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The Resistance of Mechanical Properties of *Katinting* Boat Material toward Environment

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Abstract Generally the main need for traditional fisherman is a boat. Besides, it is used as a means of transportation, it is also used as a means to obtain fish. Currently fisherman's boat is especially made of Fiber Composites or Polyester Composite material which is made of fiber as the reinforcement and polyester as the matrix known publicly as glass fiber by people. The communities of Barang Ca'di Island employed composite materials instead of wood for building/making a boat which make them get great appreciation even they (fishermen) just commonly make *Katinting* boat. However, the problem faced was that they did not know the durability and sustainability of mechanical properties toward the environment effects. The research method was done in two phases, firstly direct test and secondly the materials stored in salt water, in the open and closed areas during one year later then tested. This research aims to determine the resistance (durability or sustainability) of the mechanical properties and the observation of microstructure materials *Katinting* boat made of fiber glass toward environment effects. The results of the first phase showed mechanical properties; Tensile Strength 23.97 N/mm^2, MOE 223.375 N/mm^2, Compressive Strength 23.78 N/mm^2, Flexural Strength 5.49 N/mm^2, MOR 228.80 N/mm^2 and microstructure observation showed imperfect bond of fiber and resin as well as the pores appeared that resulted the reduction of the strength of the material. The results of the second phase showed that the mechanical properties of materials stored in brine; Tensile Strength 23.90 N/mm^2, MOE 220.274 N/mm^2, Compressive Strength 21.20 N/mm^2, Flexural Strength 4.21 N/mm^2, MOR 224.85 N/mm^2. Then those were stored in the closed area, Tensile Strength 23,60 N/mm^2, MOE 221.150 N/mm^2, Compressive Strength 23.15 N/mm^2, 5.44 Flexural Strength N/mm^2, MOR 221.75 N/mm^2. And those were stored in the open area; Tensile Strength 20.20 N/mm^2, MOE 201.125 N/mm^2, Compressive Strength 20, 67 N/mm^2, Flexural Strength 3.22 N/mm^2, MOR 198.95 N/mm^2. Based on the test data, it can be concluded that the open environment at the certain times greatly affected the mechanical properties of boat materials.

Keywords Composite boat, Environment, Mechanical properties

1. Introduction

The need for traditional fisherman is generally boat, not only as a means of transportation but also as a means of getting fish. Generally, boat is made of wood, but day by day craftsmen wood get difficulty to obtain suitable wood to make boat.

Currently, boat of fisherman particularly *Katinting* boat widely used is made from Polyester or Fiber Composites in which the material is made of fiber as reinforcement and matrix material using polyester commonly known as glass fiber by people. With the rapid development of technology today, materials which have better performance are badly needed to replace wood. The criteria of the materials must be lightweight, highly strong, h and low production costs.

Composite is one of the materials that has a strength comparison and weight stiffness, the cheap cost of production. Besides, the composite can be fabricated directly to become final shape with a bit of machining, so scrap produced fewer than metal fabrication. The way taken by the people of Barang Ca'di island e using composite materials instead of wood for boat building is greatly appreciated even generally they are fishermen, and the boats made are *Katinting*. Barang Ca'di island is one of a cluster of islands around Makassar which is occupied approximately 300 family head and generally work as fishermen. Barang Ca'di island can be reached about 1 hour by boat from the port of Makassar. The breakthrough conducted by Barang Ca'di people and the new discoveries keeping appearing are in line with the increase of demand for certain material properties. It surely increases the repertory of the types, natures and the characteristics of the composite at this time.

The breakthroughs not only involve engineering of the existing material, but also open phenomena in the nature which apparently gives something unforeseen, such as the presence of natural composite or biocomposite. The Structure of materials is natural. Although it is composed of

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a substance occured at low temperatures, there are times when providing the mechanical properties with high toughness. One of the composites based on reinforcement is fiber composites in which the reinforcement shapes fiber. It is as the reinforcement element which highly determines the mechanical properties from the composite in which the reinforcement as the successor to the load distributed by the matrix. The strength of composites is influenced by many factors, included the form of fiber, the direction of fiber, the process of making and the amount of fiber often expressed in fiber volume fraction.

Composites made by the people of Barang Ca'di island for boat materials are fiber composites in which the reinforcement shapes fiber through the wet lamination method. The numbers of boats made in Barang Ca'di island of each group of craftsmen are average 3-4 units every month, but the difficulties are faced by the craftsmen if the consumers ask about the quality/ specification of the boat made, so the research is badly needed to determine mechanical specifications or mechanical properties of the boat *Katinting*, namely tensile strength, flexural strength, and compressive strength,. In addition, physical properties, namely: weight type, elastic modulus, and durability of the materials toward environment effects such as place it in salty water, enclosed area, and opened area to be used as the basis for improving the future products by implementing the technology of composites manufacturing to produce qualified and certainly increasing the sale value of the boat so that the development community in the welfare field will increase.

