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A Finite Element Analysis of Bottom Structure of LCT Converted from SPOB

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Abstract

SPOB (Self-Propelled Oil Barge) ship is useful for transporting oil. Due to certain requests, the owner and operator have converted SPOB into LCT. If before the conversion the ship transported oil, now the ship is transporting vehicles or heavy equipment on the deck. after the transfer of function from a SPOB ship to an LCT (Landing Craft Tank) ship, the cargo transported is different, the bottom is the part that is submerged in the water, so this part is vulnerable. Therefore, it is necessary to systematically predict the weight of the load that can be held by the ship at the bottom, this is so that there is no damage to the structure at the bottom of the ship which can harm the company from the ship owner. The purpose of this study is to find the maximum stress and strain that can be accepted by the ship and the value of the stress ratio (safety factor) in the bottom construction using the finite element method. The results obtained from the maximum stress and strain of the ship after and before conversion of 96.349Mpa, 272.56 Mpa, and 0.0013628 mm, 5.042 x 10-4 mm, safety factor according to BKI after and before conversion obtained 3.624 and 1.057, the safety factor according to the material criteria is 3.685 and 1.172, respectively, for the maximum deformation of the ship, the safety factor is 6.328 and 3.287 respectively.

Keywords: Bottom Construction; Stress; Strain; Safety Factor; Finite Element Analysis

1. Introduction

In archaeology countries like Indonesia, Ship has one of the modes of transportation between islands, besides that ships are used as transportation for distributing basic needs and so on. One of them is SPOB (Self-Propelled Oil Barge) ship which is useful for transporting oil. After the conversion of a SPOB ship to LCT (Landing Craft Tank) ship, the cargo transported is different whereas the LCT ship itself is used for transporting heavy equipment vehicles. The conversion of SPOB vessels into LCT vessels is common in Indonesia, which has economic value and conversion is faster than new building [1].

The LCT is a ship used to transport large vehicles such as heavy cargo, bulldozers, excavators, dump trucks, loaders, and other heavy equipment that is indispensable for construction work. In addition, Landing Craft Tank can also transport large construction materials such as iron pipes, steel sheets, water tanks, and so. As a result of this load, it will result in the distribution of the load on the Landing Craft Tank ship. With a change in the ship's framing system, there will be a change in the stress characteristics. The ship is made to transport heavy equipment and vehicles, and the repeated loading and unloading process can have impacts on the strength of the ship to accept the amount of stress and strain of this ship. The bottom

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is the part immersed in the water, so this part is the vulnerable part. Therefore, it is necessary to systematically predict the weight of the load that can be held by the ship at the bottom, this is so that there is no damage to the structure at the bottom of the ship which can harm the company from the ship owner. Moreover, this LCT ship is a conversion from SPOB ship where these two ships have different functions, where previously the tank loaded oil after the ship converted the inside of the tank into a void tank [2].

In shipbuilding engineering, all components have a certain physical size for the load on the component, which must be measured precisely to withstand the forces to be applied to them. In the development of shipyards, the construction plan is one of the main factors. As for what affects the strength of the construction, namely the distance between frames, longitudinals spacing, length of unsupported beam, sections properties of beam and plate etc. Strength analysis on bottom structure aims at estimating forces experience by the bottom in order to anticipate the stress and strain that can harm the ship's structure, Besides that, there is still little literature that discusses this conversion ship where the bottom area structure does not change the previous construction [3].

Previous studies have examined numerous ship construction problems using finite element method. For example, Pawara et.al, examined the structural strength of Ferry Ro-Ro's car deck [4], with the same ship, Alamsyah et.al, investigated the fatigue life of the rampdoor [5], and analysed strength and fatigue life of sedan car ramp of Ferry Ro-Ro [6]. Wulandari. et.al, analysed of longitudinal strength of deck of a container ship [7], and performed strength analysis of the deck of ship conversion SPOB to LCT [8]. However, the purpose of this study is to determine the maximum stress and strain that can be received by the ship on the bottom structure of the ship and determine the value of the safety factor in the bottom construction of the ship after and before conversion using the same method.

