseudoarundinacea (Steudel) Widjaja) is one type of bamboo widely found in Indonesia. However, andong bamboo species is classified in durable class IV [10] against subterranean termite attacks and dry wood termites [11].

The abundance of andong bamboo and jabon waste in Indonesia provides an opportunity to produce composite products (medium density fiberboard-MDF) made from jabon-bamboo. However, research on the durability of fiberboard-MDF made of the two types of lignocellulose combined is still very few. Wood and other lignocellulose materials in low durable class (IV-V) are easily damaged by the wood destroying organisms both from fungi, beetles, wood marine borer and termites. Many studies have been conducted on the strength class of composite products, but study on the durability of composite products is relatively small. Durability is a major factor [11] in using bamboo, especially for furniture, construction and handicrafts.

Activated carbon is a carbon compound that has been processed by activation so that the compound has a very large pore and surface area in order to increase its adsorption power [12]. The addition of activated carbon aims to improve the quality of MDF because one of the uses of activated carbon is as an adsorbent for the metal Hg, Pb, Cd, Ni, Cu in the industrial wastewater radiator, nickel coating and copper coating [13]. With the absorption of metals in the MDF, it is hoped that the MDF's durability from termites attack will increase. This manuscript presents the results of study on the durability of MDF made of jabon and andong bamboo with additive substances in the form of activated carbon against the attack of Cryptotermes cuyocephalus Light dry wood termites and Coptotermes curvignathus Holmgrem subterranean termites.

2. Materials and Methods

The materials used in this study are medium density fiberboard (MDF), activated carbon, and dry wood termites (DWT) and subterranean made of the two types of lignocellulose combined, and ST. The MDFs used were 4 (four) types of composed of a mixture of jabon, andong bamboo waste and activated carbon as listed in Table 1. Activated carbon sourced from mixed sawn wood waste. Charcoal was produced at a temperature of 300 °C, and activated carbon was chemically activated with Potassium Hydroxide (KOH) at a temperature of 700 °C for 60 minutes. The process of making activated carbon produced a moisture content of 5.959%. Chemical activation with KOH involved the following:

\[
\begin{align*}
4 \text{ KOH} + \text{C} & \rightarrow 4\text{K} + \text{CO}_2 + 2\text{H}_2\text{O} \\
6 \text{ KOH} + 2\text{C} & \rightarrow 2\text{K} + 3\text{H}_2 + 2\text{K}_2\text{CO}_3 \\
4 \text{ KOH} + 2\text{CO}_2 & \rightarrow 2\text{K}_2\text{CO}_3 + 2\text{H}_2\text{O}
\end{align*}
\]

In testing DWT, MDF-sized 30 cm x 30 cm x 1.5 cm were made into sample size of 5 cm x 2.5 cm x 1, 5 cm referring to the modified SNI 7207-2014. Durability test of the MDF against DWT required the following apparatus and materials: scales, glass tubes, cotton, wax and Cryptotermes cuyocephalus Light DWT as many as 50 for each sample test. The MDF durability test against ST attacks was carried out on the MDF sample sized 2.5 cm x 2.5 cm x 1.5 cm (making test samples referring to the SNI 7207-2014). The materials and equipment used were: jampot, siftered sands, water and Coptotermes curvignathus Holmgrem ST as many as 200.

Table 1. Type of MDF for durability test against termites
MDF durability testing method for termite attacks refers to SNI 7207-2014. MDF durability test against ST was carried out for 4 weeks while the test against DWT was carried out for 12 weeks. Tests were carried out at the Pulp and Entomology Laboratory of Forest Products Research and Development Center in Bogor. At the end of the test, following data were recorded, the difference in sample mass, degree of attack, and number of surviving termites (natality) before and after the test were obtained. The data obtained were processed in a randomized complete design with SPSS 22 program. The MDF durability classes were determined as shown in Tables 2 & 3.

Table 2. Wood durability classification against dry wood termites based on mass loss

| Class | Sample condition | Mass loss (%) |
|-------|------------------|---------------|
| I     | Very Durable     | <2,0          |
| II    | Durable          | 2,0-4,4       |
| III   | Moderately durable | 4,4-8,2     |
| IV    | Not durable       | 8,2-28,1      |
| V     | Extremely non-durable | >28,1       |

Table 3. Wood durability classification against soil termites based on mass loss

| Class | Sample condition | Mass loss (%) |
|-------|------------------|---------------|
| I     | Very Durable     | <3,52         |
| II    | Durable          | 3,53-7,50     |
| III   | Moderately durable | 7,50-10,96   |
| IV    | Not durable       | 10,96-18,94   |
| V     | Extremely non-durable | 18,94-31,89 |

