RESEARCH METHODOLOGY

Time and Place of Research

This Research was conducted in Laboratory of Bio-composite, Laboratory of Wood Solid, and Laboratory of Wood Engineering, Study area Faculty of Forestry, Bogor Agricultural University, Indonesia. Examination of durability of OSB to against termite attack was done in arboretum of Faculty of Forestry. The research was carried out from October 2009 up to May 2010.

Material and Equipment

The material applied in this research was strands Betung bamboo (B), Andong bamboo (A) and Tali bamboo (T) about the ages 3 years comes from Botanic Garden Bogor. Glue applied was Methylene Diphenyl Diisocyanate (MDI) from PT. Polychemi Asia Pacific Jakarta was used as a binder to manufacture OSB with resin content of 5%. Equipments applied consist of chain saw, stick iron, oven, rotary blender, spray gun, temperature press, washbasin, plastic sack; bag, aluminum foil, aluminum foil, digital weighing-machine, micrometer, caliper, Universal Machine of Brand testing Instrument.

Procedure for making OSB

OSB was made by three layers, face layer, core layer, and back layer. Strands Ratio of 50: 50 based on weight strands. Target of density set to 0, 7 g/cm³ of the size 30 cm x 30 cm x 1 cm. This research was done nine strand combinations from three strand bamboo Betung bamboo (B), Andong bamboo (A) and Tali bamboo (T) bonded with Methylene Diphenyl Diisocyanate (MDI) amount of 5%. Total OSB made 45 boards (9x5).

Figure 1 Sketches OSB from Bamboo
Process of Making OSB

Preparation of Raw Material

Each bamboo strands was made in size 7 cm in length, 2.5 cm in width, and thickness 0.06 cm. Strand was then dried in the oven at temperatures of around 60°C reached moisture content between 5-6%. The dried strand was kept in plastic bags. To determine slenderness and aspect ratios of the strands, 10 strands from each species were randomly selected. Caliper was used to measure the length, width and thickness of the strands. The slenderness and aspect ratios were calculated according to following formula (Maloney 1993),

\[
\text{Slenderness Ratio} = \frac{\text{Strand Length}}{\text{Strand Thickness}}
\]

\[
\text{Aspect Ratio} = \frac{\text{Strand Length}}{\text{Strand Wide}}
\]

Figure 2 strand bamboo (a) Betung (b) Andong (c) Tali

Figure 3 (a) strand storage (b) oven dryer
Mixing of Strands with Glue (blending)

The Commercial MDI adhesive was used to bond the strands to OSB. Before done blending (material mixing) was done balance strands bamboo. Glue applied amount of 5%, on dry weight strands, Rotary blender drum was used to mix strands with adhesive. Adhesive was applied to strands using a pressurized spray gun. The boards in this study were manufactured with target dimension of 30 x 30 cm and target density of 0.7 g/cm³. Strands used to manufacture an OSB was 600 g (based on strands oven dried weight), and 5% resin content was prepared based on oven dry weight of strand or about 30 g. The calculation of composition of strand and resin needed to manufacture OSB was follow:

\[
\text{Strand} = \frac{100 \times (30 \times 30 \times 1) \text{ cm} \times 0.7 \text{ g/cm}^3}{105} = 600 \text{ g}
\]

\[
\text{Adhesive} = \frac{5 \times (30 \times 30 \times 1) \text{ cm} \times 0.7 \text{ g/cm}^3}{105} = 30 \text{ g}
\]

Figure 5 (a) showed the glue MDI (b) blender machine

Sheet forming (mate forming)

The OSB manufactured consisted from three layers: face layer, back layer, and core layer. The mats were manually formed with face and back layers were aligned perpendicular to the core layer. The weight ratio of the face-to-core-to-back layers were set at 50: 50, 1:2:1. Nine strand combinations from Betung Bamboo (B), Andong Bamboo (A), and Tali Bamboo (T) were manufactured (arranged in face, core, and back layers, respectively), which is:

1. BBB 4. AAA 7. TTT
2. BAB 5. ABA 8. TBT
3. BTB 6. ATA 9. TAT
Figure 6 showed the strand mates forming

Hot pressing (hot pressing)

The Board sheet was pressed by heat (hot temperature) at press machine with temperature of amount 160°C, specific pressure 25 kgf/cm² during 7 minutes with movement system of single step. To get the desired thickness hence at press plate is applied by stick iron with thickness of 1 cm as control. Pressure meter gauge value (Pg) was determined by using formula as follow:

\[
Pg \ (\text{kgf/cm}^2) = \frac{PJ}{r^2ni}
\]

In which \( P \) is pressure on board (kgf/cm²), \( J \) is joint area (cm²), \( r \) is radius of cylinder (cm), and \( n \) is number of cylinder. And \( i \) is machine efficiency.

Figure 7 showed the hot presser machines.

Conditioning

The Sheet condition OSB which is ready made was done during one week at room temperature. The room temperature was ranged 25-30°C with relative humidity of 60-65%. Then was cut to become the test piece based on standard JISA 5908: 2003.

Figure 8 showed the board conditioning.
Testing of OSB

All boards were cut and tested according to Japanese industrial Standard JISA 5908: 2003 for particleboards to determine the physical properties: density, moisture content, water absorption, thickness swelling and mechanical properties: modulus of rupture (MOR, modulus of elasticity (MOE), internal bond strength (IB) and screw holding power (SHP). Field test were performed to determine resistance of OSB against subterranean termites attack. Four replications were performed for each type of specimen. The test specimens were obtained from each board according to cutting diagram showed in Figure 9.