2. Materials and Methods

2.1 Ship Data

The main dimensions of the ship are given in Table 1.

Table 1. Main Dimension.

Dimension	Notation	Value (m)
Length Overall	L_{OA}	42.15
Length Water Line	L_{wl}	37.2
Breadth	B	8
Height	H	2.4
Draught	T	2.05
Coefficient Block	Cb	0.82

2.2 Local Load

Local loads are loads that only affect certain parts of the hull, one of which is pounding stress. Severe local stress occurs at the bottom of the bottom and the forward frame when the ship is pushed upstream. Pounding stress is known to be most severe under light weight conditions, and occurs in the bottom shell area in front of the impact bulkhead [10].

2.3 Concentrated Load

Concentrated load is a load that is concentrated in a place or a field. In this case, it can be formulated as follows:

$$Concentrated\ Load = \frac{Wobject}{Total\ Tires} \quad (1)$$

2.4 Side Load

The submerged side load of the ship can be calculated and its value is found based on the calculation of the rules of BKI 2016 vol II Sec.IV.B.2.1:

$$Ps = 10(T - z) + Po.Cf(1\frac{Z}{T}) \quad (2)$$

where:

Po= basic external dynamic load

T=ship draft

Z= vertical distance of the center of the load from the base line

2.5 Bottom Load

The bottom load can be calculated and the value found based on the calculation of the 2016 BKI

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Vol.II Sec.IV.B.3 rules:

$$Pb = 10.T + Po.Cf \quad (3)$$

Where:
Po= basic external dynamic load
T= ship draft
Cf= distribution factor

2.6 Sloshing Load

In the present study, the calculated load is the load that moves in the cargo hold before the conversion where the previous ship was an SPOB ship. Therefore the load used is 80% by using the following equation [11]:

$$Pslh-t = 7\rho g f slh\left(\frac{bslh}{B}0.3\right)GM^{0.75} \quad (4)$$

Where:
ρ=Density of diesel oil
g=acceleration due to gravity 9.81 m/s2
fslh= 1-2(0.7-(bslh/B-0.3) GM0.75
GM=0.3.B

2.7 Finite Element Method

The finite element method is a numerical method that is suitable for use with digital computers, with the use of this method an elasticity continuum is divided or discreted into several sub-structures or elements which are then used by a matrix, the deflection of each point or node and associated with loading, material properties, geometric properties and others. The finite element method has been widely used to solve various kinds of mechanical problems with complex geometries [12].

3. Results and Discussion

3.1 Modelling

At this stage, the modeling process is carried out by using 3-D Autocad software, and then the model is imported to Ansys Workbench. The model is shown in Figure 1. The construction process begins by defining the geometry for each element to be made according to its shape, size and type of property. The geometry of the model is made into a system that is interconnected to become a single unit in the model construction system.

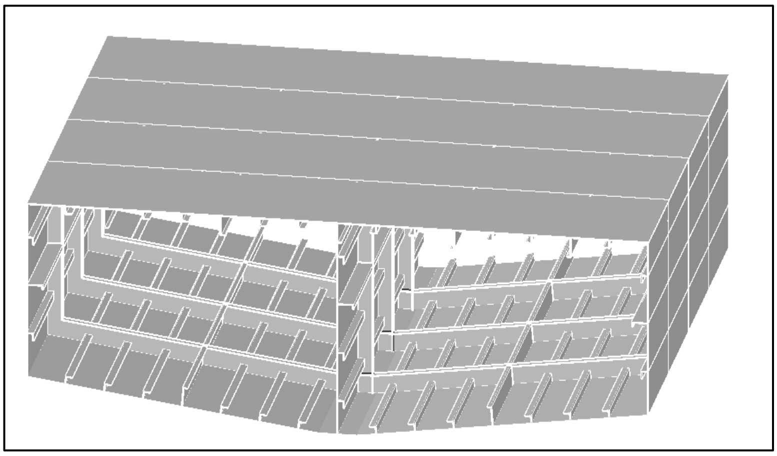

Fig. 1. 3-D Autocad model.

