

Design and Production of FRP Catamaran Boat for Better River Transportation in Randuboto Village, Sedayu District, Gresik Regency

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Abstract: Gresik is one of the regencies in East Java which has become one of the important port cities of the archipelago in the past, many of them use the river as a logistics route, At present, the crossing boat in Randuboto Village have several limitations, namely safety issues, stability issues and wooden boat construction which have some disadvantages. Catamaran boats have several advantages compared to single-hull boat like better cross-stability, smaller resistance in the same Breadth. Limited wood supply causes the price of wood to soar and difficult to obtain. The production of wooden boat is difficult to get raw materials so that the wooden boatyard are not well developed. Alternative materials that can be used for shipbuilding are fiberglass. Fiberglass material has several advantages including lightweight, easy to form and cheap. The methods of this research is conducting a survey to existing wooden boat to get the main dimension of the boat. Secondly, do the design process like design of linesplan, general arrangement and construction calculation. The result of this research is catamaran boat that have main dimension $L = 12$ meters, $B = 3,1$ Meters $T = 0,5$ meters $H = 1,2$ meters. Currently, boatbuilding process is still being carried out.

1 INTRODUCTION

Gresik Regency is a district in East Java Province, Indonesia. Gresik Regency has an area of 1,191.25 km². The territory of Gresik Regency also includes Bawean Island, which is 150 km off the coast of the Java Sea. Gresik Regency borders Surabaya City and Madura Strait in the east, Lamongan Regency in the west, Java Sea in the north, Sidoarjo and Mojokerto Regencies in the south. Gresik is a downstream area of Bengawan Solo River, and several other rivers such as Kalimas and Kali Lamong, so the use of wooden boat transportation to cross from one area to another (Muhatta and Soesanti, 2018).

The availability of wood in Indonesia as raw material for boat is increasingly difficult to obtain, because woods are shrinking every year. With these conditions, the price of wood will be increasingly expensive, causing the production costs of building wooden boat increase. If this continues, the people's shipyard in Indonesia can no longer meet the needs of traditional boatbuilding because the capital used is

getting bigger. Therefore, alternative materials for wood replacement are needed.

Lack of wood material is relatively expensive, requires regular maintenance. As the age of the boat increases, the aspect of boat maintenance costs increases. The age of the vessel increases, it will affect to cost of exploitation and maintaining the boat.

Thus the maintenance of wooden boat is one of the problems of traditional fishermen. Maintenance of wooden boat hull is carried out every 6 months, more often than fiberglass boats, which is once every 1.5 years. Although the cost is more expensive, fiberglass boat maintenance results is better and reduce the frequency of treatment. The reduced frequency of this treatment can lead to lower initial costs being spent.

The advantages of boat built from FRP are no leaking in the hull with continuous piece of FRP with no gap to allow water into hull. FRP does not shrink or swell so leakage and re-caulking are avoided. FRP is non-organic and will not rot. As a plastic it cannot be eaten by marine borers. FRP is inert, as a plastic it will not corrode (Anmarkrud, 2009).

The advantage of catamaran is that for the same displacement the catamaran hull has been proven to produce 20% less resistance compared to monohull vessels. In addition, the broad deck allows for more cargo transport (Coackley, 1991).

In this paper, the process of design and production of FRP catamaran boat for river crossings in Gresik. Boat design has the advantage of being safer and more comfortable, better stability and can carry more loads.

2 METHOD

Generally, catamaran boat design and construction process uses spiral design method, with engineering design to get more optimal design.

A survey of existing vessels is carried out to determine the current condition of the ship. The survey method is to measure the dimensions of the ship so that the length, width and loaded of the ship are obtained. Another objective of surveying the condition of the boat is to know the aspect of safety, stability of the boat



Figure 1: Condition of Existing Wooden boat.

We can see in Figure 1, existing crossing river boat made of wood, have one hull of the boat (less stability) and no railings to protect passengers from the danger of being plunged into the river. and there are no lifejacket as important safety equipment for passengers. From the survey results, then we design safe crossing vessels, have good stability and consider passenger safety aspects (Watson, 1998). the results of the data obtained from the survey of the condition of the existing vessels are as follows:

Table 1: Data obtained from Existing boat.

Dimension		
Length	:	12 meters
Breadth	:	3 meters
Height	:	0,9 meters
Draft	:	0,49 meters
Speed	:	10 knots
No. Amount of Motorcycle	:	7
No. Amount of Passenger	:	10 persons
Engine capacity	:	P

2.1 Lines Plan

Lines plan is the initial design of the crossing river boat which consists of 3 main design namely body plan (front rear view), sheer plan (side view) and Half Breadth Plan (Ferry, 2013).

The lines plan design is based on the results of the survey on existing crossing vessels and incorporates other design parameters such as aspects of feasibility, safety and design parameters of catamaran vessels (Liu, 1998). The following figure is the linesplan design that has been made using CAD software.