Figure 9 showed the cutting diagram

Notes
1. MOE and MOR in parallel direction to the grain (20cmx5cm)
2. MOE- and MOR in perpendicular direction to the grain (20x5cm)
3. Weight loss percentage (20x5cm)
4. Density and moisture content (10cmx10cm)
5. Screw holding power (10x5cm)
6. Internal bond (5x5m)
7. Thickness swelling and water absorption (5x5cm)
8. Density parallel (5x5cm).
Physical Properties Tested

Density

The Density test was performed using specimens with dimension of 10x10 x 1 cm in length, width and thickness respectively. Initial dimension and weight of the specimens were measured. Density D (g/cm³) was calculated using this equation:

\[ D = \frac{m_1}{V} \]

In which \(m_1\) and \(V\) are weight (g) and volume (cm³) of specimen before oven drying, respectively.

Figure 10 showed the density specimen tests.

Moisture Content

The Determination of board moisture content was done with calculating difference between initial weights of weighing after being dried in oven for 24 h until reaching constant weight at temperature 103±2 °C. The moisture content (MC) of the board was calculated with the following equation:

\[ MC = \frac{m_1 - m_0}{m_1} \times 100\% \]

In which \(m_0\) is oven dry weight of specimen (g) and \(m_1\) is weight of specimen before oven drying (g).

Figure 11 showed the moisture content specimen tests.
Water Absorption

The Determination of water absorbency was done with calculating heavy difference before and after soaking in cool water during 2 and 24 hours. The water absorption (WA) was calculated with the following equation:

$$WA = \frac{m_2 - m_1}{m_1} \times 100\%$$

In which $m_1$ is weight of specimen before soaking (g) and $m_2$ is weight of specimen after soaking (g).

![Figure 12 showed the water absorption specimen tests](image)

Thickness Swelling

The Thickness swelling test was performed using the same specimens of water absorption test. The thickness of the specimens were measured before and after soaked into water for 2 hours and 24 hours. The formula used to determine the thickness swelling (TS) was calculated with the following equation:

$$TS = \frac{t_2 - t_1}{t_1} \times 100\%$$

In which $t_1$ and $t_2$ are thickness (cm) of specimen before and after soaking, respectively.

![Figure 13 showed the thickness swelling specimen tests](image)
**Mechanical Properties Tested**

**Modulus of Rupture (MOR)**

The Determination of MOR and MOE was done in parallel with universal testing machine (instron) of testing machine (UTM). Examination done at direction of long parallel and board wide parallel. Examination was done by giving burden with speed of 10 mm/minute at centered of test piece. Distance applied was 15 cm x board thick (minimum 15 cm). The MOR was calculated using this equation:

\[
\text{MOR (kgf/cm}^2\) = \frac{3PL}{2bh^2}
\]

In which \(P\) is maximum load at the point of delaminating: \(L\) is span length \(b\) and \(h\) are width and thickness of specimen.

![Universal Testing Machine](image)

Figure 14 showed the universal testing machine (Instron).

**Modulus of Elasticity (MOE)**

MOE was done by using the same test piece with MOR. Examination also is done in parallel with examination MOR, but registered in by this examination is change of deflection all changes in certain burden. The MOE was calculated using this equation

\[
\text{MOE (kgf/cm}^2\) = \frac{\Delta PL^3}{4\Delta Ybh^2}
\]

In which \(P\) and \(Y\) are load deflection at proportional limit: \(L\) is span length \(b\) and \(h\) are width and thickness of specimen.
Internal Bond Strength (IB)

The Examination of Internal bond strength was done by gumming both surfaces of board at iron log then the iron log pulled in at the opposite and hardness of internal bond strength. The formula used to determine the internal bond strength (IB) (kgf/cm²) as follows:

\[ IB = \frac{p}{b L} \]

In which \( p \) is maximum load at the point of delaminating, \( b \) and \( L \) are width (mm) and length (mm) of specimen respectively.

Screw Holding Power (SHP).

The test was performed on the installing long fairish spanner 20 mm and diameter 2 mm. The spanner was stuck to board OSB in 8 mm then was abstracted surface perpendicular with speed of 2 mm/menit. Style required to abstract spanner shows strength of OSB in holding spanner.

Resistance of OSB Against Subterranean Termites Attack

This test was performed at the arboretum of Faculty of Forestry, Bogor Agricultural University, Bogor, Indonesia. Resistance of OSB against subterranean termites attack was determined through field test. It was reported that the species of subterranean termite in tested location was Macrotermes gilvus. Aspects that were observed included damage and weight loss percentages of specimens. The test was performed using specimens with dimension 20 x 5 x 1 cm in length, width, and thickness respectively. The specimens were dried in an oven dryer with temperature of 103.2 °C for 24 hours to get its oven dry weight. The specimens were then buried until leave 50 mm of board length above the ground, with space of 600 mm between each sample. After 3 months, the specimens were taken from the ground, then were cleaned and putted into oven dryer with temperature of 103 °C for 24 hours to get oven dry weight. The formula used to determine the weight loss percentages (WLP) of the board is:

\[ WLP = \frac{w_1 - w_2}{w_1} \times 100\% \]
In which \( w_1 \) and \( w_2 \) are weight of specimens (g) before and after buried on the ground, respectively.

Figure 15 showed the weight loss specimen tests.

**Data analysis**

To determine the effect of strand combination on the properties of OSB, with completely random design were performed; with factor \( A \) were defined as the combination of strands (which is consists of nine levels of combinations). All runs were performed in four replications.

For all the experiments described above, data were analyzed using a SPSS 16.0 software package. Analysis of variance (ANOVA) and Duncan's multiple range test (using significance level or a \( \alpha \) 0.05).