3.2 Mesh Convergence

The meshing stage is the stage of uniting the segments in the model to be analyzed so that the simulation process can be carried out. This process is also a step in dividing the geometric structure into smaller ones using ansys workbench software.

Meshing convergence is the determination of the number of iterations before the calculation. Where this determines the number of elements and the accuracy of the solution that can be accepted in an analysis carried out on the model, one of which is stress data, from each mesh variation the mesh size with the highest stress is used, this is due to the more accurate data obtained. Where the variation data used are 50 mm, 60 mm, 70 mm, 85 mm, it can be seen in Table.2. From the results of the mesh convergence, the mesh size is 50 mm.

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Table 2. Mesh Size

Mesh Size(mm)	Total Stress (MPa)	Nodes
50	96.349	83436
60	95.444	57169
70	96.174	42842
85	73.657	28310

3.3 Loading

3.3.1 Wave Coefficient (co)

$co = \frac{L}{25} + 4.1\ co = 4.19$ (5)

$\mathrm{cL} = \text{lenght coefficient cL} = \sqrt{\frac{L}{90}} \text{for L} < 90 \text{ m}$

$\mathrm{cL} = 0.6843488$

3.3.2 Basic External Dynamic Load (Po)

$$Po = 2.1\,.\,(Cb + 0.7).\,Co.\,Cl.\,f.\,Crw$$

$Po = 9.15\frac{kN}{m2}$ for leather plate, weather deck ; $= 6.87\frac{kN}{m2}$ for Main Frame, deck beam

$= 5.49\frac{kN}{m2}$ for web frame

$Crw = service\ range\ coefficient = 0.75$

$f = 0.75$ main frame, deck beam

3.3.3. Deck Load

$$Pd = \frac{(Po.\,20.\,T.\,Cd)}{(10 + Z - T).\,H}$$

$Pd = 15.11\ kN/m2$ for weather deck plate

$Pd = 11.33\ kN/m2$ for deck beams

$Pd = 9.07\ kN/m2$ for large beams, deck supports

3.3.4. Side Load

$$Ps = 10(T - z) + Po\,.\,Cf\ \left(1 + \frac{z}{T}\right) kN/m2$$

$Ps = 0.0212\ kN/m2$ for girder system

$Ps = 0.0231\ kN/m2$ for frames

$Ps = 0.026\ kN/m2$ for plates

3.3.5. Bottom load

$$Pb = 10\,.\,T + Po\,.\,Cf\ \ kN/m2$$

$Pb = 27.6\ kN/m2$ for frame base on open wrang

$Pb = 29.925\ kN/m2$ for bottom plate

3.4 Strength Analysis After conversion

Figure 2 shows the top view of the truck on the ship deck from 11 to frame 15, the load on the deck of the ship is loaded with trucks weighing one truckload of 8 tons, the load used on the deck is a centralized load, to find the actual load acting on the deck. then the unit load ton is changed to Newton where the result is 79712 N then the result is multiplied by gravity of 9.8 m/s2. The loads that applied in the analysis are given in the Table 3.

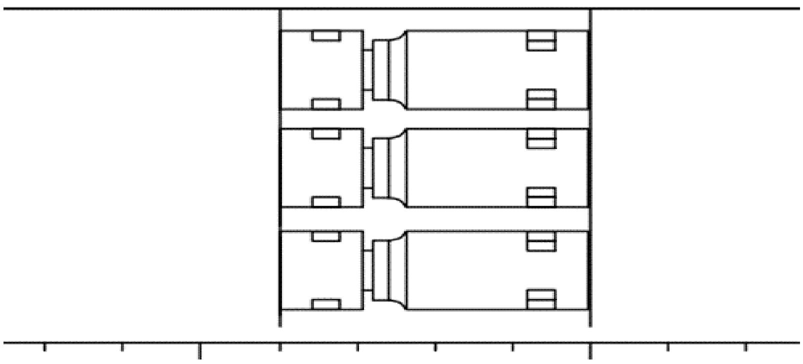

Fig. 2. Top View of Truck.

