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MODELLING OF RUMBIA LEAF STALK (GABA-GABA) AS WALL MATERIAL AND ITS THERMAL CONDUCTIVITY CAPABILITY

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ABSTRACT

The selection and use of environmentally friendly materials is the use of reusable building materials such as wood, bamboo, rattan, rumbia, alang-alang, coconut fiber, bark and others. Materials that are widely used as building materials by the community since the first is the plant rumbia. As an example is the use of leaves and stems rumbia as a roof and wall of traditional residential buildings. Rumbia as part of the family of palm plants, leaves and stems that have dried up has a good enough thermal absorption. However, the use of the leaves of rumbia leaves as a wall in traditional buildings is still very simple, ie only by tied and woven. In addition, lately stalks and leaves of rumbia are no longer used as building materials, but left to be waste logging rumbia.

The objective of this research is to model the rumbia/sago leaf stalk material as a composite particle board, to know the physical and mechanical characteristics of composite stalk particles and the material's thermal conductivity. The method used is material engineering with experimental approach. Variable testing based on compressive strength 400 kg/cm2 and duration of forging/ pressing of 12 hours and 5 hours. Test procedure under SNI 03 2105-2006 for composite particle board and taking into account JIS A 5908 - 2003 and FAO 1996 standard values, thermal conductivity testing refers to ASTM C 177.

The result of examination of physical properties of composite particle board in sample with duration of 12 hours duration found 6% - 17% yield difference with 5 hours durable sample. While for testing the mechanical properties of MOR and MOE obtained the difference of 6% to 11%. In general, samples with long-lasting behavior *are 12 hours better than the 5-hour durable sample. So also with the results of thermal conductivity testing. In samples with a duration of 12 h inrush resistance has a greater thermal conductivity of 10% than 5 hours of seismic durability. Thus, the more solid the composite particle board the greater the thermal conductivity value. Similarly, the thickness of the material can store larger calories than thin ones.*

Key words: Modeling, Material building, palm leaf stalk (gaba-gaba), Thermal conductivity

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1. INTRODUCTION

Indonesia is famous as an agricultural country where most people work as traditional farmers. One of the forms of agriculture is the plantation of rumbia (Metroxylon sago Rottb) (Flach, 1997). However, the utilization of rumbia plants is still not maximized, where the waste is mainly the petiole, stalk leaf many removed. In fact, since ancient times the community has been using the leaves and stems as a roof and wall of traditional residential buildings. For example Rumoh Aceh, Sasadu in Jailolo, Minahasa house, Banjar house, Bajo tribe house, and Honai in Papua. However, the leaves and stalks of rumbia used as building material are highly flammable (Cecep et al, 2011). In addition, the use of stalk rumbia as a wall in traditional buildings is still very simple, ie only by tied (Arifin, 2010).

Seeing the benefits of the leaves that are so potential to be developed, it is necessary to research the stalks rumbia can be more useful. One of which is utilized as a laminated board manufacture which is then used for household or industrial needs. This derivative board is made by using auxiliary material such as adhesive. This adhesive will help build stronger lamina bonds resulting in good board properties. In this study selected adhesive epoxy as a binder and stalk leaf rumbia, thus forming laminate material. Each laminate made from the leaves of rumbia with different variable ratios will have different physical and mechanical properties. It is expected that with the known mechanical laminate board stalk leaf rumbia is expected to be made as an alternative building materials, such as ceiling and furniture walls. The objective of this research is to model the rumbia leaf stalk material as a composite particle board, to know the physical and mechanical characteristics of composite stalk particles and the material's thermal conductivity.

2. PREVIOUS RESEARCH

Chiang et al. (2016) reveals that stem ripe tree branches have as much potential as particle board materials. The palm tree rhizomes that have been processed as particle board have high hydrophilic and porosity characteristics. The palm tree leaves with higher loading of the PF adhesive reduces the water absorption rate. This reflects the replacement of the hydroxyl group with the carbon atoms in the PF chain. In addition, PF adhesive is resistant to extreme temperatures at 800 ° C, so sagging particles of sago with PF adhesive have high thermal stability. This is due to the high crystallization index which has high thermal stability. Sago pepper particles with PF adhesives have high time heating and temperature to increase decomposition without altering structure or loss of strength.

