Indonesian Journal of Maritime Technology (ISMATECH)
Vol. 1, Issue 2, December 2023
eISSN: 3025-518X
DOI: https://doi.org/10.35718/ismatech.v1i2.1070

Numerical Evaluation of Transversal Strength of Traditional Fishing Vessel in Penajam Paser Utara, East Kalimantan, Indonesia

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KEYWORDS
Fishing Vessel
Transversal Strength
Field Survey
Numerical Method
Ansys Workbench

ABSTRACT – Challenges in procuring wood as the primary material for ships have led to a decline in overall quality. Meeting the demands of shipbuilding often involves neglecting consideration for the quality and characteristics of construction materials. Additionally, the shipbuilding process commonly overlooks technical and operational aspects associated with construction specifications. Ship damages frequently result from the selection of wood types, sizes, and ages that do not meet construction criteria or fall below the standards for achieving optimal construction. Many ship constructions are identified that fail to meet the requirements for ensuring the safety and security of the crew, ship, and cargo during operations. This research aims to numerically assess the transverse strength of fishing vessels operating in Penajam Paser Utara using Ansys software. Survey results indicate an average size of fishing boats in this area as 10 – 20 meters in length. 2.6 - 3.5 meters in width, and 1.6 – 2.5 meters in height. The stress analysis results from Ansys Workbench were recorded at 2.3402 MPa

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INTRODUCTION

Penajam Paser Utara (PPU) Regency in East Kalimantan Province boasts abundant fishery resources. The majority of PPU residents are engaged in the fishery sector [1], constructing numerous traditional fishing boats with diverse designs. However, their lack of technical expertise and knowledge in ship technology has led to challenges in areas like engine repair and maintenance [2], and understanding ship dimensions [3]. In response to these issues, training initiatives have been implemented to enhance their skills and address these specific challenges.

Historically, traditional fishing boats, crafted from wood, have served as the primary tools for fishermen in capturing fish over the ages. These boats showcase diverse designs, a characteristic prevalent in nearly every region across Indonesia. In the PPU area, the construction of traditional fishing boats predominantly adheres to conventional methods drawing on hereditary knowledge, instincts, and learning from adapting to natural conditions. When constructing traditional fishing boats, fishermen or craftsmen need to consider both the expenses involved in manufacturing and operating these vessels, as well as ensuring the robust structural integrity of the boat while sailing. This comprehensive approach enables fishermen to assess the profits and determine the anticipated operating lifespan of the fishing boat. This foresight allows them to gauge the return on investment [4].

The primary challenge of obtaining wood as the main material for constructing traditional fishing boats has led to a decline in both quality and service life. The imperative to fulfill the demand for traditional fishing boat construction often results in overlooking crucial factors such as material quality, type, service life, and size, neglecting their impact on the structural integrity of the boats [5]. The traditional fishing boat production process tends to neglect technical and operational considerations. This oversight leads to the utilization of suboptimal material characteristics, diminishing the quality and longevity of the wood in traditional fishing boats. This situation arises from mismatches in the type, size, and age of the wood used, falling significantly short of achieving optimal construction standards. Consequently, various initiatives have been undertaken to address this issue such as laminating frames with fiberglass in traditional wooden ships [6], and exploring alternative materials made from bamboo and rattan fiber [7]. In the present study, investigating the transversal strength of traditional fishing vessels in the PPU is performed to determine the maximum stress working in the hull to obtain the optimal construction design of the ship. Numerical analysis with Ansys Software is used to determine the maximum stress. Previously, the method has been performed in wooden ships to determine the stress in structural join [8]. In the present study, the ship hull is examined to obtain the transversal strength.

METHOD

Field Survey

Obtaining main dimension of the ship involves conducting a survey to direcly measure the ship intended for modelling. Figure 1 shows the fishing vessel in PPU to be measured, and the method of measurement as illustrated in Figure 2.

Figure 1. fishing vessel

Figure 2. Measuring the ship construction

Design of ship model

The obtained data from the previous survey is collected and processed to draw the ship construction. First, AutoCAD is used to create 2D drawings of the ship, including profile, top views, and side views. the example drawings produced by AutoCAD are shown in Figure 3.

