Technical Analysis of PVC Pipe Materials for Hull Vessel

by Hartono Yudo

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Technical Analysis of PVC Pipe Materials for Hull Vessel

Wilma Amiruddin and Hartono Yudo
Naval Architecture Department, Diponegoro University, Indonesia

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Abstract: The use of PVC pipe material as a hull vessel can have a technical and economic influence when compared to a wooden ship. This study aims to determine the difference in the longitudinal strength of the ship from of both. It's based on the maximum stress produced by referring to the BKI Class for Wooden Ship Regulations. To see the technical benefits due to differences in the use of the material, treatment was given by setting the same loading capacity (17 GT) for both ships as the dependent variable and the main principles as the independent variable, PVC ship: Loa = 18.3 m, B = 4, 25 m, H = 0.75 m, T = 0.5 m and Wooden Ship: Loa = 15 m, B = 5.2 m, H = 1.8 m, T = 1 m. Analysis results is the maximum stress of PVC fishing boats (σ Deck = 9.714 N/mm2) have a greater than wooden fishing boat (σ Deck = 4.2817 N/mm2). The difference in strength values can be used as a consideration in deciding the use of PVC material or wood material.

1 INTRODUCTION

Bamboo rafts as early of the history of shipbuilding or ships in modern times are now used for certain conditions in the interior. Along with the development of technology, in this case pipes made of PVC (polyvinyl chloride) plastic have made PVC pipe ships in Taiwan with the same principles as bamboo rafts. The length of the ship ranges from 30-40 feet. The ship is used by fishermen to catch fish, with diesel engine drives. Figure 1 shows examples of the shape of the pipe profile as intended.

Figure 1: PVC Pipe.

Polyvinyl chloride (PVC) is a pipe made of plastic and several other vinyl combinations. It is a third-order thermoplastic polymer in terms of the number of uses in the world, after polyethylene and polypropylene. In around the world, more than 50% of PVC produced is used as construction material. PVC is relatively inexpensive, durable, and easily assembled. PVC can be made more elastic and flexible by adding plasticizers.

In Indonesia traditional ships are generally made from wood materials, likewise fishing vessels used by most fishermen. The wood used has certain requirements both physically (sufficient strength) and durability (resistant to decay and from wood-destroying animals). In addition, wood is also old and long-sized. The problem that arises from the use of this material is the reduced material stock and increasingly expensive prices. The growing speed of wood needed is relatively slow compared to the consumption of wood material. Logging trees that are still enough to meet these needs can damage the environment.

A fishing vessel made from PVC pipe has been built in a traditional shipyard in Pekalongan. The construction of this ship is also an alternative to new wood replacement materials. The use of this new alternative material requires a research on its feasibility, both technical and economic. The study in this paper will provide an analysis of one of the technical aspects, namely the strength of the length of the ship.

The maximum flexural stress value obtained from the use of PVC material as a hull material will be compared to the strength requirements of wood material commonly used as raw material for wood

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shipbuilding. The results of the strength analysis from the use of PVC pipe material will be used as a material for consideration in the design plan and PVC shipbuilding in the shipyard.

2 METHOD

2.1 Longitudinal Strength

The purpose of the calculation of longitudinal strength is to determine the stress experienced by the ship's body as a unit in the longitudinal direction. It is caused by the condition where the weight of the ship at a point along the vessel is not supported by buoyancy to the same size. If the difference in longitudinal spread between gravity and compressive force is greater, the load that works on the ship is also greater. The longitudinal spread of the weight of the vessel is determined by the load state, while the spread of the upward pressure force is determined by the shape of the submerged part of the ship and the wave conditions. Generally, the calculation of longitudinal strength is made based on the static balance between gravity and buoyancy. The longitudinal flexure of the vessel is shown in Figure 2, and the cross section modulus expression is shown in Figure 3. Based on the description above, the amount of flexural stress (σ) can be calculated extending with the concept of technical mechanics in general, as follows (Eyres, 2001) :

$$\sigma = M/I.y \quad (1)$$

$$Z = I/y \quad (2)$$

$$\sigma = M/Z \quad (3)$$

which :
M = longitudinal bending moment.
y = the distance of a point to the neutral axis.
I = moment of inertia cross section of the neutral axis.
Z = cross section modulus.

