Analysis Strength Structure Fising Vessel of Composit Sandwich Plate System Using Finite Element Method

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Abstract. Fiberglass composite material is currently widely used as an alternative material or substitute material for metal and wood materials for the manufacture of fishing boats, because it has its own advantages, among others, easily formed in accordance with needs, has good strength and stiffness. However, in the operation of the ship the bow section often experiences a collision or collision so that when the ship is operating and leaning on the dock which causes a collision where the kinetic energy of the boat turns into a collision energy absorbed by the boat's hull that is hit by a collision. The energy damaged the hull of the boat that was hit, so the front of the ship needs to be done by adding a new material that is a composite sandwich made with the aim of optimal weight efficiency, but has high rigidity and strength. There are many variations in the definition of sandwich composites, but the main factor of the material is the lightweight core, thus reducing the specific gravity of the material and the strength of the skin layer which gives strength to the sandwich composite. This research was carried out a static structural analysis of composite sandwich material using Ansys Workbench 14.5 software. A model is designed and analyzed using 3D CAD software, which is for ships that have the potential to experience collisions. From the simulation results of the Finite element method, the maximum principal stress of the model shows that the maximum point is 11.6 MPa. The maximum stress occurs at the ivory bottom, which is 6.9759 kN/m² or 6.97 kPa, this occurs due to the bow of the fishing boat experienced a great imposition.

1. Introduction

Fiberglass Composite Materials are currently widely used as alternative materials or substitutes for metal materials that have their own advantages, among others, easily formed according to needs, has a good strength and stiffness, resistant to corrosion [10]. Composites have been used extensively in several industries that require a lightweight and rigid construction including construction of ship hulls, aircraft, car bodies, trains, and so on.

Sandwich composites are made with the aim of optimal weight efficiency, but has high rigidity and strength. There are many variations in the definition of sandwich composites, but the main factor of the material is the lightweight core, thus reducing the specific gravity of the material and the strength of the skin layer which gives strength to the sandwich composite [11]. Using a composite sandwich is advantageous for buoyancy because the specific density of the composite is so small that it is even smaller than the specific gravity of wood. The specific gravity of a fiberglass-strip bamboo-polyester sandwich composite with polyurethane foam cores ranges from 0.0971 - 0.3921 gr/cc, lower than the average wood density of 0.6 gr/cc [2]. But the use of conventional sandwich composites without core reinforcement for boat hull is not without problems. The problem faced when using sandwich composite materials without core reinforcement is that this material cannot withstand pressure, collisions and impacts. This is because the core does not have high strength and rigidity when receiving flat direction pressure.
Core strengthening is done by [3] with zpin. Z-pin made of T300 carbon / bismaleimide with a diameter of 0.28 mm is inserted in the core with closed-cell polymethacrylimid foam material. Flat direction compression test on sandwich composites results in collision strength. Modulus of elasticity and energy absorption capacity increased by 260 - 300% compared to before being strengthened with z-pins. However z-pin does not improve collision strength, modulus of elasticity and post-impact energy absorption capacity.

Research that studies the characteristics of composite sandwiches with uniaxial reinforcement has also been carried out by [6]. In the case of a collision on a sandwich composite with cores that have not been strengthened, the impact force can be constant over a very limited displacement range. After the cores are strengthened with a thin layer of graphite fiber-epoxy upright, the forces held by the composite become highly variable with respect to the transverse displacement of the composite sandwich. Likewise, if the core is strengthened with graphite fiber - epoxy, the sandwich structure absorbs normal energy by increasing. Some forms of reinforcement that are inserted into the core without adding weight to the sandwich composite developed by the researchers are reinforcement, stitches, bundles, pegs and strips [3]. But the reinforcing material and its production method require complicated equipment and high production costs. The solution that can be developed to overcome this problem is to add an amplifier to the core with materials that are cheap and easy to process.

2. **Experiment Model**

2.1 **Sandwich Plate System**

Sandwich Plate System (SPS) is a lightweight material which is a two plate structure of wood material separated by an elastomeric core material [9]. The metal plate is joined to the parameter bar on the edge of the plate, the polyurethane elastomer core is between the plates by the injection process.

![Sandwich Plate System (SPS) Material](Welch.D, 2005, Presentation, Glasgow College of Nautical Studies)

Figure 1 shows the cut shape of the SPS material sample, the combination of wood as the top layer and the bottom plate, and the polyurethane material as the core layer.
2.2 Polyurethane Material
Duraposita chemical (Small Medium Industrial Consultant), Polyurethane which was first discovered by a German chemist, Prof. Otto Bayern in 1937, developed into a material that has a class of its own and has many uses. The initial formation of this material resembles fibers that are designed to rival nylon fibers. However, further research shows that Polyurethane can not only be used as a fiber, but can also be used to make foams, elastomeric material rubber plastic, glue, coating and others.

The results of the investigation of making Polyurethane foam, by comparing the density levels of different polyurethane foam which is 16 kg / m³ and 62 kg / m³ [12]. Tests carried out include tension test, compression test, shearing test, Poisson's ratio test, fatigue test and burning test on the form of material specimens according to ISO 845 standards; 844; 1926; 9722 and ASTM C-273 [12]. In addition, Polyurethane with a density of 62 kg / m³ can be used as a lightweight material barge or ship in shallow water seen from the results of compression, tension and shear testing conditions.