3. Results and Discussion

The results of durability test of MDF made of andong-jabon against Cryptotermes cynocephalus Light are presented in Graphic 1. Based on the weight changes, the MDF made of jabon and andong bamboo with a composition of 50:50 volume ratio, density of 0.55 kg/m³ and 0.45 kg/m³ are included in durability class IV (Not durable). The addition of 4% activated charcoal in the manufacturing process of the MDF raised the durability class to III (Moderately durable). There was a significant difference between A2 and other MDFs.
Figure 1. The degree of attack of dry wood termites on the MDF

The greatest degree of termite attack is found in the MDF with a density of 0.45 kg/m³ which is equal to 70% (great attack). The value of this degree of attack is inversely proportional to the average natality of termites which is equal to 62.80% which is presented in Table 4.

Table 4. Average of the degree of attack and natality of dry wood termites against MDF

| Type of MDF | Degree of attack | Natality (%) |
|-------------|------------------|--------------|
| A1          | 40               | 34.40        |
| A2          | 40               | 34.60        |
| A3          | 70               | 62.80        |
| A4          | 40               | 35.20        |

Previous study has shown that jabon is in durable class V [6] while andong bamboo is in durable class IV [11,14]. Table 4 shows that the MDF made from jabon and andong bamboo waste is not durable to the attack of DWT (durability class IV). The addition of activated carbon was able to improve the durability of the MDF from class IV to class III. MDF without additive substances (A1 & A3) has a higher cellulose content compared to MDF containing 4% additive substances. This is consistent with the results of previous studies [15, 16, 17, 18] that the main food of termites is cellulose. However, several cases have been found that DWT consume lignin as food [19].

The number of surviving termites is not always related to the MDF durability class [20]. The same can be seen in Table 4. The average number of surviving termites after testing on A1, A2 and A3 ranges from 34.40% -35.20% while the durability test shows a class that is not durable. One of the factors causing low natality is the nature of cannibal termites but not predatory [10, 16]. Activated charcoal can absorb and store heat. Increased temperatures on MDF containing activated charcoal are likely to cause DWT deaths [13].

The results of the durability test of MDF made of jabon-andong bamboo against the attack of Coptotermes curvignathus Holmgren were not much different from those of the MDF test on DWT. The test results are presented in Graphic 2. The four MDF tested for durability to ST showed durability class IV (not durable). There was not difference between A1, A2, A3 and A4. It confirms that density and the addition of 4% active charcoal did not improve the MDF durability.
Figure 2. The degree of attack of subterranean termites on the MDF

Average of degrees of attack showed that A1, A2, A3 and A4 were 90 degree and the average life of termites after test was 83.40-86.50% which showed in Table 5. This informs that the degree of ST attack is directly proportional to the ST natality. Addition of activated charcoal as much as 4% to the MDF did not affect the durability of the MDF.

Table 5. Average of the degree of attack an natality of subterranean termites against MDF.

| Type of MDF | Degree of attack | Natality (%) |
|-------------|------------------|--------------|
| A1          | 90               | 86.50        |
| A2          | 90               | 83.40        |
| A3          | 90               | 86.10        |
| A4          | 90               | 84.50        |

_Coptotermes curvignathus_ Holmgren is one of the most damaging wood-destroying insects, particularly in the tropical area such as Indonesia. Economic losses due to termite attacks could reach up to 2.8 trillion rupiahs [21]. Judging from the degree of damage, ST cause higher damage to the MDF compared to DWT. This is due to their different behavior patterns [22]. DWT feed on wood or lignocellulose material as well as using it for nesting, thus the damage caused is only in the form of burrows in wood. In contrast, ST feed on wood but not making it a nest, since they are nesting in the ground. The damage to the MDF caused by termite attacks has also been investigated [20], the study stated that it needed environmentally friendly preservatives to protect the MDF from damage caused by the termites and fungi attack.

4. Conclusions

The durability of fiber boards made from a mixture of Jabon and Andong bamboo with a density of 0.55kg/m$^3$ and 0.45kg/m$^3$ is classified in not durable (class IV) against attacks of dry wood termites and subterranean termites. The addition of activated charcoal showed an increase in durability from class IV to III against dry wood termites. The MDF with the addition of activated charcoal addictive substances has no effect on the durability class of MDF against the attack of subterranean termite attacks.
The Durability of the MDF made of jabon-andong bamboo needs to be improve by adding environmentally friendly preservatives such as biotermiticides to the MDF manufacturing process.

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