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Analysis Of the Effect Of Impermeability Test On Laminated Board Systems Bamboo Petung On Ship Shell Material Joints

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Abstract*—Wood material is one of the materials in the manufacture of shipAnother alternative is bamboo. Bamboo material plays an important role because bamboo has another advantage of this bamboo, which is lightweight and has a fairly high flexibility. To make a good bamboo board, a strong adhesive and combination of components is needed for shipbuilding. In this study, the type of bamboo used was petung bamboo. The purpose of this study was to determine how the effect of the tightness test on the petung bamboo laminated board system at the ship's shell material connection and to determine the value of the tightness used to test the petung bamboo laminated board system on the ship's material connection. Meanwhile, the benefit of the research is to provide understanding and insight on various matters relating to the Impermeability Test of the Petung Bamboo Laminated Board System at the Connection of the Vessel Material. The method in this study uses the standard Air Pressure Test which aims to see whether or not it can be applied to bamboo ship building technology. This test uses a pressure ranging from 0.2 psi. The results of this study showed that the vertical joint laminated board showed 140.2 lbf/in2 and 139.4 lbf/in2 while the inclined joint laminated board is 124.4 lbf/in2and 123.8 lbf/in2.

Keywords—*Bamboo, Vertical Joint, Impermeability, Air Pressure Test*.

I. INTRODUCTION

Ship transportation is one of the marine transportations that has a role in improving the economy in an area or region. In shipbuilding, the materials used for shipbuilding are metal materials such as iron or steel andwood[1]. However, over time the use of wood in the shipping industry is getting lower, this is because the availability of wood in the last period has decreased, so to overcome this problem several alternatives are found to replace wood, one of which is bamboo. Bamboo currently has an important role in people's lives, because bamboo has properties that can be used such as straight, strong, hard, easy to form, split and easy to work [2]. The advantages of bamboo used as a construction material are that bamboo is a renewable material, construction costs are cheap and short and do not require modern equipment. Another advantage of this bamboo is that it is lightweight and has a fairly high flexibility. To make a good bamboo board, it takes adhesives and a strong combination of components for shipbuilding.

The bamboo used is petung bamboo which has another name, Dendrocalamus Asper which is large with a rootstock diameter reaching 26 cm and a height of 25 cm, this bamboo is generally also more tenuous, grows in gardens and is yellowish green [2]. One of the techniques used to improve the quality of bamboo is lamination. Lamination is a process of uniting one part of the material with another material, the material that has been put together can be similar or different types and become a unity that cannot be separated. [3]. This lamination technology is an environmentally friendly technology, useful for preserving forests because using this technology can reduce as little as possible the occurrence of deforestation. In the lamination process in this study, researchers chose to use epoxy glue adhesive (Melamine Formaldehyde) because this type of adhesive is able to withstand water absorption (adhesion) very well and has the highest mechanical strength. The technical specifications are as follows; Specific mass 1.20 gr/cm3, young modolus : 3.2 Gpa, Poisson number : 0.37, Tensile strength : 85 Mpa[3].

Based on the above problems, the study discusses "Analysis of the Effect of Impermeable Tests on Petung Bamboo Lamination Board Systems on Ship shell Material Connections" This study was conducted by analyzing the strongest connections between petung bamboo laminates using epoxy through wind testing or impermeability tests. With this test, it is expected to be able to obtain information about the strength of petung bamboo lamination at the ship's shell joint.

The relationship between the surface area of the connection and impermeability is that if the surface area is large, the impermeable strength is stronger, while if the surface area is small, the impermeable strength is weaker. The purpose of this study was to determine how the effect of impermeability tests on petung bamboo lamination board systems on ship shell material joints and determine the impermeability value used to test laminated board systems on petung bamboo on ship material connections. Meanwhile, the benefit of the research is to provide understanding and insight intovarious matters related to the Impermeability Test of the Petung Bamboo Lamination Board System at the Connection of Ship shell Material.

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II. METHOD

This research is experimental research conducted by testing. This research requires Dendrocalamus Asper petung bamboo size (5m/length), Epoxy Resin (5kg/bucket), ST 40 Steel, Butt Joint on the box as much as 1 , oblique joint (Scarft Joint) on the box as much as 1 and compressor tool.

