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Strength Evaluation of Pompong Structure Made from High Density Polyethylene Plastics as Basic Materials

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ABSTRACT

High density polyethylene plastic (HDPE) can be used as an alternative material for the construction of pompong ships in the Riau coastal waters, as the wood material is limited at this time. A study to understand the specifications of strength of pompong that are commonly used in Riau waters (3 GT, 10.2 m Length) has been conducted. The tensile strength of HDPE plastic is tested according to ASTM D638-02a standards with the intention of material strength properties and then being compared with the strength of the material that satisty the rule class standards. Results shown that the tensile strength is 17.12 MPa Yield Strength and the Ultimate Strength is 24.82 MPa. Data are then verified using a finite element method (FEM), where the ship are modelled using ANSYS Workbench 12.0 (3 models). The maximum stress of all models occur in the load cases 1 and load case 3. The load case 1 is the condition when the ship is empty, payload 100% and fuel 100%. While the load case 3 is full charge of 100%, net charge 100% and 10% fuel. The maximum tensile stress is 11.67 MPa, however, the tension does not exceed 17 MPa as required by the class rules. Its safety factor is 1.45, meanwhile the maximum compression stress is 15.82 MPa with a safety factor of 1.26 toward the standard class rule.

Keywords: *Riau Coastal, Pompong,High density polyethylene*

INTRODUCTION

Pompong vessel definition in general is a proper name for a traditional wooden boat, said the term is known by the people in the surrounding waters of the Straits of Melaka. Meanwhile, according to Zarkasyi (Zarkasyi, 2006) is included in the type "Motor Vessel" (KM) is small, the small boat pengoprasiannya use a machine that is stored in the hull. So the two definitions can be interpreted that the ship pompong is smaller vessels are generally made of wood materials (timber ships) which pengoprasiannya using the machine. The ships are in general use diesel propulsion engine and use diesel fuel (diesel oil).

Coastal Riau islands in Indonesia is an area that needs a lot of inter-island transportation tools, the tools used in general transportation is pompong ship. However, the number of vessels in the traditional pompong riau coastal waters began to decrease due to the difficulty of finding wood as the main material of the ship. So some shipyards traditional pompong many have closed.

As an entrepreneur ship owner would want dioprasikan The ship can be tough in any condition and guaranteed his safety so that the activities of trade or fishing voyage may continue to happen. For that we need new ways to make the ship made a new alternative. High density polyethylene (HDPE) can be made as an alternative material as a basis for shipbuilding because a lot of advantages that exist in these materials for shipbuilding

The advantages of HDPE plastic as a base material according Boat shipbuilding Indonesia are: First, HDPE plastic is very durable against material aging and corrosion (lasting a minimum of 50 years). Second, resistance to impact damage cracks a little better. Third, HDPE flexible and durable, resistant to the worst weather conditions, Fourth, can be recycled and many more advantages (Indonesia, 2014).

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Of the various advantages that exist in HDPE plastic, the researcher tried to analyze the strength of the material is directly and verify the material using appropriate methods.

There are two main types of material that can be used as a boat or ship that is plate-shaped HDPE plastic material and powder or pellets. The success of an idea into a business example is the Turkish state that became one of the country Boat makers with entirely HDPE material. innovative products for building boats made entirely of plastic HDPE has been made over the last five years (Indonesia, 2014). In the second picture looks example HDPE ship image that has been built and has operate at sea.

Figure 1. HDPE *Work Boat*

The benefits of HDPE in the manufacture of ships, among others, are as follows:

1) Because HDPE highly durable against material aging and corrosion (lasting a minimum of 50 years).
2) Durability rift good so little impact damage.
3) HDPE flexible and durable, resistant to the worst weather conditions
4) It is easier to assemble than the HDPE material of steel, wood, aluminum or other composite materials.
5) Resistant to ultra violet, Stable, fire resistant and low maintenance
6) 100% recyclable.

Besides 6 point benefits at above, the plastic material has several advantages over fiberglass and aluminium materials. More detail can be seen in Table 1 below:

Table 1. Comparison between the material characteristics of fiberglass, aluminum and HDPE plastics [6].