The particle board is one of a kind of composite product or wood panel which is made up of wood particles or other lignocellulosic materials, which are bonded with adhesive or other bonding material then hot forged (Moody et al, 1999). According to Sudarsono et al, (2010), the particle board is a sheet of heat mixing of wood particles or other nephognoselulose materials with organic adhesives and other materials. The quality of particle board is a function of several factors that interact in the process of making the particle board. The physical and mechanical properties of particle board such as density, broken modulus, elastic modulus and internal stickiness and thickness development are good enough parameters to estimate the quality of particle board produced (Moody et al., 1999). According to Haygreen and Bowyer 1989, in Sinulingga HR, 2009) the higher the particle board density of a particular raw material the higher the strength, but the dimensional stability decreases by the increase in the density. Particle density is affected by wood density. The particle board density is the main factor with a density of 5% -20% higher than the wood density. Addition of adhesives will affect the density and produce heavy particle board (Tsoumis 1991, in Sinulingga HR, 2009).

The water absorption capacity of a particle board is influenced by the particle type. According to (Hesty 2009), the greater the pressure of felts, the temperature of the felts and the combination of both the smaller the water absorption board laden. The difference in absorption of the fiber board to water is related to the board density inversely proportional to the water absorption. The larger the board density the smaller the absorption capacity of water. Internal stickiness is a measure of the bond between the particles in a particle board sheet (Ariesanto, 2002).

Building materials play a role in this energy savings, because the building materials used have characteristics and can affect both energy. Characteristics of building materials in operational energy is: "thermal properties", ie on each building material has a different value so that the influence of heat to the room is different too. Similarly, the characteristics of building materials on the "material" of each different building materials. Noerwasito (2005) states that the most influential thermal properties are: "decrement factor" and "admittance" where they are also determined by other thermal properties, namely: conductivity, heat specification and density of building materials.

Houwink and Salomon (1965) define adhesive as a material that has the ability to combine material through a touch of surface. Epoxy adhesive is a thermosetting synthesis product of a polyepoxy resin reaction with acid or base (acid) or base (Gunawan, 1999). Epoxy may be obtained in the form of one or two component systems including solvent-free liquid resins, solutions, resin-paste pastes, powders, pallets, and pastes. The two-component system consists of curing resins with mixed poly epoxy when used. The epoxy adhesive is a liquid and is a two component system consisting of resin and hardener mixed when used with a ratio of 50% each. The storage time is three months to a year. The weight of the labur is 175 gr/m2 (Hindrawan 2005).

3. METHODS AND DATA ANALYSIS

3.1. Method

This study was experimental referring to SNI 03-2105-2006 standard for composite particle board, JIS A 5908 - 2003 and FAO 1996. Meanwhile, testing of laminated board in ASTM D 143 2005, and for testing thermal conductivity mul In ASTM C 177.

3.2. Material and Procedure Data Analysis

Materials used in research is stalk leaf of rumbia or in Indonesia known as gaba-gaba. Figure 1 shows the gaba-gaba material used in this study.

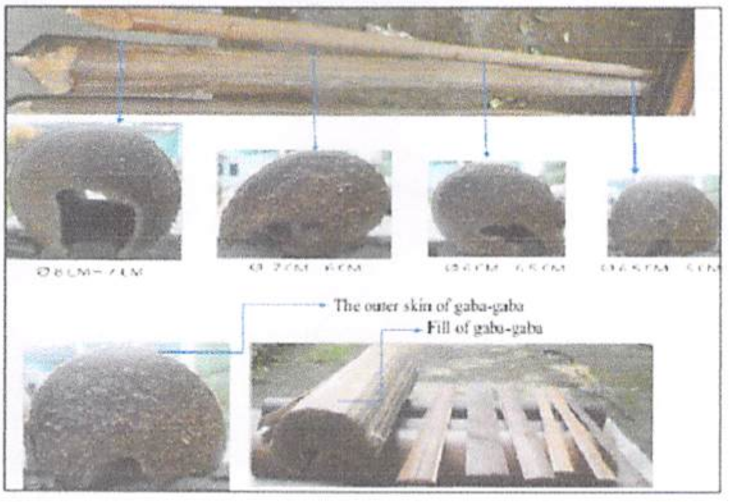


Figure 1 Stalk leaf of rumbia

Gaba-gaba has the following characteristics:

- Color: green in wet conditions / still alive, brown in dry conditions;
- Form: the eighth of a circle and a taper;
- Dimensions: at the base of the stalk of the diameter of 5 to 8 cm and at the end of the stalk is a diameter of 2 - 3 cm display 12 meters stalk;
- Weight: light in saturated dry state, large stalk weight 0.45 kg/stem and 0.12 kgrod/stem.
- Texture: This palm leaf stalk in a blanket filled with 1-2 mm thick hard skin, soft-textured fill fibrous, highly flammable and high water absorption.