The implementation of this test uses the Air Pressure Test testing standard. This test is carried out to determine the tightness between the joints through wind pressure testing. The results of the tests that have been carried out to see whether it can be applied to bamboo ship construction technology. The wind pressure test is carried out on box-shaped bamboo specimens that will be adjusted to the bamboo vessel as it was originally formed.

This research was conducted in an experimental laboratory at the Welding and Material Laboratory, Shipping Engineering, Diponegoro University, Semarang. Composite material is a material formed from a combination of two or more forming materials through an inhomogeneous mixture, where the mechanical properties of each forming material are different. [4]

In this study using Petung Bamboo (Dendrocalamus asper Black) as a substitute for wood in the main material of shipbuilding, this bamboo is known as one type of large bamboo with wide leaves on the 11th segment there is a prominent root circle, branching which shows on segments 8-10. There are 3 types of bamboo stem colors, namely brown, yellow, and green. [5] Petung Bamboo has a Flexural Strength of 134.972 MPa, Parallel Tensile Strength of Fiber 228 MPa, Parallel Compressive Strength of Fiber 49.206 MPa, Perpendicular Compressive Strength of Fiber 24.185 MPa, Parallel Shear Strength of Fiber 9.505 MPa, and Modulus of Flexural Elasticity of 12888.447 MPa. [6]

Lamination is a process of uniting one part of the material with other materials, the materials that are put together can be similar or different into a unity that cannot be separated. [6]

In the lamination process itself there are 3 main aspects that need to be considered, namely the bamboo aspect, the adhesive material aspect (epoxy), and the gluing technology aspect. [7] Laminated bamboo comes from bamboo pieces made in parallel directions. The laminate size uses a size of 30x30x2 cm.

Figure 1. Laminated Board

The manufacture of this laminate uses Epoxy Resin adhesive glue. Epoxy is a glue that is suitable for gluing board joints to wooden ships. The advantages of epoxy glue are that it has good quality, strong adhesion, is resistant to sea water and is very easy to use. However, epoxy glue has the disadvantage of being less flexible, the nature of the film is classified as harder and the price is relatively expensive. [8] General composition of Epoxy Bisephenol a Resin 80-90%, Modified Epoxy resin 5-15%, Alkyl Glyeidyl Ether 5-15%, Mercapton Polymer 50-60%, Tertiary Amine 5-10%, Polymide Resin 20-35%, Triethylene Tetramine <3 %, Alifatic Amine.

Figure 2. Resin Epoxy

Connections are often said to be very risky parts or have the least strength in all aspects, so that failure is good from structural failure or damage that exists due to the connection. According to SNI 01.5008.4-1999 explains that laminated jointboards are of two types, namely solid jointed board and non-solid jointed board. [9]

The connection in this test uses a non-solid jointed board. An incomplete dial board is a connection board that comes from a joint bar or short wood that is joined.

The types of connections used in this test are Oblique Joints and Butt Joints.

Figure 3. Butt Joint

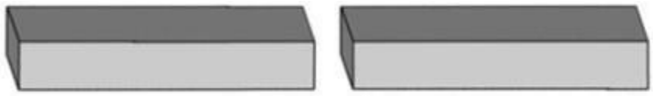

Figure 4. Scraft Joint

Adhesive joints with high strength values can be compared with other joints in terms of the weakening and deformation factors that occur. So, this shows that theButt Joint is stronger to accept compressive force because the plane of the oblique joint slice is not able to accept a large compressive force. [10]

The method used to test an object with high-pressure air is called the Air Pressure Test. The Air Pressure Test is a form of leak testing in pipes and tanks using high pressure. The pressure exerted on this test ranges from 0.2 psi. [11] In conducting this test using foamy soap liquid to see leaks that arise because the air coming out of the tank is characterized by the release of soap foam bubbles from the top of the leaking tank. Once a leak is known in the specimen it should be marked as a signal that the site should be repaired.