Application	Fibreglass RHIB	Aluminium	HDPE Rhino 590
Impact Resistance	Poor	Good	Excellent
Repair ability	Good	Good	Excellent
Mass	Good	Excellent	Poor
General Abuse Resistance	Poor	Poor	Excellent
UV Resistance	Poor	Excellent	Excellent
Operator Skill Level	Skilled	OK	Unskilled
Maintenance Requirements	High	High	Low
Sandy Beach Landings	Good	Good	Good
Rocky Beach Landings	Poor	Poor	Excellent
Punture Resistance	Poor	Good	Excellent

Rhino Marine, 2006

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MATERIALS AND METHODS

Method of tensile test of High Density Polyethylene (HDPE) materials using ASTM D638 standard. Whereas verification of the strength of the ship model analysis using finite element method (FEM). Tensile test carried out to determine the properties of materials on fracture strength of materials that can be applied to the structural strength of the vessel either lengthwise or crosswise. In accordance with DNV [7] that in order to rule class for craft has a standard strength of materials that must be fulfilled such that the Ultimate Tensile yield stress and tensile stress.

Materials Preparation. Material specimens used in this Paper is High Density Polyethylene (HDPE) 3840 RU. Material obtained from the company's CV. Pioneers Mandiri Jaya is located at Palm Watu Street, No.89 DS, Gresik-Indonesia. The material made by heating the HDPE plastic at temperature of 230^0C and with time ±30 minutes. In accordance with the ASTM standard test of HDPE plastic can be used ASTM standard. In this paper, using a specimen D638-02a – IVB type. As for the size of the specimen based on the type can be seen in Figure 2 below.

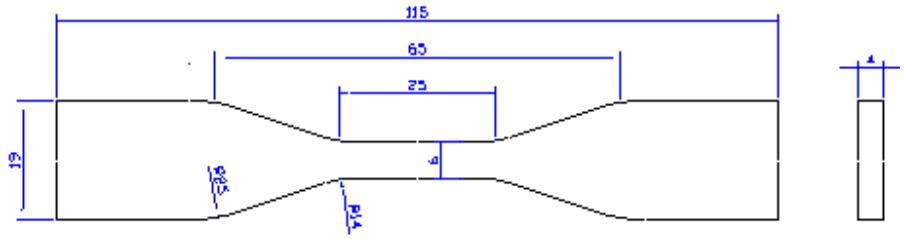

Figure 2. Specimens standard with ASTM standards [8].

Table 2. Specifications Specimen HDPE Plastic Material

No.	Specimen code	Width [mm]	Thick [mm]	CSA [mm^2]	l_o [mm]
1	I	6,08	4,03	24,50	25
2	II	6,13	4,05	24,83	25
3	III	6,05	4,10	24,80	25
4	IV	6,07	4,16	25,25	25
5	V	6,22	4,17	25,94	25

Under the ASTM standard D638-02a that tolerance to the width and thickness of the specimen was 0.5 mm [8]. This proves that the specimens to be tested in table 2 above still meet the overall standards. As for the differences between the standards with the greatest test material seen in the width of the specimen No.V is 0.22 mm and is smaller than a standard maximum limit of 0.5 mm.

Testing Process. On HDPE plastic material tensile test carried out in accordance with the work steps described in the previous point. While the specimen image that has been in the tensile test can be seen in Figure 3.

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(A) (B)

Figure 3. Testing Process (A)monitor results, (b) specimen results

RESULTS AND DISCUSSION

The true stress strain curve is showing the strain tensile strength of a material. The curve is derived from the curve obtained from the force per area of cross-section accretion of material with the magnitude of the length due to the tensile force. in Figure 4 below is a stress strain curve that occurs in HDPE plastic tensile testing.

