Development of Bamboo Materials for Body Speed Boat Application

Andi Lamappasessu(✉), Dwi Rahmalina

Department of Mechanical Engineering, Faculty of Engineering, Universitas Pancasila, Jakarta, Indonesia
mappasessu1@gmail.com

Abstract. The research of natural fibers in various engineering fields is currently developing, because of its availability, easy to process according to its designation, low-cost, good mechanical and physical properties and is friendly to the environment. The use of bamboo (bamboo strip reinforced/BSR) material with a laminate system, for the manufacture of speed boats is a promising alternative material. The bamboo used is the Andong Bamboo (Gigantochloa pseudoarundinacea) for the manufacture of its skin, the bamboo material is widely available in Indonesia. To ensure that the bamboo material used can meet the requirements of mechanical properties as a material for making Speed Boats with Hand Lay Up Laminate system and a Composite system, an analysis is carried out on the results of testing tensile strength, bending strength, modulus of elasticity and specific gravity of the materials. There are Fibreglass Reinforced Polymer (FRP), Fibre Bamboo Reinforced Polymer (FBR), Bamboo Strip Reinforced for Outer Part (BSR;OP), and Bamboo Strip Reinforced for Middle Part (BSR;MP). The next step is to compare the results of the tensile strength, bending strength, modulus of elasticity and specific gravity of the bamboo raw material to the Fiberglass Reinforced Polymer (FRP) composite material. As the standards used for tensile, bending, elastic modulus and material density tests are the Rules for Fiberglass Reinforced Plastic Ship 2016 and the BKI Regulation, the 2016 Regulations for Classification and Construction of Wooden Ships set by the Indonesian Classification Bureau for Speed Boat building materials, ISO 527-4 and ISO 14125. From the test results, the type of material that has the best mechanical characteristics will be selected to be used as an alternative raw material for shipbuilding/speed boat, will be a source of information for the preparation of rules related to shipbuilding/speed boot from bamboo material. The use of bamboo material as a material for making ships/speed boats will make the body lighter and increase load capacity, reduce or even eliminate the use of Fiberglass Reinforced Polymer (FRP) material which is the cause of pollutant in waters: rivers, lakes and seas.

Keywords: Bamboo, Composite, Body Speed Boat.

1 Introduction

Research on bamboo materials for the construction of land buildings has been carried out, while research on strip type bamboo materials for ship/speedboat bodies has not been carried out. Bamboo material is lighter, easier to obtain, easy to process, meets

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both mechanical and physical requirements and is friendly to the environment. Bamboo material will be used as a substitute for fiberglass material currently widely used on the body of the ship / speedboat and is a source of pollution in rivers, lakes and seas.

In this research, a test piece of bamboo strips and Fiberglass Reinforced Polymer (FRP) strips will be tested to determine the better mechanical properties of bamboo strips. Fig. 1. Speed Boats and Yatch from Fiberglass Reinforced Polymer (FRP) material.

Fig. 1. Speed Boats and Yatch

Glass Reinforced Plastic (GRP) is the most common component of marine vessels (Yatch, Speed Boat, Jet Sky, Ring Buoy, etc). The implication is that GRP aging in the marine environment is a source for the release of micro (<5 mm) and macro plastics, plus fragmented asbestiform-like silicate fibers which are pollutants in sea, river and lake waters.

2 Methods

2.1 Material

The Future Wood is a term for bamboo as a natural raw material for the manufacture of a variety of creative and innovative products that are friendly to the environment. Bamboo can be used as a raw material for making speed boats using a lamination, hand lay up or composite system. The type of bamboo that is suitable to be used as a basic material is Andong bamboo (Gigantochloa Pseudoarundinacea) through a manufacturing process to be made into the construction of body reinforcement & body skin for speed boats (shell expansion).

Based on the tensile and flexural strength tests, Ori bamboo has a tensile strength of 185.55 MPa and a flexural strength of 86.92 MPa. Meanwhile, Betung bamboo has a tensile strength of 149.75 MPa and a flexural strength of 74.82 MPa. These results indicate that the two types of bamboo have superior strength over teak and are very likely to be used as a material for making ships. Research by Prof. Heri Supomo the Surabaya Sepuluh Nopember Institute of Technology (ITS), found that Ori bamboo and Betung bamboo could be further utilized for ship construction.

2.2 Preparation for Material Testing

Testing the mechanical properties of bamboo raw material for the manufacture of speed boats/ships uses the ISO 22157-1:2004 standard (E.Bamboo Determination of physical and mechanical properties part I. Requirements) and ISO/TR 22157-2:2004 (E.Bamboo Determination of physical and mechanical properties part II. Laboratory Manual) published by BSN (2007). The test was carried out on samples (test pieces) with air-dry conditions using a testing machine (Universal Testing Machine UTM) (see Fig.2).