The basis for testing using a pressure limit of 0.2 bar is based on the provisions of the Rules for The Classification and Construction for Seagoing Ships. An example can be seen in BKI Rules Vol. Section 3 regarding Tightness Test. For bamboo laminate board standard using JIS A 5908 standard (JSA, 2003).

At the time of testing, laminate boards use steel plates as the medium used to enter the wind. Steel is often used in ship building construction because it is strong, flexible, and resistant to corrosion. [12]

The moisture content of bamboo can have a significant impact on its physical and mechanical properties. The moisture content of bamboo can affect bamboo lamination. The ISO 22157-I-2004 standardization specifies a moisture content of less than 12% for food products. The moisture content of this product is calculated from the weight of water (g) divided by the dry weight of bamboo. The moisture content is calculated from the water weight (g) divided by the dry weight of bamboo by the equation:

$$KAS = \frac{Bb - Bk}{Bk} \; x \; 100\% \quad (1)$$

The standard moisture content used in the test was 12%. The moisture content of freshly cut wood is still around 40-200%, while the water content in Indonesia ranges from 12-18% or an average of 15% [13]

The moisture content can also be calculated by the percentage ratio of water weight in bamboo with the dry weight of the kiln. The weight of dry bamboo kiln is the total weight of bamboo without water due to drying in the furnace at a temperature of 101-105 C. [14]

The location for making this bamboo specimen is in the Jogja bamboo preservation workshop and preservation (Rosse Bambu) and for testing this specimen is located at the Welding and Ship Material Laboratory of Shipping Engineering, Diponegoro University.

The implementation of this test uses the Air Pressure Test test standard. This test is carried out to determine the tightness between the joints through wind pressure testing. The test stages are the test specimen is inserted into the towing tank to determine the presence of wind bubbles emerging from the specimen, the test specimen is inserted air from the compressor, Recording is carried out by observing the maximum pressure on the barometer against the test specimen that is damaged or emits angina, The location of the damage will be marked, the test is carried out 3 times on each specimen.

III. Results and Discussion

A. *Material Manufacture*

Bamboo laminate is made from petung bamboo (Dendrocalamus asper Black) which is used as the main material in making bamboo laminated board.

The adhesive used in the manufacture of laminated boards and splicing specimens is epoxy resin using a ratio of 4: 1 for resin and hardener. The epoxy resin used is a champstar brand purchased at the Demak champstar company.

B. *Laminated Board Specimen Making*

The process of making laminated board specimens begins with cutting bamboo sticks from before the internodes to a stem length of 30 cm. Then the bamboo stalks are bladed, the bamboo slats are made by removing the outer skin. Then bamboo slats are made by removing the outer shell. Then the blades are carried out a splitting process to get a size of 30 cm x 1cm.

Laminated boards are dried to a moisture content of less than 12%. Drying of laminated boards is carried out for a safe 2-5 weeks depending on the weather. Then smooth the surface with a sanding machine.

The dried laminated boards are then used as reinforcing composites to make LBC (Laminated Bamboo Composites). LBC is obtained by using a hydraulic press with a pressure of 2.0 MPa. Figure 5 describes the pressing process of laminated boards.

Figure 5. Hydraulic Press

C. Laminate Board Connection Making

After the specimen is in the form of laminated board, the cutting part of the laminated board is carried out in the middle with variations of upright joints and oblique joints. The laminated board that has been cut is glued together using epoxy resin and pressed so that there are no voids in the laminate board joints.

D. Test Specimen Making

The process of making Laminated Board can be done by cutting bamboo above 1 meter from the root then cut the bamboo according to the segments, slats according to the required width of 20mm with a thickness of 2m, brush on the surface of petung bamboo so that the resin sticks strongly, then use a brush to do the coating, when perfectly, Align the bamboo slats that have been cut and then formed into boards according to the size and arrangement of laminated bamboo slats fibers, coat the resin on all parts then let stand until the board dries and hardens, after the specimen is in the form of a board, bamboo cutting is done in the middle with variations of upright joints and oblique joints.