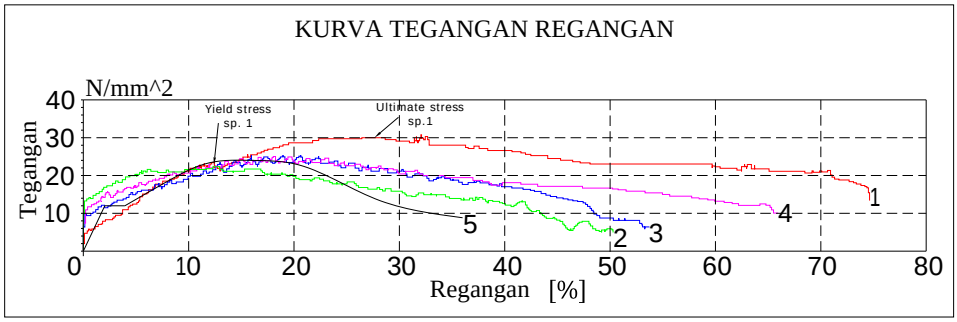

Figure 4. Stress and Strain Curve

Table 3. Data Result

Spc. Code	Max. Load (N)	Yield point (N)	Δ *l* (mm)	Yield Strength (N/mm^2)	Tensile Strength (N/mm^2)	Elong- tion (%)	Reduct. of Area (%)
I	735,45	548,13	18,4	22.37	30,01	74.00	87.27
II	547,38	459,16	12,4	18.49	22,05	49.20	84.90
III	611,01	398.55	12,8	16.07	24,63	50.80	85.33
IV	613,71	431.53	16,2	17.09	24,30	64.80	85.15
V	600,00	300,00	9,00	11.57	23,13	36.00	82.30
Rata-rata				17,12	24,82	54,96	84.07

Based on the results of tests performed as shown in Table 3 and figure 4 is stress strain curve can be obtained a determination that the magnitude of the yield strength of HDPE plastic is at 17.12 MPa, 24.82 MPa Tensile strength, Strain 54.96% and depreciation amounted surfaces 84.07%. HDPE plastic shrinkage strain and turns show a great price so it can be concluded that turns the plastic material includes an elastic material.

Tensile Strength Pompong Ship Structure Analysis Based Plastic HDPE. Analysis of the structure of the pompong Ship made of HDPE plastic in this Paper using the finite element method (FEM) or the finite element method, the goal is: allow it to get deployment stress on vessel structure to be analyzed. FEM analysis in this research is using static structural analysis with Ansys Workbench

Software 12.0. A model was designed and analyzed by using the software on the whole hull. While the strength of the deck house in this study ignored.

Models Product. Ship models created using AutoCAD 2014 software with 3D solid shapes that can be seen in Figure 8.3 below. The model is described in the form of real scale 1: 1 in accordance with the size of the construction that has been previously calculated using Rule-class ships.

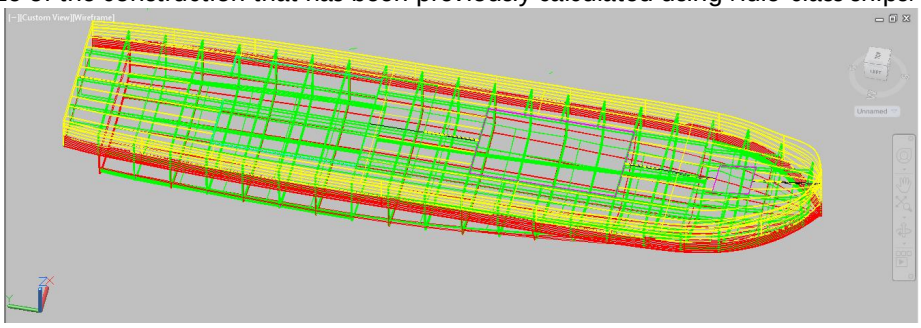

Figure 5. The process of making 3D models with AutoCAD 2014.

Meshing. Matric meshing process is dividing the surface model into multiple nodes and some elements matric. In the first model is a model ship mashing pompong done automatically per part or by division geometry, pictures can be seen in Figure 6. meshing are done to get a total amount of 21283 nodes and 8714 elements.

