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Mechanical and Physical Properties Ofmedium Density Fiberboard Produce from Renewable Biomass of Agricultural Fiber

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Abstract*— The development of Medium density fiberboard (MDF) made from renewable biomass of pineapple (Ananas comosus) leaf fiber and their suitability as a construction material has been investigated. Two different types of board with a target density of 0.8 gr/cm3 were manufactured. The board was prepared in three layers of about 1:1:1 weight ratio in unidirectional and cross-oriented board using low molecular weight (LM) PF resin type PL-3725 and high molecular weight (HM) PF resin type PL-2818 for impregnation and adhesive purposes. For comparison, boards with the same structure were prepared using high molecular weight PF resin only. The mechanical properties of the boards have been examined as well as their physical properties. The results shows that generally, mechanical properties, Modulus Of Elasticity (MOE), value was improved with mix PF resin as well as Modulus Of Rupture (MOR). Pineaplle leaf fiber resulted in significantly higher MOR, consistent with our observation during the test. This information is useful when a high MOR is required in application. Other mechanical properties such as internal bonding (IB) and screw-holding capacities (SH) improved as those of MOE and MOR. Fiber from agricultural residues such as pineapple leaf are longer than wood fiber. This might explain why screw-holding capacities increased since the failure in those tests is mainly due to tear force. Diffrences in the physical properties between the board types were caused by the presence of the low molecular weight PF resin for the impregnation of the fibers. As using of mix PF resin, thickness swelling (TS) properties improved as well. No significant difference was found for both mechanical and physical properties. The effect of the PF resin for impregnation was noted; however, fiber orientation had no effect on both physical and mechanical properties of the specimens.

***Keywords*— Medium density fiberboard (MDF); Pineapple leaf fiber; Physical and mechanical properties; Structure of fiber.**

I. INTRODUCTION

In recent years, it has been difficult to obtain solid woods,and this causes problem for wood-based industry. To meet the standards required for a high-class residential environment, substitute wood-based materials including natural materials are required as construction materials. In addition, such systems contribute to the recycling of agricultural wastes. Nowadays, attention has been paid to non-woody fiber which was has gained high importance as a sustainable plant fiber resource for composite products. The use of agricultural fiber for panel composite materials is commonplace in many part of the world. There are vast supplies of agricultural fiber residues in Indonesia. Pineapple is one of important economic fruits for Indonesia with a strong domestic and export demand. But. there has been a lack of successful harvesting for this fruit,which could be attributed to residues from their leaves.Manufacturing composite materials using pineapple leaf fibers is an option for sustainable utilization in areas where this material is abundant. Due to its large production of pineapple, Indonesia is an ideal place for development of the composite materials. One of the big issues regarding composite products is the strength performance of the board.Therefore it is indispensable to evaluate the physical and mechanical properties of the board produced from pineapple leaf fibers. Production of composite products has increased dramatically. One of them is Medium density fiberboard (MDF). MDF is a wood-based panel that is composed of wood fibers bonded together with resin under heat and pressure. MDF have a wide application for both structural and non-structural uses.In order to recycle natural resources to meet demand caused by the decrease in supplies of solid wood and woodbased materials, several researchers have succeeded substitutes for wood fiber, using lignocellulosic fibers. Composites made from agro-fibers have been investigated (Grigoriou et al., 2000; Nobuhisa & Masatoshi, 2004; Lee et al., 2004; Philip et al., 2006).This research is sure to contribute in developing novel production processes of agro-waste pineapple leaf fiber for construction materials and to determine their strength (mechanical and physical properties).

II. Material And Methods

A. Materials

Pineapple (Ananas comosus (L.) Merr. leaf was used as raw materials. Two types of PF resin were chosen for impregnation and adhesive purposes; low molecular weight (LM) PF resin type PL-3725 and high molecular weight (HM) PF resin type PL-2818 (Gunei Chemical). Methanol and water were also used as the solvent.