2. Methodology

The method used is the experimental method to make composites with wet lamination method which is in line with the ways to make the boat materials in home industry in Barang Ca'di island, then to perform tests on the composites. The tests conducted were weight type test, tensile test based on ASTM D-638, compression test based on ASTM D-790, flexural test based on ASTM-793 and microstructure observations using Scanning Electron Microscope (SEM). Test material was made directly by boat craftsmen in the island Barang Ca”di with the following processes: firstly, fiber roving and fiber mat and resin that had been mixed with a catalyst were prepared. Then fiber sheet was united with resin by placing the first sheet (1) on the mold and then it was smeared with the mixture of resin and catalyst by using a brush and then placed the second sheet (2) then resin and catalyst were smeared again on it, and then the third sheet (3) was placed on its top to form lamination sheet with a three-layer sheets. After that the lamination sheet was set aside in room temperature until the resin was frozen as a whole, and then cut the materials for the sample test in accordance with the standard for testing specific of weight type, tensile, flexural, compressive, and microstructure observation.



Figure 1. Composite Sheet Production Process



Figure 2. Sample Test

The implementation of test took two phases. Firstly, the material was tested directly, and secondly the test material was placed in particular places, in salty water, in the closed area, in the open areas. Mechanical properties test was carried out at the BLKI Makassar laboratory while microstructure observation was conducted at SEM Department of Metallurgy and Materials, Faculty of Engineering, University of Indonesia. The observation made at the SEM was the condition of the bond between fiber and resin.

3. Results and Discussion

3.1. The First Stage Test (Direct Testing)

Based on data analysis, the result of Tensile Strength was 23,97 N/mm^2, MOE 223,37 N/mm^2, Compressive Strength was 23,78 N/mm^2, and Flexural Strength was 5,49 N/mm^2 and MOR 228,80 N/mm^2.

3.2. The Second Stage Test (Environment Effect)

In Brine (Salt Water) Environment, based on data analysis, the result of Tensile Strength was 23,90 N/mm^2, MOE 220,274 N/mm^2, Compressive Strength was 21,20 N/mm^2, and Flexural Strength was 4,21 N/mm^2 and MOR 224,85 N/mm^2 of the materials posted in brine (in salt water).

In Closed Area Environment, based on data analysis, the result of Tensile Strength was 23,60 N/mm^2, MOE 221,150 N/mm^2, Compressive Strength was 23,15 N/mm^2, and Flexural Strength was 5,44 N/mm^2 and MOR 221,75 N/mm^2 of the materials posted on the closed area.

In Open Area Environment, based on data analysis, the result of Tensile Strength was 20,20 N/mm^2, MOE 201,125 N/mm^2, Compressive Strength was 20,67 N/mm^2, and Flexural Strength was 3,22 N/mm^2 and MOR 198,95 N/mm^2, of the material placed on an open area.

3.3. The Result of Microstructure Observation

The result of SEM observation shows the bond among the reinforcement with matrix (polyester), cracks, pores in the interfacial region. The observation can be seen in Figure 3; 4; 5 and 6.

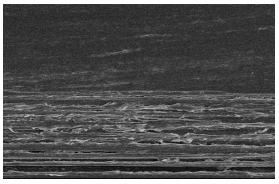


Figure 3. The Form of bond between fiber and e resin without any weaknesses

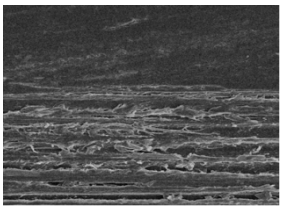


Figure 4. The imperfect form of the bond between resin and fiber

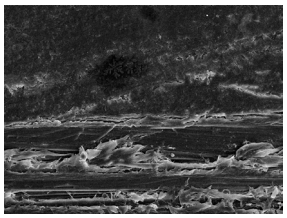


Figure 5. The form of cracks and pores in the bond of fiber and resin

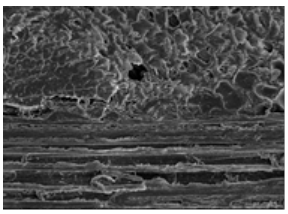


Figure 6. The form of the pores in resin

3.4. Discussions

3.4.1. Characteristics

Based on the data analysis and the results obtained from the direct test can be shown in Table 1. It can be said that the characteristics of mechanical properties of the boat material are the value of the tensile strength of 23.97 N/mm^2. It indicates that the composites made by craftsmen were able to accept the imposition of tensile and compressive strength values of 23.78 N/mm^2. It was also quite high so it is not matter to make *Katinting* boat from composite materials, which have very small strain and highly elastic modulus. This material was suitable for boat requiring great strength with very small strains and high stiffness, but the flexural strength value shows 5.49 N/mm^2 which is very small so during using e composite boat, curved burden and hard crash are not allowed because of making boat easily broken.