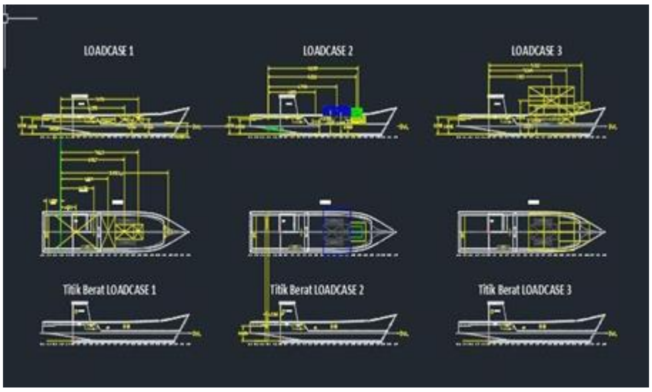

Figure 3. Drawings Produced by AutoCAD

The drawings produced using AutoCAD are processed to proceed to 3D models. The 3D drawings are created using Rhinos to obtain proper models. The model produced by Rhinos is shown in Figure 4. Finally, the model is converted to the Ansys version to proceed to the analysis step. The ansys version model is shown in Figure 5.

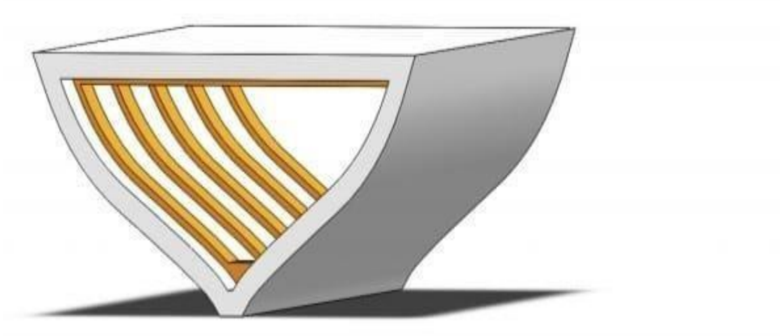

Figure 4. 3D Model Produced by Rhinos

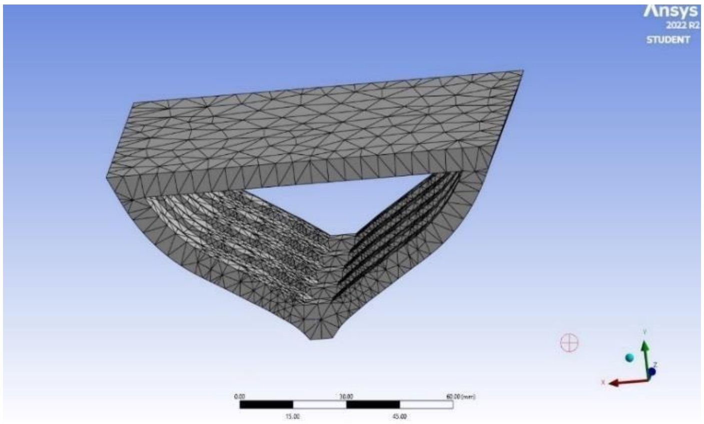

Figure 5. Ansys version model

Material Specification

Bungur wood was chosen as the material for the Fishing Ship model. There are 9 variables of mechanical properties of wood required [9]. The comparison between fiber direction, wood elastic modulus, and wood shear modulus is based on assumptions found in previous study [10]. Information about the mechanical properties of the material can be found in Table 1 as follows.

Table 3. Properties of Bungur Wood.

No.	Value	Unit
Density	810	Kg/m^3
Elastic Modulus (x)	13900	MPa
Elastic Modulus (y)	9266.66	MPa
Elastic Modulus (z)	772.22	MPa
Shear Modulus (xy)	1379	MPa
Shear Modulus (yz)	114.91	MPa
Shear Modulus (xz)	91.33	MPa
Poisson's Ratio	0.33	-

Load on Ship Construction

The loading that occurs in the base construction means that the load caused by loads and waves is in accordance with the regulations set by the Indonesian Classification Bureau (BKI) [11]. The equation used in calculating the load is as follows.