The procedure of making a composite particle board of gaba-gaba

The stages of making composite particle board are as follows:

- Hard outer shell of removable leaf stalk,
- The stems are then shredded using a scar machine. The grated results are light particles and fibers of the gaba-gaba as shown in figure 2.
- Mixing particles and fibers with epoxy and gasoline adhesives:

a) Mixture printed on cold press mold measuring 144 x 61 cm.

b) Comparison of mixtures of particles, fibers, with epoxy and gasoline adhesives for particle board:

- 2 cm thick is 2.4 kg of fiber particles: 1 kg of epoxy: 4 liters of gasoline,
- 4 cm thick with a ratio of 4.8 kg of fiber particles: 2 kg of epoxy: 8 liters of gasoline,
- 6 cm thick with a ratio of 7.8 kg of fiber particles: 3 kg of epoxy: 12 liters of gasoline.

(a) (b) (c)

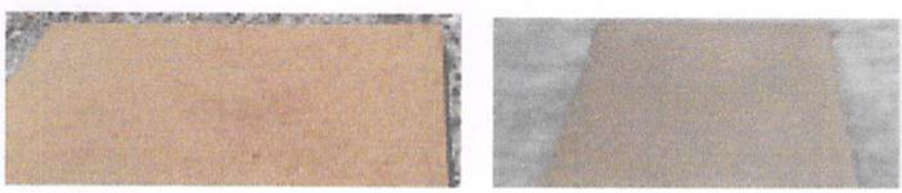
Figure 2 (a) The process of destruction of gaba-gaba, (b) Fibers, (c) Particles

All cutting and testing procedures refer to SNI 03-2105-2006 standards for composite particle board, ASTM D 143 2005 standard for laminate board cutting and testing procedures, and for thermal conductivity material testing procedures using ASTM C 177.

4. RESULTS AND DISCUSSION

4.1. Physical Characteristics of Gaba-gaba Composite Particle Board

There are two boards gaba-gaba composite particles resulting from this experiment. First, the board is forged for 12 hours, while the second board is forged for 5 hours. Visually, the shape of the two boards can be seen in figure 3. The physical characteristics test results are shown in table 1. From table 1, it can be seen that the test results Water content, density and thickness development of composite board for the first sample was better than Second sample. The results show that the parameters are mutually influential. Density values are strongly influenced by moisture content, density and thickness development.



(a) (b)

Figure 3 The shape of the board of gaba-gaba composite particles (a) forged for 5 hours, (b) forged for 12 hours

Table 1 Test results of Physical Characteristics of the Gaba-gaba Composite Particle Board

Sample code	Time of forged (hours) with forged is 400kg/cm2	Physical characteristics of particle board		
		Water content (%)	Density (g/cm^3)	Thick Development (%)
MUP A 2cm	12	9.30	0.221	3.97
MUP B 2cm	5	11.11	0.211	6.95
MUP A 4 cm	12	11.54	0.204	3.39
MUP B 4 cm	5	13.41	0.200	4.40
MUP A 6 cm	12	10.95	0.220	3.97
MUP B 6 cm	5	12.40	0.208	6.95

The smaller water content is affected by the larger density resulting in smaller thickness development. This can be seen in samples with 12-hour durability, where this sample has a greater density level due to very evenly distributed adhesives. So that, it can be absorbed in the pores of the particles and also the adhesive drying process is very evenly at the time of removing the forging. In contrast, small densities result in large water content and increased thickness development as seen in samples with 5-hour durability.

In samples with 5-hour durability, the test material was redeveloped during removal of the forging. It results in the occurrence of porosity on the board and forming the air cavity so that the adhesive and fiber particles do not bind properly. it also causes the air humidity is affecting increasing the water content of the test sample before drying.

4.2. Mechanical Characteristics of Gaba-gaba Composite Particle Board

Bending test results are shown in Figure 4. It is seen that the value of modulus of rupture (MOR) for test samples with durable felt 12 hours was higher than the test sample with a durable felt 5 hours. As for the value of the modulus of elasticity (MOE) it is known that samples with a durability of 12 hours are lower than the 5 hour long-lasting sample.

From Figure 4 above it can be seen that the duration of pressing pressure of 12 hours has a MOR value of MUP A 2 cm sample 1.101.30 kgf/cm2, MUP A 4 cm 726.55 kgf/cm2, MUP A 6 cm 3,103.35 kgf/cm2, and MOE value in sample MUP A 2 cm 137,270.00 kgf/cm2, MUP A 4 cm 79,665.63 kgf/cm2, MUP A 6 cm, 358,790.37 kgf/cm2. While on sample with duration of pressing for 5 hour have MOR value at sample MUP B 2 cm 925.40 kgf/cm2, MUP B 4 cm 726.55 kgf/cm2, MUP B 6 cm 636.48 kgf/cm2, and MOE value for MUP B 2 Cm 573,592.50 kgf/cm2, MUP B 4 cm 127,465.00 kgf/cm2, MUP B 6 cm 188,837.04 kgf/cm2.