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Table 3. Load

Load	Value	Unit
Point Load	130.196	kN
Side Load	0.00151	MPa
Bottom Load	0.0039	MPa

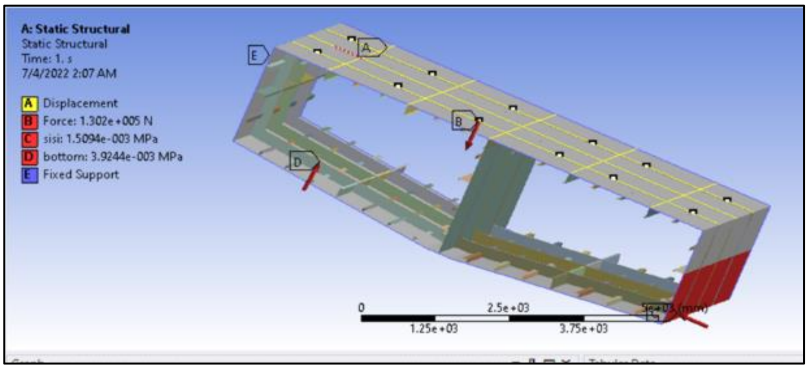

Fig. 3. Model Load.

At this stage, the load input stage is carried out on the LCT ship model, then input the load from the value that has been obtained for the running process.

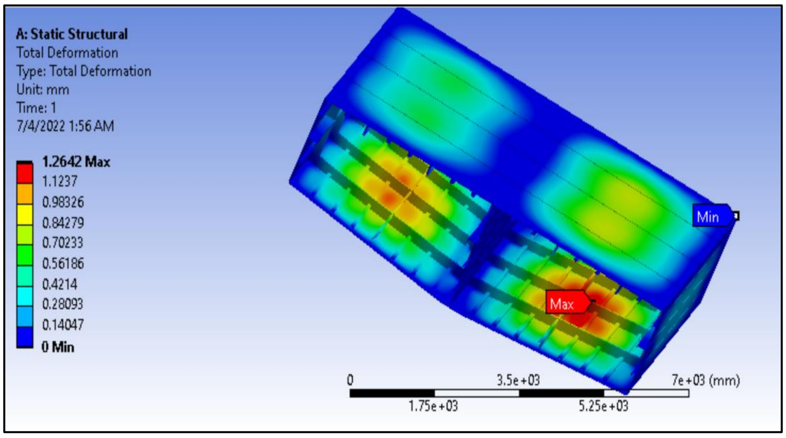

Fig. 4. LCT Model with total deformation.

Figure 4 shows the results of running the ship's load after load correction, it shows that the total deformation is 1.2642 mm at nodes 83436, where the load acts in the direction of the z-axis.

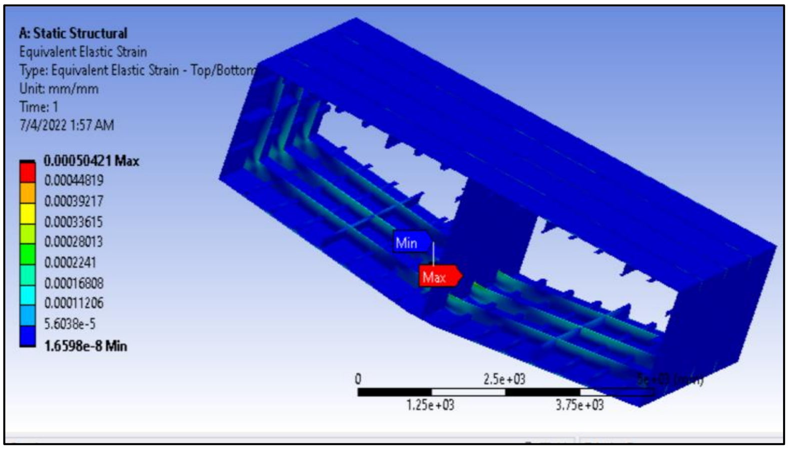

Fig. 5. Strain on LCT model.