3.4.2. Environment Effect

Based on the data analysis and the result of the second phase of test about the existence of environment effect showed that the mechanical properties of materials stored in brine (salt water), Tensile Strength was 23.90 N/mm^2, MOE 220.274 N/mm^2, Compressive Strength was 21.20 N/mm^2, Flexural Strength was 4.21 N/mm^2, MOR 224.85 N/mm^2. In a closed area, Tensile Strength was 23,60 N/mm^2, MOE 221.150 N/mm^2, Compressive Strength was 23.15 N/mm^2, Flexural Strength was 5.44 N/mm^2, MOR 221.75 N/mm^2. And in open area Tensile Strength was 20.20 N/mm^2, MOE 201.125 N/mm^2, Compressive Strength was 20.67 N/mm^2, Flexural Strength was 3.22 N/mm^2, MOR 198.95 N/mm^2. Based on the test data, it can be concluded that the open environment at a certain times greatly affects the mechanical properties of boat material.

3.4.3. Micro Structure

The production of materials tested using hand lay-up method also allows the occurrence of defects because at the time a lot of air bubbles appeared during manual rolling. The defects were caused by air cavities resulting incomplete wetting of the fiber. This caused the reduction of mechanical strength. High cavity was able to decrease strength and to increase variations in mechanical properties. This occured because of stress concentration which could initiate the delamination at the fiber surface. The pores and cracks occurred can be seen in Figure 5 and 6.Those can occur during the process of merger between the polymer-based materials in the liquid phase and the reinforcing material based organic material, allowing the bond to the radical.

The phenomenon of bond mechanism between matrix material surface and reinforcement can occur due to the interaction of valence radical or interlocking among surfaces. The microstructure observation as Figure 1 in the interfacial area between the matrix and reinforcement identifed wettability between matrix and reinforcement so that the presence of pores and cracks will lead to lower mechanical power.

Table 1. Summary of Mechanical Properties of Environmental Conditions

Conditions	Tensile Strength (N/mm^2)	MOE (N/mm^2)	Compressive Strength (N/mm^2)	Flexural Strength (N/mm^2)	MOR (N/mm^2)
Direct Test	23,97	223,37	23,78	5,49	228,80
In Brine (Salt Water)	23,90	220,274	21,20	4,21	224,85
Closed Area	23,60	221,150	23,15	5,44	221,75
Opened Area	20,20	201,125	20,67	3,22	198,95

4. Conclusions

Based on the results of research on mechanical properties of materials of *Katinting* boat, then it is concluded as follows:

1. The results of the first phase of test or direct test showed the following mechanical properties, Tensile Strength 23.97 N/mm^2, MOE 223.375 N/mm^2, Compressive Strength 23.78 N/mm^2, Flexural Strength 5.49 N/mm^2, MOR 228, 80 N/mm^2.
2. The results of the second phase of test toward environment effects indicated that the mechanical properties of materials stored in brine, Tensile Strength 23.90 N/mm^2, MOE 220.274 N/mm^2, Compressive Strength 21.20 N/mm^2, Flexural Strength 4,21 N/mm^2, MOR 224.85 N/mm^2. Those were stored in the closed area, Tensile Strength 23.60 N/mm^2, MOE 221.150 N/mm^2, Compressive Strength 23.15 N/mm^2, Flexural Strength 5.44 N/mm^2, MOR 221.75 N/mm^2. And those were stored in the open areas, Tensile Strength 20.20 N/mm^2, MOE 201.125 N/mm^2, Compressive Strength 20.67 N/mm^2, Flexural Strength 3.22 N/mm^2, MOR 198.95 N/mm^2.
3. The open environment effect of at the certain times greatly affected the mechanical properties of boat materials.
4. The flexural strength showed low enough value, so that it can be stated that this composite material cannot receive shock loads or impact.
5. Microstructure observation showed the bond of imperfect fiber and resin and the presence of pores resulting the decrease of in the mechanical strength of the material.

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