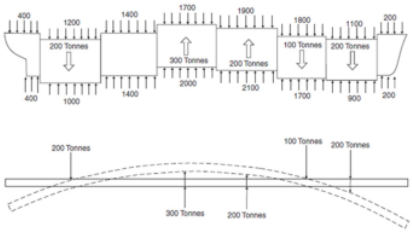

Figure 2: Longitudinal bending and vertical force in calm water conditions (Eyres, 2001).

3 PRINCIPLE DIMENSION AND MODELLING

Traditional fishing boats are built not based on complete design drawings and technical specifications. Direct measurement is needed in the field to get the ship's hull form. Modelling in Rhinoceros 4.0 Software is done to get the shape of the ship, after the principle dimension of the ship has been obtained. The calculation of traditional vessels with wood material is needed as a comparison to the results of bending stress analysis of ships with PVC pipe material.
Principle Dimension of Fishing Vessel with Wooden Material :

Length (Loa)	:	15 m
Breadth (Boa)	:	5.2 m
Height (H)	:	1.8 m
Depth (T)	:	1 m
Long Keel	:	11 m
Width Keel	:	0.5 m
Thick Keel	:	0.5 m
GT	:	17 ton

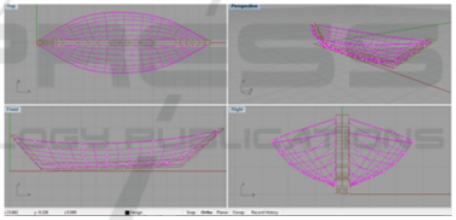

Figure 3: Modelling Traditional Fishing Vessel.

Principle Dimension of Fishing Vessel with PVC Material:

Length (Loa)	: 18.3 m
Breadth (Boa)	: 4.5 m
Height (H)	: 0.75 m
Depth (T)	: 0.5 m
GT	: 17 ton
Pipe Diameter (9 units)	: 14 inch (10 units) and 12 inch
Long Pipe	: 18.3 m

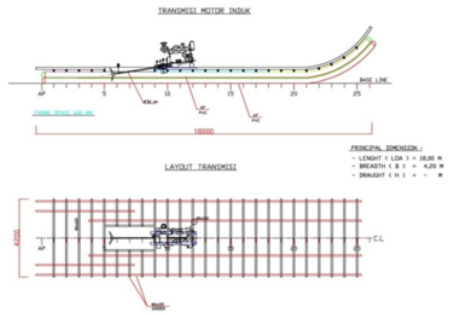

Figure 4: Construction Profile of PVC Ship.

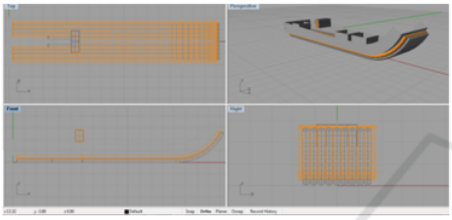

Figure 5: Modelling Traditional Fishing Vessel.

4 RESULTS AND DISCUSSION

One of the things that needs to be done with every application of new material for construction needs is to look at the safety factor. The safety factor is needed as a guarantee of safety when construction has received its maximum load when operated. The safety factor in question can be measured from the stress value (σ) that appears. The results of a construction engineering after the stress value has been analyzed, can be compared with the material stress value in question and can also be compared to the specific values of the other materials. The results of the analysis will be useful as a basis for deciding to use a particular type of material.

In connection with the use of wood material for the construction of a ship's body, it is known that several types of wood are compatible with certain parts of the ship. These parts can require different terms of strength and durability. There are five class classifications that are related to their density values. The best classification is at the density value ≥. 0,9 with absolute bending value ≥ 1100 kg / cm2 and the lowest classification is at density value ≤ 0.3 absolute bending value 360 kg / cm2. Whereas the best and lowest classification for firm press on the criteria of the same density value as absolute strength is ≥ 650 kg / cm2 (best) and ≤ 215 kg / cm2 (lowest) (anonymous, 1996). In its application to a construction, it must be noted that the stress arising must not be greater than 40% of the bending stress of the material and 30% of the tensile stress (anonymous, 2013).

The results of the calculation of bending stress on wood-material vessels can be seen in Table 1 and Figure 6. Based on the criteria set by BKI, the results of calculations for both the stresses occurring on the deck and the bottom are relatively safe.