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Figure 5 reveals the second results obtained in running the load, the maximum total strain obtained is 5.042 x 10-4 mm at nodes 83436, where the load acts in the direction of the z-axis.

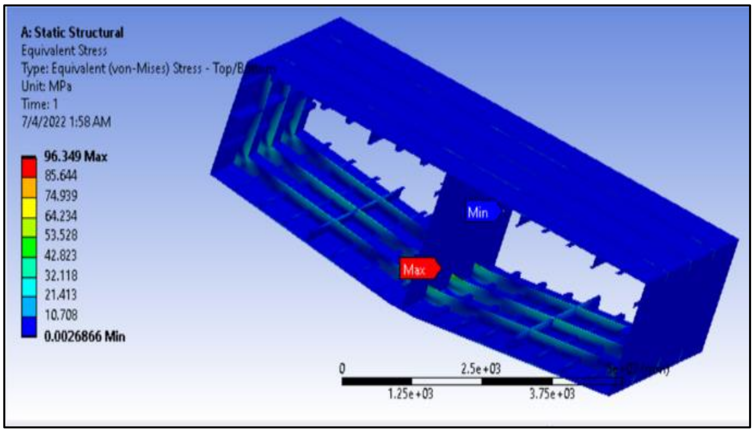

Fig. 6. Stress on LCT model.

Figure 6 reveals the third result obtained when running the load is the maximum stress received by the model of 96,349 Mpa at nodes 83436, the load acting on the model is in the z-axis direction.

3.5. Strength Analysis before conversion

The load used on the ship model before the SPOB conversion is the sloshing load with the load calculation as follows:

$$Pslh\text{-}t=(7 \times 0.917 \times 0.98)\times((\frac{8}{8})-0.3)\times 1.9282$$

$$Pslh\text{-}t=0.005950441 \text{ Mpa}$$

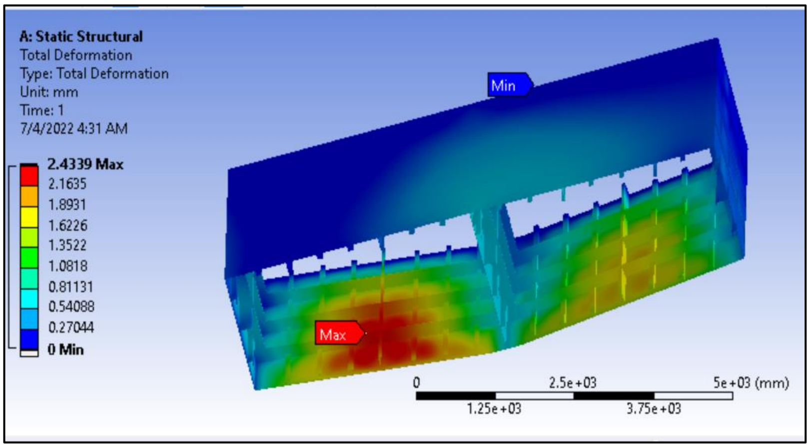

Fig. 7. SPOB model deformation.

After getting the sloshing load that will be used in the SPOB model, it will continue with the load running stage. Figure 7 shows the results of running the load on the ship model before it was changed, namely the SPOB model, it was found that the maximum total deformation was 2.4339 mm at node 79299. The load acting on the model was in the z-axis direction.

Figure 8 shows the results of running the load, the maximum strain on the SPOB model is 0.0013628 mm at node 79299. For the minimum strain, the model obtained is 2.768 x 10-8 mm. For the value of the working strain in the direction of the z-axis.