Testing the mechanical properties of fiberglass raw materials uses the standard ISO 527-4 Second Edition 2021-12 Plastics-Determination of Tensile Properties Part 4: Test Conditions for Isotropic and Orthotropic Fiber Reinforced Plastics Composites.

Fig. 2. Make of Test Piece's

3 Result

The result of tensile test, bending test, modulus of elasticity and density:

1. Fiberglass Reinforced Polymer (FRP).
2. Bamboo Fiber Reinforced Polymer (FBP).
3. Bamboo Strip Reinforced (BSR); Middle Part.
4. Bamboo Strip Reinforced (BSR) Outer Part.

3.1 Result of Tensile Strength (TS): FRP, FBR, BSR (Middle Part) & BSR (Outer Part)

From the tensile tests carried out in Table 1 about FRP, FBP, BSR (Middle Part), BSR (Outer Part) the greatest value was obtained for BSR (Middle Part): 178.170 N/mm^2 used for the inner layer of the speedboat body while BSR (Outer Part): 208.770 N/mm^2 is used for the outer layer of the speedboat body.

Table 1. Tensile Strength, Elastic Modulus: Bamboo & Fiberglass

Sample Code	Fiberglass Reinforced Polymer (FRP) TS: Average	Fiber Bamboo Reinforced Polymer (FBR) TS: Average	Bamboo Strip Reinforced (BSR) Middle Part TS: Average	Bamboo Strip Reinforced (BSR) Outer Part TS: Average	Remark's
Width (mm)	25,210	10,053	18,938	19,577	Accept
Thick (mm)	4,077	7,100	4,003	4,003	Accept
Section Area (mm^2)	102,770	71,377	79,293	78,359	Accept
Maximum Load (N)	14.214.667	698,087	12.792,0	16.356,3	Accept
Tensile Strength (N/mm^2)	138,303	9,970	178,170	208,770	Accept
Tensile Strength (N/mm^2)	4.876,1	1.509,473	15.477,933	10.579,3	Accept

3.2 Chart of Tensile Strength: FRP, FBR, BSR (Middle Part) & BSR (Outer Part)

From Fig. 3. The Tensile Strength Comparison Graph obtained the greatest value for the type of Bamboo Strip Reinforced (BSR) outer part with an average value at maximum load : 14214.667 Newton; Average cross-sectional area: 78.359 mm^2.

$$\sigma = F/A : 16,356,333 / 78,359 = 208.770 \text{ N/mm}^2$$

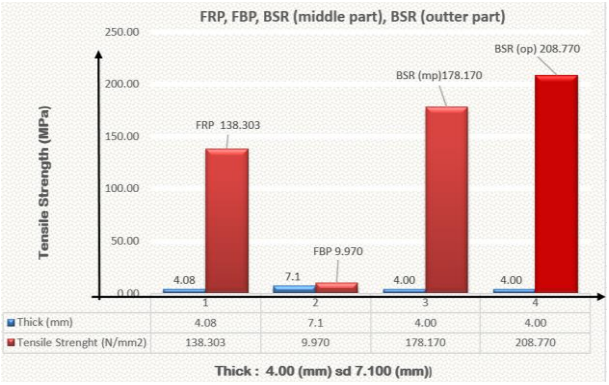

Fig. 3. Chart Tensile Strength: Bamboo & Fiberglass

3.3 Result of Bend Test (BT): FRP, FBR, BSR (Middle Part) & BSR (Outer Part)

Table 2. Bend Test, Elastic Modulus: Bamboo & Fiberglass

Sample Code	Fiberglass Reinforced Polymer (FRP) BT: average	Fiber Bamboo Reinforced Polymer (FBR) BT: average	Bamboo Strip Reinforced (BSR) Middle Part BT: average	Bamboo Strip Reinforced (BSR) Outer Part BT: average	Remark's
Width (mm)	14,987	15,430	14,807	14,827	Accept
Thick (mm)	4,077	7,193	4,099	5,120	Accept
Section Area (mm^2)	61,097	111,000	60,693	75,857	Accept
Span (mm)	65,227	115,093	65,857	82,020	Accept
Maximum Load (N)	310,107	129,393	321,953	245,900	Accept
Bending Stress (N/mm^2)	121,880	27,944	125,573	77,720	Accept
Elastic Modulus (N/mm^2)	4.494,400	1.576,933	13.638,6	5.304,6	Accept

3.4 Chart of Bend Test: FRP, FBR, BSR (Middle Part) & BSR (Outer Part).

From Fig 4. The buckling strength comparison graph obtained the largest value for the type of Bamboo Strip Reinforced (BSR) Middle part with an average value at maximum load = 321.953 Newton with an average cross-sectional area = 60.693 mm^2. The bending strength value was obtained = 125.573 N/mm^2 from the data processing of the Tensilon RTF tensile machine program – 2410.