Manufacture of cube specimens by impermeability test. Specimens are made as tightly as possible. The following is the process of working on the joints of box- shaped leather boards Prepare laminated boards that have been made with a length of 30 cm, width of 30 cm, and thickness of 2 cm. Figure 6 describes laminate manufacturing. Then prepare a box-shaped ST 40 Steel Plate with a size of 30x30x30 cm. Then on one side of the plate in the hole so that air can enter. Figure 7 describes one side of the plate that is already in the hole.

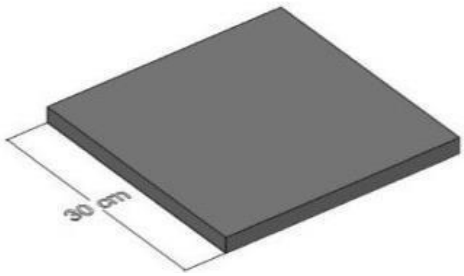

Figure 6. Laminated Board

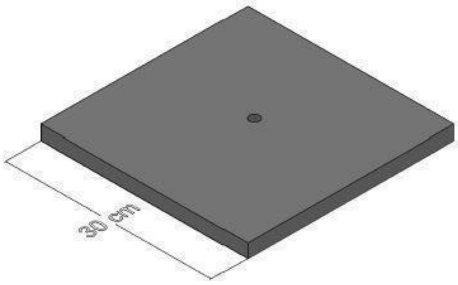

Figure 7. Laminated Plate in the Hole

Furthermore, the board is connected with variations of connections on the board. Figure 8 describes Butt Joints and Figure 9 describes Scarf Joints.

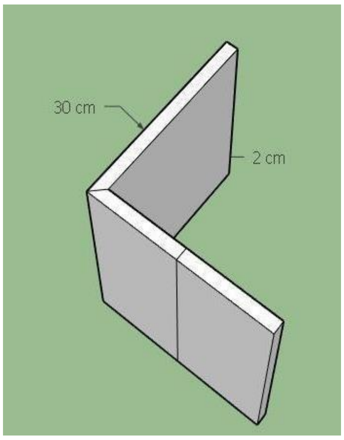

Figure 8. Butt Joint

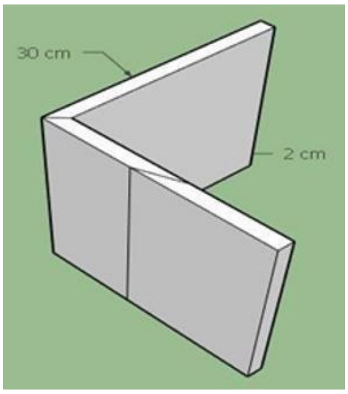

Figure 9. Scraft Joint

Next, the board is attached to the blank side of thesteel plate. In Figure 10 and Figure 11 it is a Butt Joint and in Figure 12 and Figure 13 is a Scarf Joint.

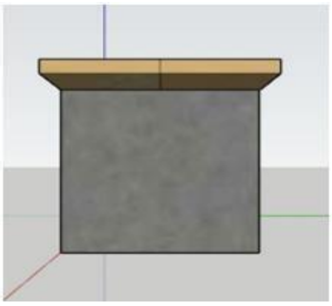

Figure 10. Butt Joint Side View

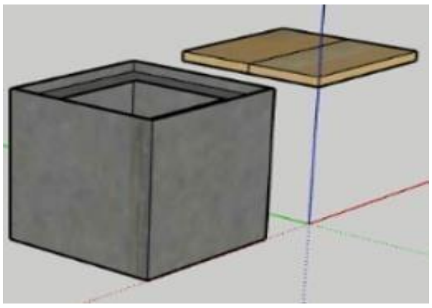

Figure 11. Butt Joint Top View

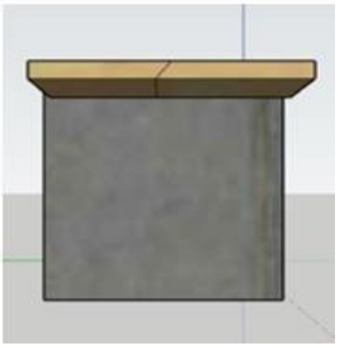

Figure 12. Scraft Joint Side View

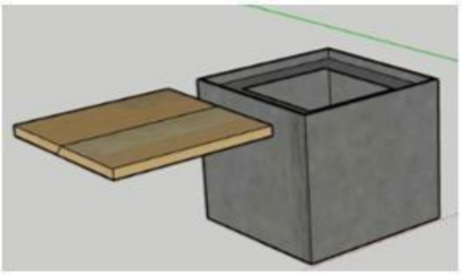

Figure 13. Scraft Joint Top View

E. Test Execution

Testing is carried out to determine the tightness between the joints through wind pressure testing. Angina pressure testing is performed on box-shaped bamboo specimens adapted to the original wooden vessel. The stages of test implementation are as follows:

1. First, the test specimen is inserted with fresh water asmuch as 4/5 of the size of the steel box.
2. The specimen is inserted into the towing tank to prove a leak in the board joint by the appearance of air bubbles from inside the specimen.
3. Test specimens that have been filled with water are air infused with a compressor device.
4. Recording is done by observing the maximum pressure on the barometer against the test board system that is damaged or emits air bubble.
5. The location where the damage occurred will be marked.
6. Tests are carried out on each box.

Figure. 14. Box of 4/5 Water

Figure. 15. Specimens Inserted into Towing Tank

Figure. 16. Process Specimen Inserted Air

Figure. 17. The Presence of Air Waves Out of the Specimen

F. Result

The results of specimen testing using the Air Pressure Test method, Table 1 and figure 18 explain the impermeability value of the Air Pressure Test variation of the Upright Joint.

TABLE 1.
RESULT OF BUTT JOINT TESTING WITH AIR PRESSURE TEST METHOD

No	Butt Joint	Maximum Pressure (MPa)	Demaged Specimens
1.	I	0,966	√
2.	II	0,951	√
3.	III	0,956	√

√ : Specimens demaged at joints

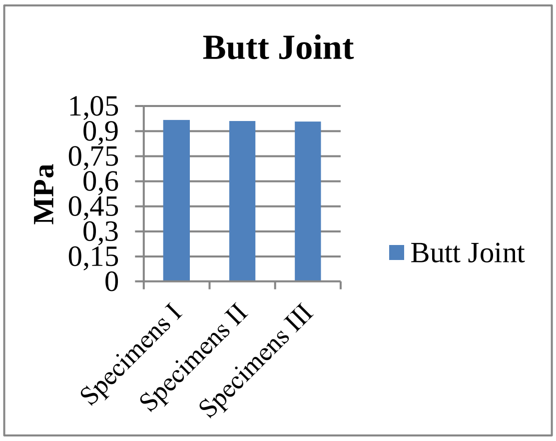

Figure. 18. Graph of Butt Joint Test Result

From Table 1 and Figure. 18 get data, for test specimen I the maximum pressure is 0.966 MPa if used as PSi gets a value of 140.2 lbf / in2 and test specimen II maximum pressure 0.961 MPa if used as PSi gets a value of 139.4 lbf / in2 and test specimen III maximum pressure 0.956 if used as PSi gets a value of 138.7 lbf / in2 . The average in the upright joint test has a value of 0.961 MPa.

Standard Deviation:

$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}} \tag{2}$$

S = Standard Deviation
x_i = 1st data value
x = Average Value of Data
n = Amount of Data

$$S = \sqrt{\frac{(0{,}966 - 0{,}961)^2}{3}}$$

$$S = 0{,}0028$$

TABLE 2.
RESULT OF SCARF JOINT TESTING WITH AIR PRESSURE TEST METHOD

No	Scarf Joint	Maximum Pressure (MPa)	Demaged Specimens
1.	I	0,858	√
2.	II	0,853	√
3.	III	0,845	√

