Analysis on Deck Ship Conversion SPOB to LCT 234 GT Using Finite Element Method

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***Abstract*—Landing Craft Tank (LCT) is a sea transportation that serves to carry various types of cargo and heavy mining equipment and has a large size. In shipbuilding, the construction structure on the ship is not only designed to be able to accept the load from the cargo being transported but also must be able to withstand external loads caused by waves. With the modification of the Self-Propelled Oil Barge (SPOB) ship into a Landing Craft Tank (LCT), the calculation and planning process on the deck structure of the Landing Craft Tank (LCT) ship really needs to pay attention to the stress and strain strength in order to meet the safety factors that have been set in accordance with the applicable rules. This study aims to determine the maximum allowable stress value and the safety factor of the modified structure of the Landing Craft Tank (LCT) ship deck construction. The method used in this research is the finite element method. In this study uses 2 variations of the type of support "Tee Bar" and "Angle Bar". The results of this study the value of material deformation that occurs on the ship's deck with a variation of "Angle Bar" of 1.1497 mm and the value of material deformation that occurs on the deck of a ship with a variation of "Tee Bar" of 0.97269 mm. The maximum stress value acting on the ship's deck with the "Angle Bar" profile variation is 152.64 MPa and the maximum strain value is 0.00072686 mm/mm. The maximum stress value acting on the ship's deck for the "Tee Bar" profile variation is 147, 63 MPa and the maximum strain value is 0.000703 mm/mm. The value of the Safety Factor based on the criteria for the material on the ship's deck is obtained by comparing the yield stress value of the material and the maximum working stress must be greater than 1, then the deck construction with the variation of the "Angle Bar" profile is 2,326 and for the variation of the "Tee" profile type. Bar" 2,405 are categorized as safe. As for the Safety Factor based on BKI rules for the variation of the "Angle Bar" profile of 1,638 and for the variation of the "Tee Bar" profile of 1,693 it is categorized as safe. then the deck construction with the variation of the profile type "Angle Bar" is 2,326 and for the variation of the profile type "Tee Bar" 2.405 is categorized as safe. As for the Safety Factor based on BKI rules for the variation of the "Angle Bar" profile of 1,638 and for the variation of the "Tee Bar" profile of 1,693 it is categorized as safe. then the deck construction with the variation of the profile type "Angle Bar" is 2,326 and for the variation of the profile type "Tee Bar" 2.405 is categorized as safe. As for the Safety Factor based on BKI rules for the variation of the "Angle Bar" profile of 1,638 and for the variation of the "Tee Bar" profile of 1,693 it is categorized as safe.**

Keywords—Landing craft tank (LCT), stress, strain, safety factor.

I. Introduction

Kalimantan is one of the largest islands in Indonesia which has very abundant natural resources, especially in the oil and gas and mining sectors [1]. In Kalimantan, there are many ships such as Landing Craft Tank (LCT), Self-Propelled Oil Barge (SPOB), Barge and Tugboat. These ships are used as transportation for transporting oil and gas and mining products [2]. Landing Craft Tank (LCT) is a sea transportation that serves to carry various types of cargo and heavy and large mining equipment [3]. With the development of the mining industry in the Kalimantan area, the demand for heavy equipment as a means of transporting mining products is also getting higher [2]. Therefore, recently, many ship modifications have been carried out to support the distribution of heavy mining equipment in the Kalimantan area. One of them is by modifying the LCT ship [4].

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In shipbuilding, the construction structure on the ship is not only designed to be able to accept the load from the cargo being transported but also must be able to withstand external loads caused by waves. Therefore, the calculation at the time of designing the ship's construction must be considered. This is done to prevent the ship from getting excessive loads [5]. As an oil carrier, the construction of the Self-Propelled Oil Barge (SPOB) ship is not too focused on the strength of the deck. Because the cargo on the Self-Propelled Oil Barge (SPOB) ship is in the hull, during the calculation and planning of the construction structure, the focus is on the strength of the hull. Unlike the Landing Craft Tank (LCT) ship which receives a very large load, caused by cargo carried on the deck of the ship. With the modification of the Landing Craft Tank (LCT) ship, the calculation and planning process on the deck structure of the Landing Craft Tank (LCT) ship really needs to pay attention to the stress and strain strength in order to meet the safety factors that have been set in accordance with applicable rules [6].