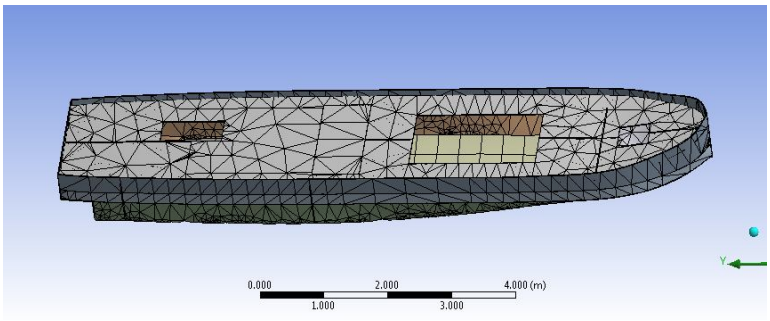

Figure 6. *Meshing* of Models

Load. loading divided into three points, namely:

1) Load case 1. load case 1 occurs when the ship leaves port: payload=0%, Fuel oil=100%, Net=100%, Fresh water=100%
2) Load case 2. load case 2 occurs when the vessel to operate: payload=50%, Fuel oil=50%, Net=50%, Fresh water=50%
3) Load case 3. Load case 3 is the ship towards the port: Payload=100%, Fuel oil=10%, Net=100%, Fresh water=10%

An example can be seen in load case 1 with Figure 7.

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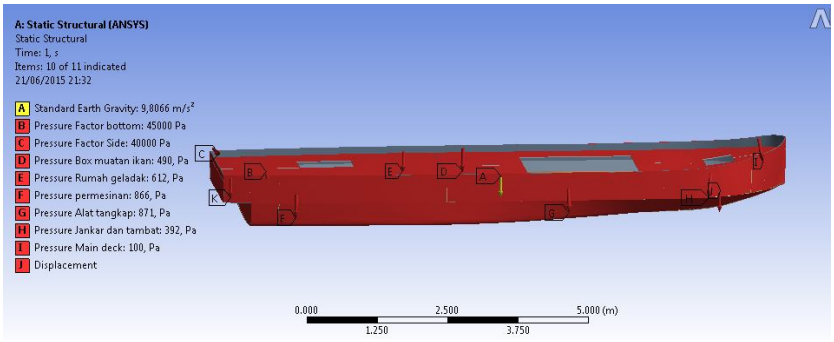

Figure 7. Force in *Load Case* 1

RESULT AND DISCUSSION

Once the design of the model is formed by various case characteristics is given in the model then the model is in the running to get the desired result. The model result can be seen at Table 4, Figure 8, Figure 9 and Figure 10.

Table 4. *Maximum Principal Stress*

Note	Load Case 1	Load Case 2	Load Case 3
Minimum	- 4,66 [MPa]	- 4, 66 [MPa]	- 4,66 [MPa]
Maximum	11,67 [MPa]	8,84 [MPa]	11,61 [MPa]
Minimum Occurs On	Side shell u	Side Shell u	Side Shell u
Maximum Occurs On	Inner bottom midship	Inner bottom AP	Inner bottom midship

For a minimum stress written in the negative sign (-) while the maximum stress is written in the form of a positive (+). The positive sign indicates actual tensile stresses occurring in the material while a negative sign is the number of the magnitude of the compressive stress that occurs in the material.