It identifies that with 12 hours of precipitant durability it significantly affects the MOR value. This sample has a greater density level due to the spread of epoxy adhesive to the pores of evenly distributed particles. As a result, during peak loads, the direct test sample is fractured. Meanwhile, for samples with 5-hour durability, at the time of release the forging of the test material will be redeveloped. This development results in the occurrence of porosity on the board and forming air cavities. Hence, the adhesive and fiber particles do not bind properly because they are suspected of less hold time. Thus, the test sample has a lower MOR compared with a high enough MOE value.

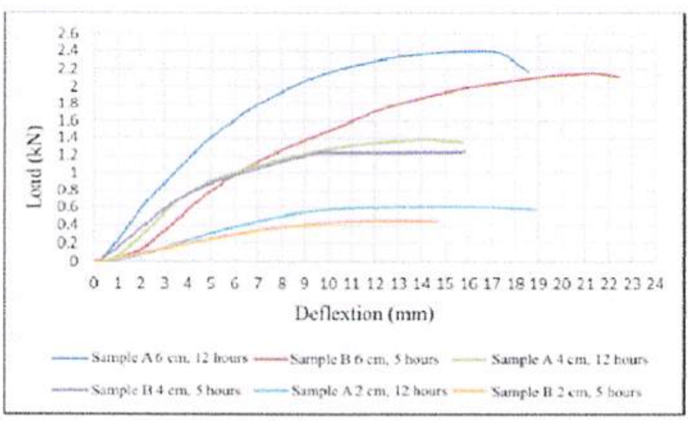


Figure 4 The MOR and MOE values of Mechanical Mechanism Test Result of Gaba-gaba Composite Particle Board

4.3. The Results of the Tension Sticky Test Of Gaba-Gaba Composite Particle Board

The results of the tension sticky test of gaba-gaba composite particle board shown in figure 5. The test sample with a 12 hour durable sealing treatment showed a stronger value higher adhesive drag than the test sample with 5 hours durability. From Figure 5 it can be seen that the particle board samples with durable felts 12 hours, indicating a higher value that the sample MUP A 2 cm 58.12 kgf / cm2, MUP A 4 cm 69.24 kgf / cm2, MUP A 6 cm 260.74 kgf / cm2. Whereas, in samples with 5-hour durability have lower values, ie MUP B 2 cm 55.88 kgf / cm2, MUP B 4 cm 58.74 kgf / cm2, MUP B 6 cm 220.26 kgf / cm2.

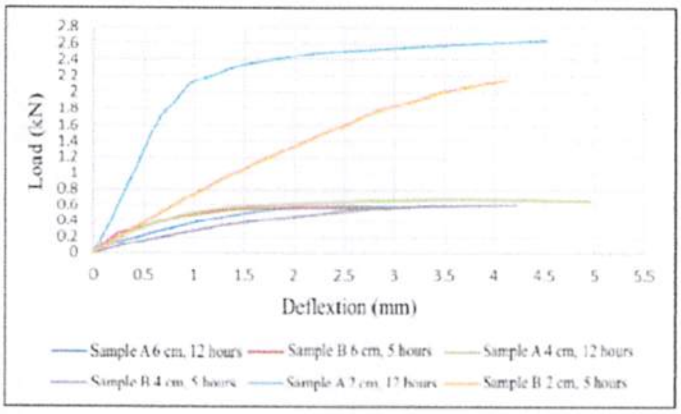


Figure 5 The tension sticky test result of Gaba-gaba composite particle board

Samples with 12-h forged durability have higher density. This is thought to be due to the highly uniform spread of epoxy adhesives that can be absorbed in the pores of the particles. In addition, the glue drying process is very uniform when removing the forging. So that, when the peak load of the direct test sample is fractured. However, for the second sample, upon removal of the forging of the test material, the sample undergoes re-development. This is allegedly due to less forging resistance time, ie 5 hour long forged. As a result the porosity of the board and form the air cavity. So that the test sample at the time in the visible separation of fiber particles due to adhesive and fiber particles do not bind well.

4.4. The Results of the Screw Constancy Test

The results of the screw constancy test for the Gaba-gaba composite particle board can be seen in figure 6. From the graph it is known that the test sample with the duration of 12-hours durability has excellent value compared to the sample with 5 hours durability.