In the calculation and planning of the profile in designing the construction structure on the ship, it must not exceed the maximum allowable stress. Because if at the time of planning the profile of the planned ship construction structure it cannot withstand the load with the maximum accepted stress limit, then the value of the stress received by the ship will be even greater. This is what causes deformation and even fatigue in the ship's construction structure caused by repeated load cycles [5].

With the conversion of SPOB ships to LCT, this study aims to determine the strength of the ship with the maximum allowable stress and strain values and the safety factor of the modified Landing Craft Tank (LCT) deck structure.

II. METHOD

A. Study of literature

The work on the Final Project must be carried out with systematic preparation techniques in order to facilitate the steps to be carried out, such as conducting a literature study. This process is carried out by collecting references such as research journals, scientific publications and theoretical books related to the issues raised. In understanding and studying the systematic calculation that will be carried out to facilitate the work on the Final Project.

- Deformation

  What is meant by elastic deformation is the deformation that occurs due to a load and if the load is removed, the material will return to its original size. Meanwhile, plastic deformation is a permanent deformation if the load is removed [7].

$$\delta = \frac{P \times L}{A \times E} \tag{1}$$

Where :
P = Load (N)
A = Surface area (mm^2)
L = Initial length (mm)
E = modulus of elasticity (N/mm^2)

- Voltage

  Stress is a measure of the ability of a material to transmit loads, and the intensity of the stress in the material, which is the load per unit area, is often expressed. The load per unit area is only obtained by dividing the given load by the cross-sectional area of the material [8].

$$\sigma = \frac{F}{A} \tag{2}$$

Where :
σ = stress (N/mm^2)
F = force acting or load (N)
A = cross-sectional area (mm^2)

- Shear Stress

  Shear stress is the stress that occurs as a result of two opposing forces that are not perpendicular to the plane of an object. Shear stress is different from tensile and compressive stress because shear stress is caused by a force that works parallel or in the direction of the force-resisting plane, while tensile and compressive stresses are caused by a force that is perpendicular to the area of the force-resisting plane [9].

$$\varepsilon = \frac{\Delta L}{L} \tag{3}$$

Where :
ε = strain
L = increase in length (mm)
L = original length (mm)

- Finite Element Method

  The finite element method is a numerical method for solving engineering and mathematical physics problems. Common problem areas of interest in engineering and mathematical physics that can be solved using the finite element method include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential [10].

B. Data analysis

The object of this research is the deck girder on the deck of the SPOB to LCT conversion ship with variations in the supports in the form of Angle Bar and Tee Bar, namely analysis of stress and strain that occurs using finite element-based software (finite element method). Data analysis is carried out with the initial step of making a model using CAD software which is then exported to Finite Element Method software. After the model is completed, combine models, meshing, input loading, pedestal, and others. Then run with the help of the software used and the results obtained in the form of output data that can be used as parameters for the analysis results such as stress values and also deformations.