Shell Bottom area (< 0.4 L ÷ aft)

$$PdBS = 2.62\,L - 1.13 \quad (1)$$

Shell Bottom area (≥ 0.4 L ÷ fore)

$$PdBS=3.29L-1.41 \quad (2)$$

Shell Side area (< 0.4 L ÷ aft)

$$PdSS = 2.63\,L - 2.35 \quad (3)$$

Shell Side area (≥ 0.4 L ÷ fore)

$$PdSS = 2.06\,L - 2.94 \quad (4)$$

Main Deck

$$PdD = 0.26\,L + 8.24 \quad (5)$$

RESULTS AND DISCUSSION

Results of Field Survey

Survey results indicate an average size of fishing boats in this area as 10 – 20 meters in length. 2.6 - 3.5 meters in width, and 1.6 – 2.5 meters in height. One of the ships that has been measured is shown in Figure 5. The main dimension of ship that obtained form the survey as follows:

Length Over All (LOA)	= 14.50 m
Depth (H)	= 1.2 m
Breadth (B)	= 2.6 m
Frame width	= 5 cm
Frame thickness	= 1.5 cm
Shell Plate Thickness	= 3 cm
Frame length	= 0.845 m

Figure 6. the measured ship

Loading Calculation

The following is the equation for calculating the load on the Shell Bottom area (≥ 0.4 L ÷ fore)

PdBS=3.29L-1.41

$$L = \frac{LWl + LOA}{2}$$

L = 14,0

PdBS=3.29L-1.41

= 46,0929−1,41

= 44,68

= 0,044,68 Kn/m^2

The following is the equation in calculating the load on the main deck:

PdD = 0.26 L + 8.24

$$L = \frac{LWl + LOA}{2}$$

L = (13,54+14,5)/2

=2,06 L−2,94

= 0,02592Kn/m^2

The following is the equation for calculating the load on the deck area:

L=14,5001

LOD = 0,20 L+8,24

=11,88KN2m⁄

= 0,01188 Mpa

Maximum Stress

The result of the maximum stress on the fishing boat structure determines the strength of the fishing boat. The smaller the maximum stress that can be received by the fishing boat structure, the stronger the fishing boat will be. From the results of the maximum stress analysis, the Fishing Ship model with an LOA of 14.50 m has a maximum stress of 55.80 MPa and a minimum stress of 0.0450 58 MPa with the critical stress point located in the Deck area connected to the Shell side area. The voltage values based on the running results on the Fishing Vessel can be seen in Figure 7, and the graph of stress value is shown in Figure 8.