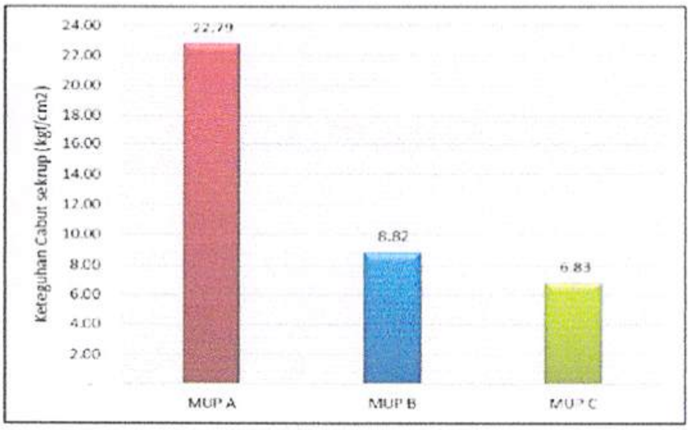


Figure 6 The screw constancy test result of Gaba-gaba composite particle board

From the graph above, it can be seen that the particle board of MUP A 6 cm sample has a higher screws screws level of 22.28 kgf / cm2 compared to the MUP B 4 cm sample of 8.82 kgf / cm2 and MUP C 2 cm of 6.83 kgf / cm2. The percentage of elasticity of bending elasticity of MUP A particle board 6 cm and particle board MUP C 6 cm is 39.6% and 30.66% against particle board MUP A 6 cm. It identifies that with 5-hour long-lasting treatments greatly affects the firmness of the screws.

At particle board MUP A 6 cm, the higher screw retracts value occurs. This shows that fibers and particles are perfectly integrated with epoxy adhesives. In this sample, the particle fiber density occurs due to the effect on the durability of the sealing during the manufacture of the test material. The durability of the seals can identify that the adhesives and fiber particles bind together more perfectly. However, when the compressive duration is less long, it causes the fiber particles to expand as the adhesive has not been completely dry.

4.5. Thermal Conductivity Test Results

There are 2 samples used in the thermal conductivity test for Gaba-gaba particle board. The first sample is a Gaba-gaba particle board with a thickness of 6 cm and a durability of 12 hours. Whereas, the second sample is a particle board with a thickness of 6 cm with 5 hours durable duration. Figure 7 shows the distribution of different temperature values of several specimens based on thickness and density variations. From the graph it is known that the thicker and denser a particle board, the greater the conductivity value.

In the durable density felts 12 hours with a thickness of 6 cm known conductivity value is 0.406 W / m ° C. Meanwhile, the conductivity of the lowest value is equal to 0.357 W / m ° C which is the durable density felts for 5 hours. this is due to a thicker board can store more heat than thin. Under certain conditions, the heat released by the particle board can increase the temperature in the surrounding environment. This has resulted into greater conductivity value anyway. Thereby, these tests need to specify the same conditions in order to achieve steady state conditions.

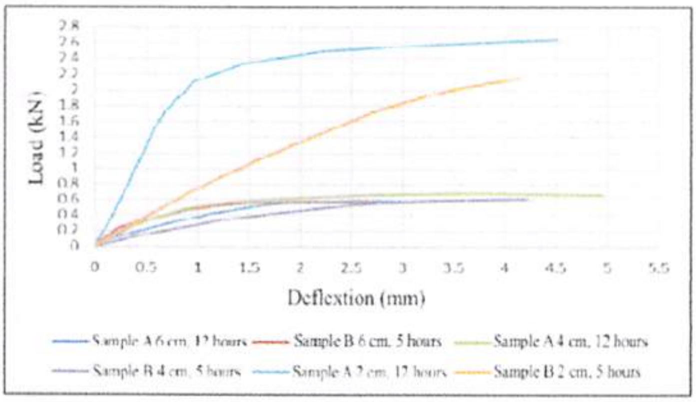


Figure 7 The speed of the heat propagation in the test material

5. CONCLUSIONS

1. Strong compressive strength and durability on the manufacture of Gaba-gaba composite particle board using epoxy adhesives greatly affect the physical properties of the composite particle board. Strong compressive strength and durability also inhibit the increase in water content, reduce water absorption and reduce thickness development. In addition, strong compression and durability also affect the mechanical properties of composite particle board, ie in increasing the strength of MOR and MOE.

2. Particle density greatly affects the thermal conductivity value of the material, where the denser the particle board the greater the thermal conductivity value. Thicker particles can store larger amounts of heat than thin ones.

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