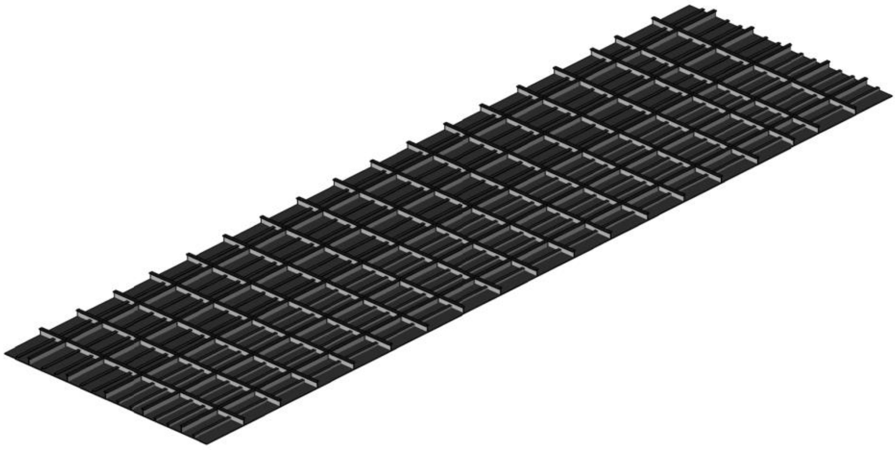
- Main Size of Ship

  In this study using a ship Landing Craft Tank (LCT) with data on the main size of the ship can be seen in Table 1 below:

TABLE 1.
MAIN SIZE DATA OF SHIP

Particular	Size	Unit
LOA	42.15	m
LWL	37.2	m
B	8	m
H	2.4	m
T	2.05	m
Cb	0.82	-

- Model Making
  The next step after the main size data of the ship is obtained is making a model using CAD software in 3D. The model made is located on the deck of the ship by varying the types of deck supports in the form of Angle Bars and Tee Bars in the following figure:



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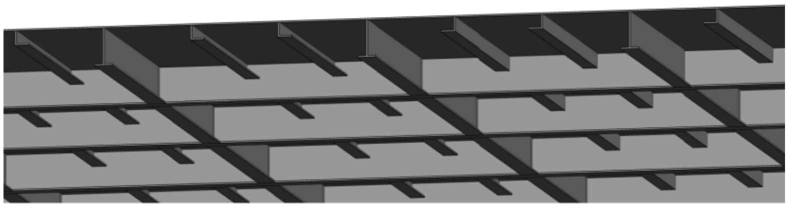
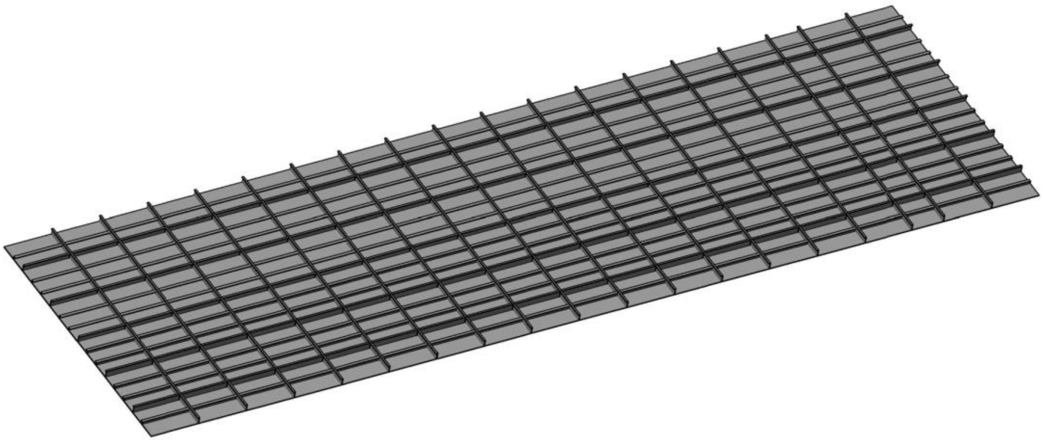


(b)
Figure. 1. 3D Tee Bar construction details.