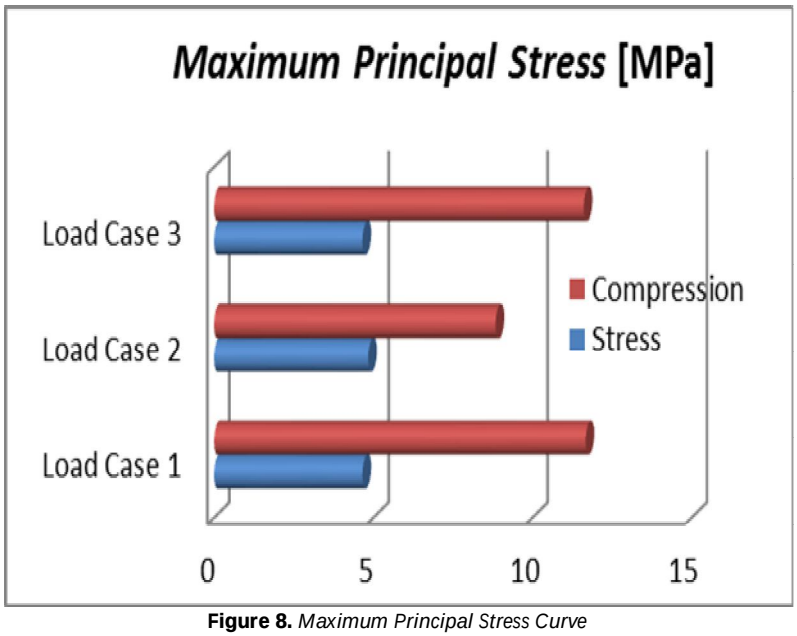

Figure 8. *Maximum Principal Stress Curve*

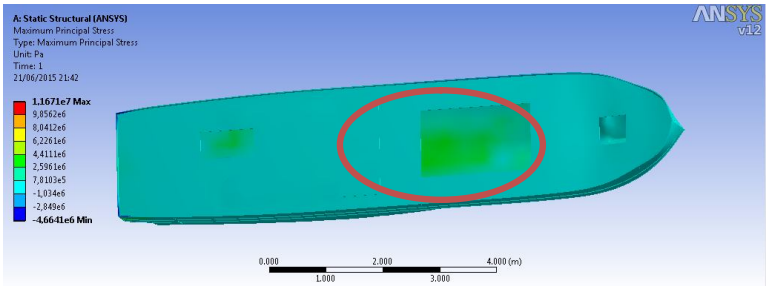

Figure 9. *Maximum principal stress* Models at load case 1

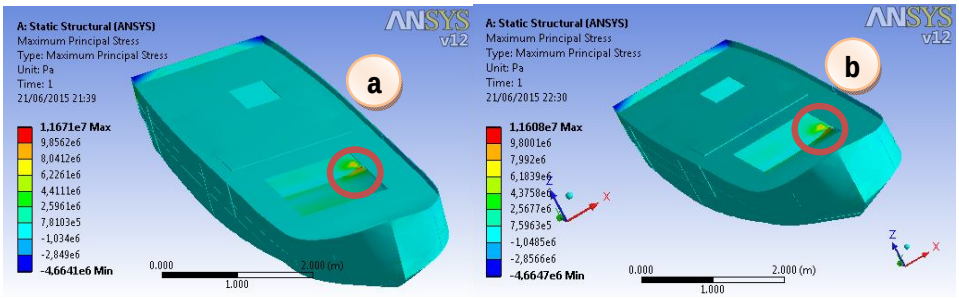

Figure 10. *Maximum principal stress* Models. a, load case 1 b. load case 3

Safety Factor. Safety factor is the safety factor used in planning the design of the ship's structure so that the power structure is secured with minimum dimensions. Safety factor against yield strength is also often referred to as a comparison between the yield strength of the material to the voltage that occurs in the design model, for more details can be seen in the following equation:
SF = *Material Strength* / *Design Strength*

Note:
SF = *Safety factor*
Material strength = 17,12 MPa
Design strength = 11,67 MPa
SF = 1,45

Based on the above calculation, the price obtained for yield strength safety factor is 1.45.

Permissible Stress. Based on the rule class [7] that the tensile stress is not allowed to exceed 80% of the tensile stress possessed material. Table 5 is the comparison between the test results with the class rule, the calculation results prove the test material shown to meet the standards

Table 5. Comparison of stress that occurs in the calculation of class rule

Yield Stress Material	Permisible Stress	Principal Stress
Yield stress with material test	Max. 80 % with yield stress	maximum principal stress result
17,12 MPa	13,69 MPa	11,64 MPa

CONCLUSIONS

The conclusions obtained in this paper are the strength of HDPE plastic type 3840 RU has been tested according to ASTM standards D638-02a has amounted to 17.12 MPa Yield Strength and Ultimate Strangth of 24.82 MPa. The tensile strength of standard HDPE given Rule class is Yield Strength: 17.00 MPa and Ultimate Strangth: 24.00 MPa HDPE plastic material that is otherwise meet

the standards of the rule class and worthy of shipbuilding materials. It has been done three modeling for verification analysis of finite element method (FEM). Of the three models of the greatest stress occurs in the inner bottom plate gear load space when the condition Load case 1 and case load conditions 3. Load case 1 is the condition of fish cargo is empty, cargo nets 100% and 100% fuel load while the third case is on while a full charge of 100%, 100% and a net charge of fuel 10%. The maximum principal stress was 11.67 MPa greatest, however, the stress of 17 MPa melibihi not required by class rules and have a safety factor of 1.45 to the tensile strength of the material.

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