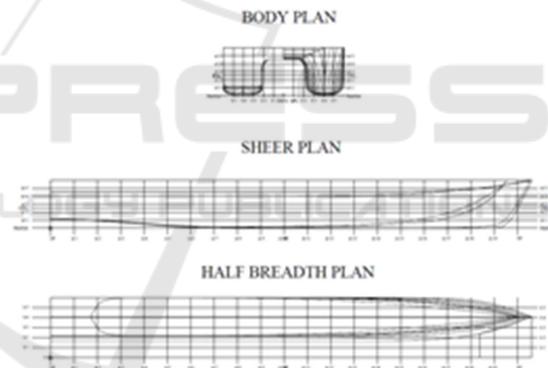


Figure 2: Lines plan of Catamaran Boat.

2.2 3D Conceptual Design

After the catamaran lines plan has been made, the next step is to create a 3D / conceptual design of the boat. The 3D design results from the catamaran ship crossing the Bengawan Solo river are as follows:

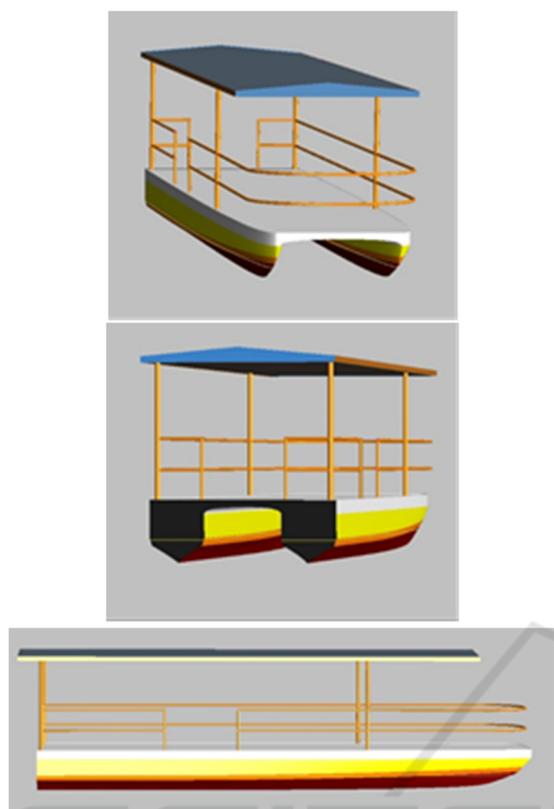


Figure 3: 3D Conceptual Design.

We can see in the figure 3 above, the catamaran boat conceptual design that has been made has several advantages: it has railing to protect passengers from danger of falling into the river, there is a roof that protects passengers from the sun's heat and rainy weather. Catamaran boats provide better stability than one hull boat. with the same width, catamaran boat have a smaller resistance compared to one hull boat.

2.3 FRP Construction Calculation

In building a ship, the applicable regulations in the area of the ship will be used. The purpose of using rules is to ensure that the construction of the ship that has been built meets the standards and seaworthy.

In Indonesia, rules that are commonly used are rules issued by the Bureau Indonesian Classification (BKI). Rules of the Indonesian Classification Bureau regarding fiberglass construction vessels include (Biro Klasifikasi Indonesia, 2015, 2016):

- Rules for FRP and Wooden Fishing Vessel up to 24 m, 2015 edition
- Rules for Fiberglass Reinforced Plastic Ships, 2016 edition
- Rules for Non-Metallic Materials, 2014 edition

In the BKI rules mentioned above, the required construction measures are specified, the strength standards of fiberglass materials and material testing standards

Under the rules of BKI Fiberglass Reinforced Plastic 2016, results from FRP testing which is composed of chopped strand mats and woven roving must not be less than what has been determined as follows (Biro Klasifikasi Indonesia, 2015, 2016):

1. Tensile Strength: 98 N / mm²
2. Modulus of Tensile Elasticity: 6.86 x 10³ N / mm²
3. Bending Strength: 150 N / mm²
4. Modulus of Bending Elasticity: 6.86 x 10³ N / mm²

The results of construction calculations carried out, obtained fiberglass laminate arrangement of catamaran boat. The laminate structure of FRP catamaran boat construction is as follows:

Table 2: Lamination Schedule of FRP Catamaran Boat.

No.	Construction of ship	FRP Laminate Arrangement
1	Bottom Plating	G+2M300+4M450+4WR800
2	Side Shell	G+2M300+2M450+3WR800
3	Deck Plating	4M450+Ply 9 mn
4	Frames	
	Transver frames	3M450+2WR800
	Side longitudinal	3M450+3WR800
	Center girder	3M450+2WR800
5	Deck Transverse	3M450+2WR800
	Deck Longitudinal	3M450+2WR800

3 FRP CATAMARAN BOAT BUILDING

After designing lines plan, general arrangement and calculation of boat construction, the next step is FRP catamaran boat building; . the steps in boat building of FRP catamaran boat are mold making, gel coating, hand lay up, Unplugging from molding, framing and stiffening section, and Finishing.