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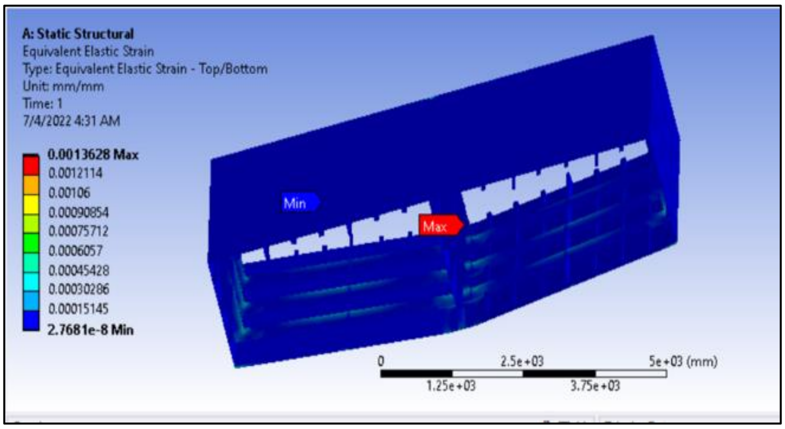

Fig. 8. SPOB model strain.

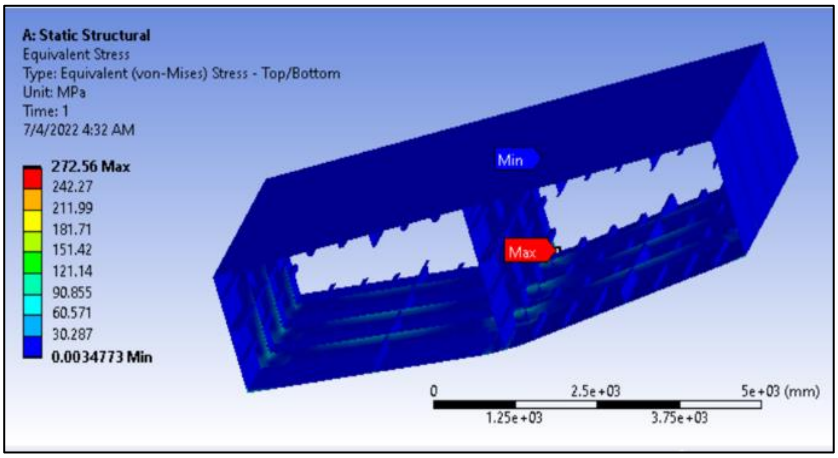

Fig. 9. SPOB stress model.

Figure 9 shows the results of running the load, the maximum stress in the SPOB model is 272.56 Mpa at node 79299 for the minimum stress obtained in the model of 0.0034773 Mpa. For the value of the working stress in the direction of the z-axis.

3.6. Safety Factor

Table 4. Safety factor according to BKI.

Model	Yield Strength (MPa)	Maximum Stress(MPa)	safety factor	
SPOB	319,444	272.56	1.172	Satisfied
LCT	319,444	96,349	3.315	Satisfied

Table 5. Safety factor based on material criteria.

Model	Yield Strength (MPa)	Maximum Stress (MPa)	safety factor	
SPOB	355	272.56	1.368	Satisfied
LCT	355	96,349	3.685	Satisfied

Table 6. Maximum deformation (IACS or BKI).

Model	Deformation Limit (mm)	Maximum Deformation (mm)	safety factor	
SPOB	8.000	2.4339	3.287	Satisfied
LCT	8.000	1.2642	6.328	Satisfied

4. Conclusions

Based on the results of the analysis carried out using the finite element method is The greatest maximum working stress that occurs before and after conversion is carried out in frames 11 to 15, respectively, is 272.56 Mpa and 96,349 Mpa. The maximum working strain that occurs before and after conversion is carried out on frames 11 to 15 is

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0.0013628 mm and 5.042 x 10-4 mm respectively. The safety factor in the model in frame 11 to frame after modification based on BKI, the BKI safety factor value is 3,315, safety factor based on material criteria is 3,685 and the maximum deformation safety factor is 6,328 from the analysis results of the ship after being converted, while when the ship not converted, the ship's safety factor before conversion was 1,172, the safety factor based on material criteria was 1,302, and the maximum deformation of the ship before conversion was 3,287. So it can be concluded that the model before and after the conversion is declared safe from these data, it can be concluded that this ship model is stronger in construction when used for the LCT ship mode.

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