Table 1: Calculation of Bending Voltage for Lengthening Wooden Ships.

Wooden Ship	M (Ton.m)	Ina (cm^4)	Y (cm)	W (cm^3)	σ (kg/cm^2)
Deck	11.207	4043067	157.62	25650.68	43.282
Bottom	11.207	4043067	22.38	180657.4	6.079

Note : H = 180 cm Y(na) = 22,38 cm

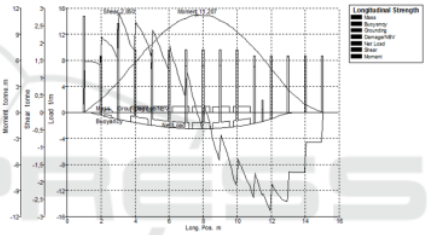

Figure 6: Strength chart extends wood-based ships.

The results of the calculation of bending stress on wood-material vessels can be seen in Table 2 and Figure 7. Based on the criteria set by BKI, the results of calculations for both the stresses that occur on the deck and on the bottom are relatively safe.

Table 2: Calculation of Bending Stress Lengthening PVC Ships.

Wooden Ship	M (Ton.m)	Ina (cm^4)	Y (cm)	W (cm^3)	σ (kg/cm^2)
Deck	8.762	534118	14.58	8839.52	97.14
Bottom	8.762	534118	14.58	36643.52	23.43

Note : H = 75 cm Y(na) = 14,58 cm

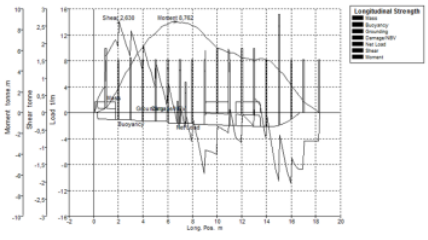

Figure 7: Chart of Longitudinal Strength of PVC Ship.

If the two results of the calculation of bending stress from the two types of ships are compared, then the bending stress of the PVC vessel has a greater value, or in other words the wooden material vessel has better strength than the PVC vessel. The difference is caused by different loading factors carried by each ship with a factor of different size of profile section (modulus). The difference in the distribution of loading causes a difference in moments, as well as the influence of its layout. The difference in cross section modulus is due to differences in construction systems and profile sizes. All of these factors will determine the value of the longitudinal bending stress.

Incompatibility in the size of the construction profile on traditional ships which are generally wood material is very possible. This is because the manufacture of the wooden ship is based on knowledge obtained from generation to generation, without detailed calculations and design drawings. A study has been carried out on wooden ships from the fishing vessel in Gresik. Based on the BKI reference, several measures of construction that are appropriate and not appropriate are obtained. This discrepancy results in a difference in stress values. The stress that occurs in the construction of fishing vessel in the field is greater than the stress that occurs in the construction of fishing vessel, the calculation of BKI, such as the tension that occurs on the deck beam, keel, and bow height. While the tension in ivory and wrangles is smaller than the BKI calculation stress (Rachman et.al, 2012). Yudo H & Yoshikawa (2015) were obtained the maximum bending moment for pipe under bending load shown in equation:

$$Mmax = 0.52MCR1 = 0.314\pi Ert2 \quad (4)$$

So, by entering the pipe data will be obtained the maximum moment that can be received by the PVC Ship.

Mmax = (7,01.105 + 5,4.105) N m
= 1,241.106 Nm

The maximum moment we get from PVC pipe data is D = 14 "as many as 10 pieces and D = 12" as many as 9 pieces with pipe thickness each t = 10 mm.

For maximum moments in hogging and sagging conditions of PVC ships, the maximum moment that occurs is equal to 8.8.104 Nm. So the safety factor is 14.

5 CONCLUSION

The results of longitudinal bending stress analysis that occur from the use of two different materials, namely wood and PVC material, as a shipboard material, are obtained:

a. Referring to the strong standard size of materials from BKI, all stresses arising from calculation results are below the material stress value set by BKI..
b. The longitudinal bending stress resulting from the calculation shows the stress of the PVC vessel is greater than the stress that arises on the wooden ship, thus the wooden vessel has a better level of security than PVC ships.
c. PVC pipes can be used as ship hulls, by arranging pipes. Lengthening strength depends on how many pipes are arranged on the hull

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