√ : Specimens demaged at joints

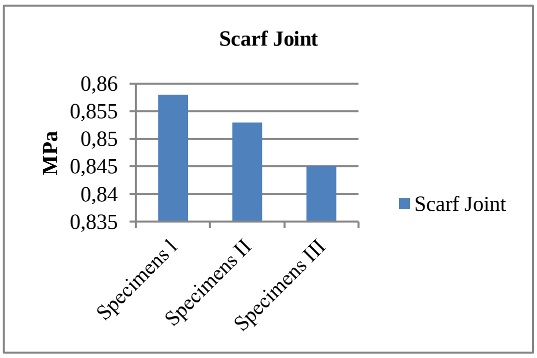

Figure. 19. Graph of Scraft Joint Test Result

From Table 2 and Figure. 19 get data, for test specimen I the maximum pressure of 0.858 MPa if used as PSi gets a value of 124.4 lbf / in2 and test specimen II the maximum pressure is 0.85 MPa if used as PSi gets a value of 123.8 lbf/in2 and test specimen III the maximum pressure is 0.845 MPa if made into PSi gets a value of 122.6 lbf / in2. The average in the tilted joint test has a value of 0.852 MPa.

Standard Deviation:

$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n}}$$

S = Standard Deviation
x_i = 1st data value
x = Average Value of Data
n = Amount of Data

$$S = \sqrt{\frac{(0{,}858 - 0{,}852)^2}{3}}$$

$$S = 0{,}006$$

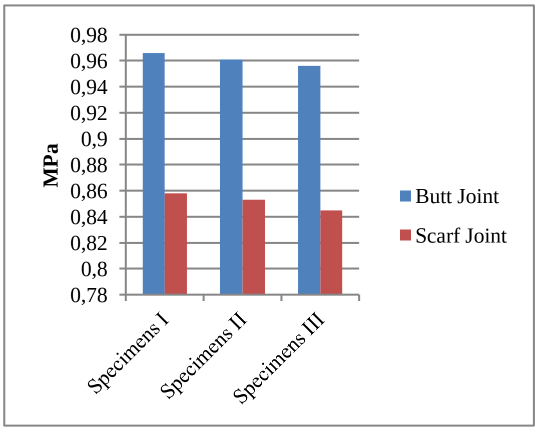

Figure. 20. Graph Comparison of Butt Joint and Scraft Joint

The result of the average ratio of upright and tilted joints is 10.9%:

1. The surface area of the Butt Joint is 103.2 cm² andthe force is 9.91752 KN.
2. The surface area of the Beveled joint is 115.4 cm²and the force is 9.83208 KN.

Comparison of Upright and Oblique Joint Specimens:

a. Butt Joint

$$\frac{Average}{Surface\ area} = \frac{0{,}961\ Mpa}{103{,}2} = 0{,}009\ Mpa/\ cm^2 \quad (3)$$

b. Scraft Joint

$$\frac{Average}{Surface\ area} = \frac{0{,}852\ Mpa}{115{,}4} = 0{,}007\ Mpa/cm^2 \quad (4)$$

Based on the results of tests that have been carried out using the air pressure test method with a pressure of 0.2 psi, it can be seen that the butt joint has a stronger strength than the scabf joint, this is seen from the results of the variation pressure test value on 2 joints, namely the Butt Joint gets a value of 0.966 MPa, 0.96 MPa and 0.956MPa while for the Scraft Joint it gets a value of 0.858 MPa, 0.85 MPa, and 0.845 MPa from the results that have been obtained it can be concluded that the Butt Joint is the strongest connection, even in previous studies that used tests of tensile strength, bending strength and compressive strength explained that upright joints are stronger than oblique joints. Bamboo laminate also has good resistance so there is a possibility that it can be used as a shipbuilding material as a substitute for wood.

IV. Conclusion

In testing 4 specimens with 2 types of joints using the Air Pressure Test test method, it can be concluded to:

1. The variation of the oblique joint is weaker than the upright joint because the inclined joint is not able to accept the greater compressive force than the upright joint.
2. The variation of the oblique joint in the Air Pressure Test test for test specimen I gets a value of 0.858 MPa and test specimen II gets a value of 0.853 MPa and test specimen III gets a value of 0.845 MPa.
3. The Butt Joint variation in the Air Pressure Test test for specimen I gets a value of 0.966 MPa, test specimen II gets a value of 0.961 MPa , and test specimen III gets a value of 0.956 MPa.
4. The relationship between the surface area of the joint and the impermeability is that if the surface area is larger than the impermeability strength is stronger and if the surface area is small then the impermeability strength is weaker.

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