B. Fiber Preparation

The fiber take out from pineapple leaf by decortications.The fibers were cut to 35 cm in length and manually combing and finally were sorted by length. The main purposes of this procedure were to homogenize the fibers in length and to obtain straight fibers. The fibers were then oven-dried to moisture content approximately 5%.

C. Resin Solution Preparation

Both resins were mixed and impregnation solution of the resins was prepared by adding methanol and water to decrease the viscosity. The weight ratio of LM:HM:methanol:water was 0.5 : 0.5 : 1 : 1. Whereas usage of HM PF resins type – 2818 only was also manufactured to compare the mechanical and physical properties effects of the impregnation.

D. Board Preparation

MDF boards at a target density of 0.8 gr/cm3 were manufactured measuring 35 cm x 35 cm x 0.4 cm. The fibers were dipped into the PF resin solutions. Excess impregnation PF resin was squeezed out by passing the fiber thorough a pair of rollers. The impregnated fibers were dried at room temperature for 24 hours to let a resin content of 20% (dry weight) of the fibers. Two sets of boards were produced using both PF resins, uni-oriented (UB) board as Type I, was created with all layers oriented in the longitudinal direction. The rest, crossoriented (CB) as Type II, was consisted of a plywood-type board with an orientation of 0º-90º-0º. The MDF was prepared in three layers of about 1:1:1 weight ratio. The mats were consolidated in a laboratory hot press with a specific pressure of 4.5 MPa and at a pressing temperature of 160ºC for 10 min to completely cure the PF resin.Afterward, all boards were conditioned at 20ºC and 65% relative humidity for seven days prior testing.

E. Mechanical Properties Test

The mechanical properties of the boards were measured according to the Japanese Industrial Standard JIS A 5905 – 1994 for fiberboard. The test included the testing of bending strength (modulus of rupture/MOR and modulus of elasticity/MOE) in parallel and perpendicular directions and internal bond strength/IB.

F. Physical Properties Test

The physical test included the testing of thickness swelling in cold water (TS) and water absorption (WA) of the board which was measured according to JIS A 5905-1994 by a simple water soaking test. The testing was measured after immersing the sample in distilled water at 20ºC for 24 h.

III. Page Style

A. Mechanical Properties

Average of MOR and MOE under various type of resins were presented in Table 1. All board types shown in Table 1 have a various bending strenght perpendicular to the main board orientation and is elevated regarding the requirements of the JIS A 5905-1994 with three type of 15, 25, and 30 Nmm-2 for biberboards. This effect is significant due to the unidirectional fiber orientation as state by Thomas et al., (2007). Generally, MOR and MOE values were improved with mix LM and HM resin. This may suggested that the low molecular weight PF resin was found to penetrate the cell wall to reduce welling and shrinkage while, the high molecular weight PF resin was found not to penetrate the cell wall during previous test and it acts as an adhesive between the fibers (Kawai et al., 2001).

Type	MOR (Mpa)		MOE (Mpa)	
	Parallel	Perpendicular	Parallel	Perpendicular
UBI	107.15 (23.63)	19.32 (5.73)	8237.82 (2703.53)	2059.17 (1161.62)
UBII	204.95 (30.32)	18.52 (2.25)	19207.43 (1504.42)	2780.73 (1572.07
CBI	96.75 (17.71)	24.91 (9.48)	12992.94 (3230.42)	2191.04 (537.26)
CBII	124.1 (51.56)	31.48 (10.7)	14355.81 (4943.81)	1433.81 (627.37)

Values in parantheses are standard deviations
I : High molecular PF resin
II : Mix high and low molecular PF resin

The internal bond strength results are shown in Figure 1.As shown in Figure 1, board type UB with high molecularPF resin showed lowest internal bond strength, however,there was no significant difference within the board types. It can be assumed that all board types having the similar target density of 0.8 gr/cm3. In fact, the IB strength of all board types resulted in this research is fulfil the requirements of JIS A 5905-1994 with 0.5 Nmm-2 for fiberboards.