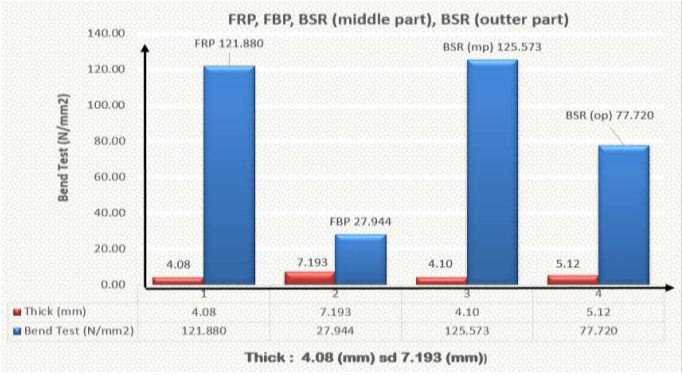

Fig. 4. Chart Bend Test : Bamboo & Fiberglass

3.5 Density

The density of the material used is the smallest density. This is intended so that the material can float in the waters so that it can be used as a temporary buoy in the event of an accident and increase the load capacity of the speed boat.

Bamboo Strip Reinforced (BSR) Middle Part				
Size	**T 1**	**T 2**	**T 3**	**Mass/Volume**
Long (mm)	0.08122000	0.08554000	0.08235000	0.08304
Widht (mm)	0.01490000	0.01520000	0.01502000	0.01504
Thick (mm)	0.00410000	0.00445000	0.00425000	0.00427
Mass (Gram)	0.00000410	0.00000395	0.00000405	0.00000403
			Density (Ton/m3)	**0.757**
Bamboo Strip Reinforced (BSR) Outer Part				
Size	**T 1**	**T 2**	**T 3**	**Mass/Volume**
Long (mm)	0.08595	0.08538	0.08555	0.08563
Widht (mm)	0.01523	0.01470	0.01495	0.01496
Thick (mm)	0.00515	0.00553	0.00527	0.00532
Mass (Gram)	0.0000054	0.0000055	0.0000053	0.00000537
			Density (Ton/m3)	**0.788**
Fibre Bamboo Polymer (FBP)				
Size	**T 1**	**T 2**	**T 3**	**Mass/Volume**
Long (mm)	0.26000	0.26000	0.26000	0.26000
Widht (mm)	0.01500	0.01500	0.01500	0.01500
Thick (mm)	0.00750	0.00715	0.00720	0.00728
Mass (Gram)	0.0000341	0.0000373	0.0000348	0.00003540
			Density (Ton/m3)	**1.246**
Fibreglass Reinforced Polymer (FRP)				
Size	**T 1**	**T 2**	**T 3**	**Mass/Volume**
Long (mm)	0.26300	0.25800	0.26000	0.26033
Widht (mm)	0.01430	0.01520	0.01540	0.01497
Thick (mm)	0.00750	0.00715	0.00720	0.00728
Mass (Gram)	0.0000563	0.0000483	0.0000529	0.00005247
			Density (Ton/m3)	**1.849**

Fig. 5. Density: Bamboo & Fiberglass

4 Conclusion

From the results of tensile tests carried out on Bamboo material compared to Fiberglass Reinforced Polymer (FRP) material, Bamboo can be used for Speedboat body material because it is lighter, stronger and environmentally friendly when compared to Fiberglass Reinforced Polymer (FRP). The manufacture of speed boat body can be done using raw materials Bamboo Strip Reinforced (BSR) Outer Part; for the outer layer of the speed boat body:

1. Material: Andong Bamboo (Gigantochloa pseudoarundinacea),
2. Tensile Strength (average) : 208.770 (N/mm^2),
3. Bending Strength (average) : 77.720 (N/mm^2)

4. Modulus of elasticity to tensile strength : 10,579.333 (N/mm^2),
5. Modulus of Elasticity to bending strength : 5,304,600 (N/mm^2)
6. Shape : Bamboo Strip Reinforced (BSR) Outter Part.

The use of bamboo strip reinforced (BSR) middle part layer in the speed boat body:

1. Material : Andong Bamboo (Gigantochloa pseudoarundinacea),
2. Tensile Strength (average) : 178.170 (N/mm^2),
3. Bending Strength (average) : 125.573 (N/mm^2),
4. Modulus of elasticity to tensile strength : 15,477.933 (N/mm^2),
5. Modulus of elasticity to bending strength : 13,638.633 (N/mm^2),
6. Shape : Bamboo Strip Reinforced (BSP).

The density of the material used is the smallest density of 0.757 ton/m3. The combination of the middle part Bamboo Strip Reinforced (BSR) and the outer part Bamboo Strip Reinforced (BSR). This is intended so that the material can float in the waters so that it can be used as a temporary buoy in the event of an accident and increase the load capacity of the speed boat

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