3.1 Mold Making

FRP boat molds are composed of wooden frames, 6 mm plywood and melamine plywood. Wooden frames are used to strengthen the mold, the body of the ship on the mold is formed using triplex and melamine plywood. Triplex joints on the mold are

caulked to flatten the surface of the mold in order to smooth the hull.



Figure 4: Mold making Process and mold result.

To produce this catamaran boat, only one mold is needed due to symmetrical catamaran hull. Ready mold need to clean and mash before lay-up, but not enough to just be cleaned and mashed. Repair any holes with appropriate filler. To repair a hole in corner of plywood, apply a fiberglass patch measured and cut to fit the hole and apply resin. For the best results, sand the surface of the mold.

3.2 Gel Coating

The mold surface is waxed as much as 5-7 times for new molds. The last process in making the mold is the provision of PVA (Polyvinyl Acrylate) membrane, this is so that the boat does not stick to the mold. The process of FRP boat lamination begins with the provision of Gelcoat layer (the outer layer as a protective hull) on the mold, this layer is given 2 times so that the resulting FRP catamaran boat is thicker in color.



Figure 5: Gel Coating Process.

3.3 Hand Lay Up

The next step after gelcoating is hand laying up, installation of the first layer with MAT 300 fiber material, so that the coating can attach well to the complicated parts of the ship (corners, etc.). The second layer is fiber MAT 450 material (thicker than

MAT 300), then we give WR 800 layer, the next layer uses MAT 450 and so on to the last layer according to the lamination schedule.



Figure 6: FRP Lamination Process.

The first coat is called seal coat, Using a roller to apply on the surface of boat and firm pressure and directional strokes to spread the resin as evenly as possible. Cut fiberglass cloth to the shape needed and attach the fiberglass cloth to the hull using tape, tacks or staples. The second coat is called the bond coat. Before this coat applied working from one end of the hull to the other, apply the bond coat over the fiberglass. Remove the material attach to fiberglass cloth to the boat before the bond coat sets up completely and repeat. The finish coat should be smooth and even, but should also be thick enough to allow sand the hull evenly without damaging the cloth. Give the final coat enough time to dry, preferably overnight.

Releasing is the FRP Hull release process, which has been finished laminated and in a curing condition, from the ship's mold.

3.4 Framing and Stiffening Sections

Frames serves as a reinforcement for the boat. Boat frame is made of a mixture between CSM and WR which is molded to "U" form profile. Fiberglass boat frame consists of several types of construction, including: Web Frame, Girder, Stiffener, Side Girder, Center Girder and Side Stringer.



Figure 7: Frame installation result.

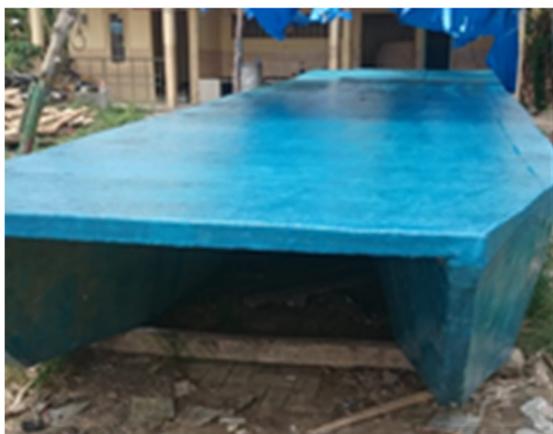


Figure 8: Catamaran Boat has been finished.

4 SUMMARY

This article analyzed design and production of catamaran boat using Fiberglass Reinforced Plastic as the material with crossing route in Bengawan solo river in Gresik. Technical analysis conducted with preliminary design. Using parent base design methods, the main dimensions of FRP Catamaran Boat as follows: L (length) = 12 [m] B (Width) = 3.1 [m] H (High) = 1.2 [m] T (Loaded) = 0.5 [m]. From the results of technical analysis obtained design of lines plan, general arrangement and boat construction of Catamaran boat made of fiberglass reinforced Plastic. catamaran boat conceptual design that has been made has several advantages: it has railing to protect passengers from danger of falling into the river, it has a roof that protects passengers from the sun's heat and rainy weather. Catamaran boats provide better stability than one hull boat. with the same width, catamaran boat have a smaller resistance compared to existing boat.

The Boatbuilding process of FRP Catamaran Boat has been carried out, consist of mold making process,

polishing, Gel coating, hand laying up, releasing and Finishing

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