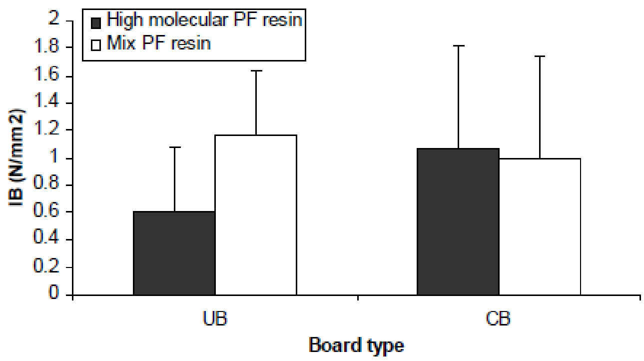

Fig. 1. Mean values of the internal bond strength.

B. Physical Properties

Average of thickness swelling (TS) and water absorption were presented in figures 2 and 3 respectively. As using of mix PF resin, TS properties improved as well. It was observed that the swelling of croos-oriented boards was higher than for uni-oriented boards. It might be caused the cross-oriented boards showed better performance in integration between fiber and resin. The similar result was also found by Sasa et al., 2008. The TS for all board types fulfil the requirements of the JIS A 5905-1994 for fiberboards (17% or under required).

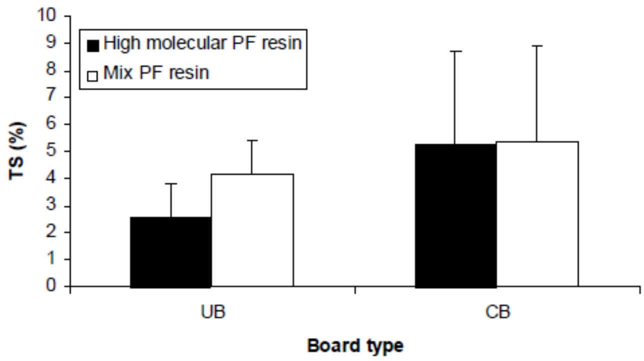

Fig.2. Mean TS of each resin type after immersion in water at 20°C for 24 h

The water absorption property tends to show similar results as TS as well. The water absorption increased for cross-oriented board. The lowest water absorption of about 7.67% was found in uni-oriented board with high molecular PF resin only.

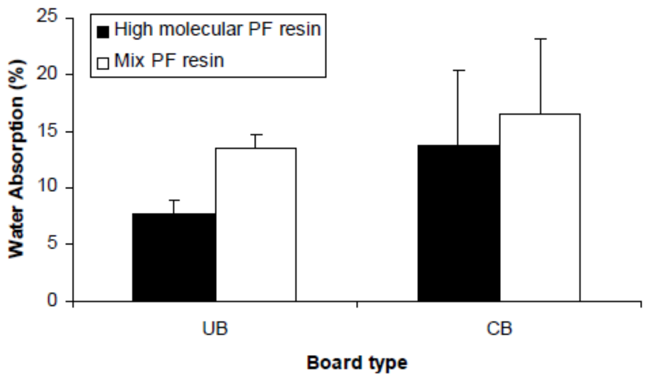

Fig.3. Mean water absorption of each resin type after immersion in water at 20°C for 24 h

IV. Conclusions

The properties of the pineapple leaf fiber showed the possibility the production of construction materials made from plant fibers. The mechanical properties (bending strength and IB) and physical properties (TS and water absorption) values were elevated the requirements of the JIS A 5905-1994. The mechanical and physical properties seem to be promising for the development of a construction material. It might be useful as an alternative construction material for region with abundant of agricultural fibers. Additional research by using the natural adhesive is indispensable for the near future to enhance the properties of the bio-based composite.

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