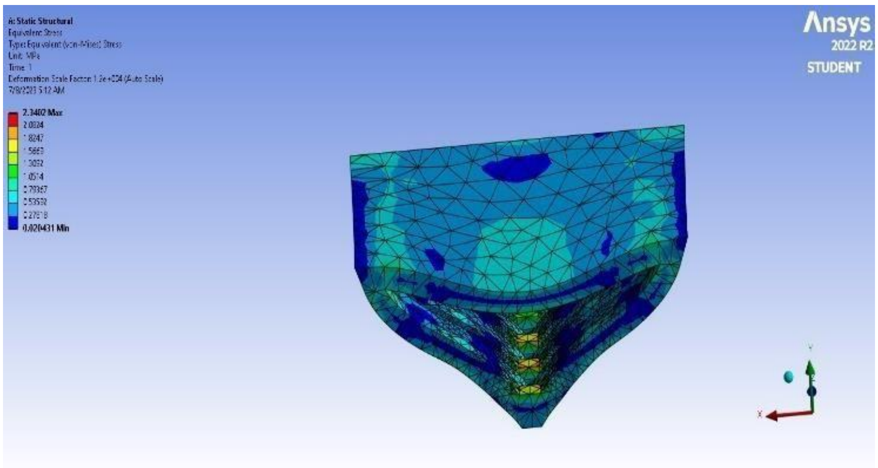

Figure 7. Maximum stress

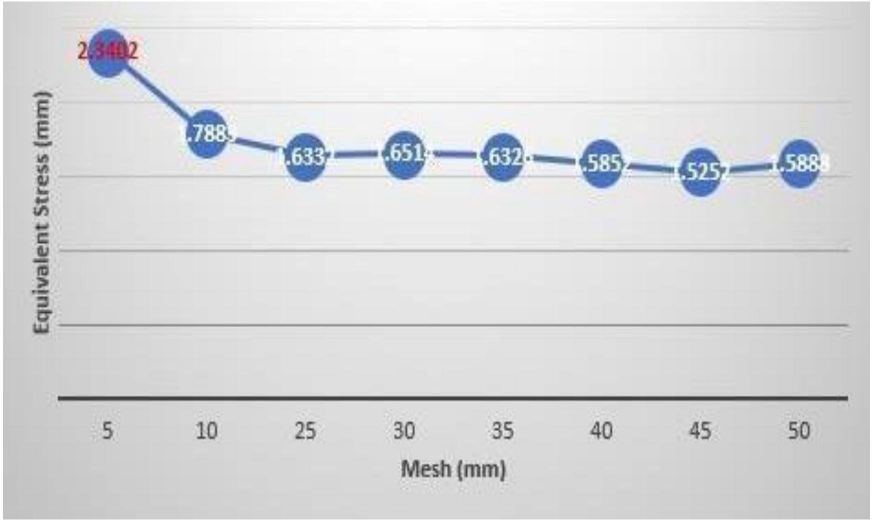

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Figure 8. stress value

Deformation

Apart from maximum stress, it turns out that deformation also determines the structural strength of the fishing boat, where the smaller the deformation, the stronger the fishing boat. From the results of the deformation analysis, a fishing vessel with an LOA of 14.50 m has a deformation of 3,102 MPa and the critical point of deformation is located in the Deck Area. The deformation value based on the running results of the fishing vessel in Figure 9.

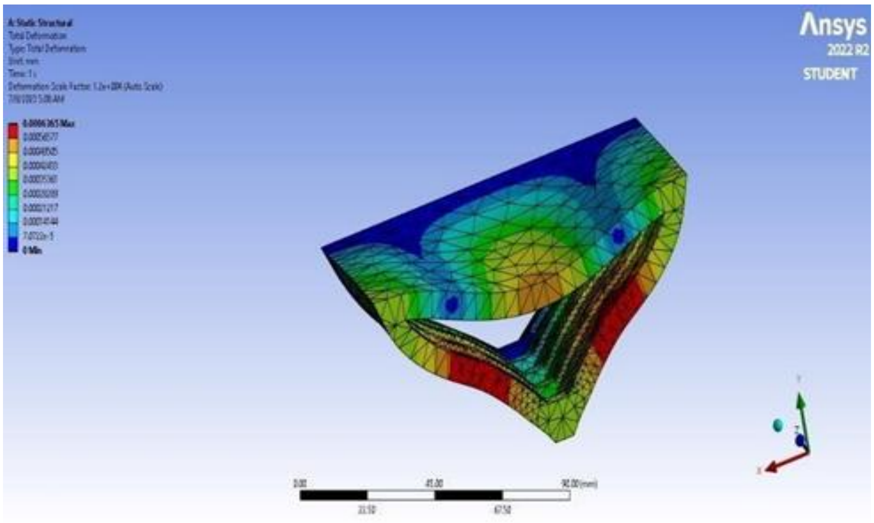

Figure 9. Deformation

CONCLUSION

Based on the results of the Transverse Strength Analysis of the North Penajam Paser Traditional Fishing Vessel, the conclusion was obtained, namely. From the results of the deformation analysis of the Fishing Vessel with an LOA of 14.50 meters, it has a deformation of 3,102 MPa and the critical point of deformation is located in the Deck Area and the results of the maximum stress analysis of the Fishing Vessel model with LOA 14.50 meters has a maximum stress of 55.80 MPa and a minimum stress of 0.0450 58 MPa with the critical stress point located in the Deck area which is continuous with the Shell Side Area. The Safety Factor resulting from the comparison of the allowable stress to the maximum simulated stress shows that all fishing vessel model constructions are safe.

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