2.3 Composit Sandwich Fiberglass
This composite uses an unsaturated polyester matrix with matt fiber reinforcement and woven roving (WR) weighing 400 grams / m. Composite skins are printed directly on the core. Woven roving fiberglass is held on a flat core. Hardened unsaturated polyester is poured over fiberglass roving woven and leveled. Hardened Unsaturated polyester is a polyester resin that has been mixed with a catalyst in a ratio of 99: 1. While the volume fraction of Woven roving fiberglass to the skin composite is 30%. Skin printing by hand lay-up process in which skin is made by stacking 3 layers of fiberglass, alternately between layers is poured hardened polyester resin [7]. The curing process on the sandwich composite lasts for 24 hours. After the curing process is complete then the specimen cutting process is continued in accordance with predetermined testing standards. Bending test specimens according to ASTM C393-00, and compressive test specimens according to ASTM C365 [1].

![Figure 2. Making material sandwich specimens](image)

2.4 Fenete Elemen Metode
Vessel structure calculations are carried out using criteria given by the Rule Class of ships on Fiberglass material for small vessels under 24 m rule class used in this study, which refers to the regulations [4] and [5]. The results of these calculations are the size of the structure of the Fiberglass sandwich ship designed.

In the [4] regulations regarding passenger ships under 24 m, the formula for finding pressure on the bottom shell (PdBm) is:

\[
P_{dBm} = \begin{cases} 
2.7L + 3.29 \text{ [kN/m}^2]\text{,} & \text{untuk } \geq 0.4L : \text{Fore} \\
2.16L + 2.63 \text{ [kN/m}^2]\text{,} & \text{untuk } < 0.4L : \text{aft} 
\end{cases}
\]
Frame distance does not have standard rules of maximum and minimum limits but BKI (2013) rules recommend the formula:

\[ a = (350 + L) \text{ [mm]} \]  \hspace{1cm} (3)

The thickness of the bottom shell in the construction of ships made from composites is not regulated in [4] but it is contained in the [5] rule class. Calculation of construction in DNV class has the following formula:

\[ T_y = k_s \frac{\sqrt{P_E}}{L} (14 + 3.6 L) \text{ [mm]} \]  \hspace{1cm} (4)

Analysis of the strength of the ship structure is done by finite element method (FEM) or finite element method. In this analysis a ship model is made with the shape and size according to the previous calculation, the model is analyzed its strength to get the stress distribution on the ship structure to be analyzed and to know the maximum stress that occurs in the ship structure. FEM analysis was carried out using Ansys Workbench 14.5 software. Maximum principal stress is the part that shows the main stress that is greater. The main stress is the tension in the direction perpendicular to the surface. For more details, can be seen in accordance with the illustration in Figure 3 below.

![Figure 3. Illustration maximum principal stress](image)

3. **Result and Analysis**

3.1 **Model Design**

The ship model was created using AutoCAD 2014 software with 3D solid shapes which can be seen in Figure 8.3 below. The model is depicted in real form with a scale of 1: 1 consisting of leather and ivory with construction sizes that have been calculated previously using the ship's Rule class. The results of the 3D image are exported into the ACIS format, the purpose of the ACIS format is that the model images in AutoCAD can be imported into Ansys software in the form of 3D Solid images.
3.2 Meshing

The meshing matric process is to divide the surface of the model into several nodes and several matric elements. In this first model the model is done mashing automatically per part or based on the distribution of geometry.

The number of parts in this model is 2 parts and from the mashing done, the total number is 12296 nodes and 5166 elements. Figure 4.16 above is a model design that has been mashing in accordance with the criteria described previously.
3.3 **Imposition and Support**

Provision of loading on the bow of the ship in accordance with the design of the ship. While loading on the skin of the ship in accordance with the criteria of the surface pressure of the hull skin in accordance with the Rule class of the Ship. The rule class used is [5]. The amount of pressure that occurs on the skin or hull consists of 4 categories, namely as follows:

a) Graffity loading of 9.8 m/s^2
b) Bottom pressure: the pressure that occurs on the skin of the hull below the waterline due to external forces, the magnitude of the pressure that occurs is 45 kN/m^2 or equal to 45,000 Pa.

c) Load Load (60 kN/m^2) Load estimation

d) Side pressure: the pressure that occurs on the skin of the hull above the waterline due to external forces, the magnitude of the pressure that occurs is 40 k /m^2 or equal to 40,000 N/m^2

![Figure 6. Styles that work on models with Ansys 14.5](image)

3.4 **Material properties dan kondisi batas**

Supports or boundary conditions on the model using displacement supports. In this study it is assumed that the ship is in a calm waters area and because the ship is dynamic in accordance with the displacement of the ship so that the support used is displacement by lowering the ship in accordance with the draft ship which is 0.4 m [8]. For this pedestal the ship is forced to dip into the water in accordance with the desired water laden. In bow construction using fiberglass sandwich plate composite material, so as a determination in engineering data in ANSYS software, the property material for sandwich material must be entered.
Figure 7 is a drawing procedure for entering data into the software. The sandwich composite material that is inserted according to [5] is as follows:

- **Density** = 950 [kg/m$^3$]
- **Tensile Yield Strength** = 17 [MPa]
- **Tensile Ultimate Strength** = 24 [MPa]

After the model design is formed with various material properties and characteristics given into the model, the model is run to get the desired results. The results are compared and analyzed based on cases and also based on the principle of strength. Maximum principal stress is the part that shows the main stress that is greater. The main stress is the tension in the direction perpendicular to the surface. For more details, can be seen in accordance with the illustration in Figure 8 below.

Gambar 8. Penyebaran tegangan Maximum principal stress dengan Ansys
The maximum principal stress results from the model show that the maximum point is 11.6 MPa which occurs at the ivory bottom which is 6.9759 kN / m² or 6.97 kPa. This happens because there is a large burden in that section.

4. Conclusion
From the simulation results that have been done using the finite element method (FEM), the maximum principal stress of the composite sandwich plate ship model shows that the maximum point is 11.6 MPa with the maximum stress occurring on the ivory bottom of 6.9759 kN / m² or 6.97 kPa.

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