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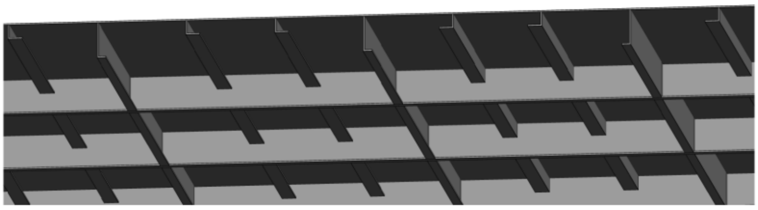


(b)
Figure. 2. 3D Angle Bar construction details.

III. Results and Discussion

A. Load Calculation

In this study, the assumed load is the ship's load when carrying loads in the form of an excavator under dynamic external loads and deck loads.

- Vehicle load on the ship deck

  Calculations in determining the load loaded by the ship will be used to provide the actual load on the ship's deck which has an area of 224 m2. Giving this load will be used at the stage of the model that is designed to be running. Where the load to be loaded on the ship's deck is Excavator PC 200-8 LC. The calculation of determining the load is done in actual and manually by using a simple calculation of determining the weight of the load.

$$W_{load} = \frac{ModelLoadWeight}{ActualModelArea} \tag{4}$$

Where :
W = 1,11111E-06 ton/mm^2 (load for 2 wheels)
W = 5,55556E-07 ton/mm^2 (load for 1 wheel)
W = 0,005535569 MPa

- Dynamic external load on the ship

$$P_O = 2{,}1 \cdot (C_b \cdot 0{,}7) \cdot C_O \cdot C_L \cdot f \tag{5}$$

Where:
C_o = wave coefficient
C_b = block coefficient
f = probability factor
C_L = length coefficient
C_{rw} = service range coefficient

- Deck load on the ship

$$P_D = P_O \frac{20 \cdot T}{(10 + z - T) \cdot H} \cdot C_D \tag{6}$$

P_O = basic external dynamic load
C_D = distribution factors
T = draft
H = height
z = vertical distance from load center to baseline

By using the assumed load approach formula, the results are shown in Table 2.

TABLE 2.
LOAD CALCULATION RESULTS

Load	Quantity	Unit
P_O	5.49	[kN/m2]
P_D	9.07	[kN/m2]

B. Calculation Modulus Variation Construction

Calculation of profile modulus based on BKI Vol. II Rules for Hull 2017 Section 10 B. 4.1 by using the following formula [11]:

$$W = c \cdot e \cdot l^2 \cdot p \cdot k \tag{7}$$

Where:
W = modulus
c = coefficients
e = girder span
l = unsupported span
p = load on Weather Decks
k = steel factor

- Deck girder with Angle Bar

  After calculating the minimum modulus with a surface area of 1,02 cm^2. Then the profile can be determined as follows:
  Profile selection:
  Modulus =166,27(cm^3)
  Dimension = L 200 x 50 x 8 mm

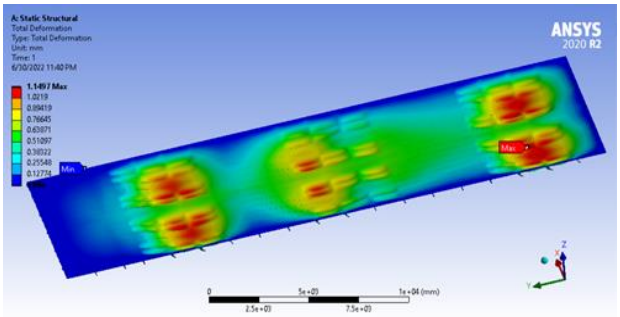
- Deck girder with Tee Bar

  After calculating the minimum modulus with a surface area of 51 cm^2. Then the profile can be determined as follows:
  Profile selection:
  Modulus =194,15(cm^3)
  Dimension = T 200 x 100 x 8 mm

C. Analysis Results

The results of the analysis with the help of finite element software are the value of material deformation, maximum stress (equivalent maximum stress), and maximum strain (equivalent elastic strain) on variations of deck support construction.

The deformation material value for the Angle Bar and Tee Bar construction variation is as follows:



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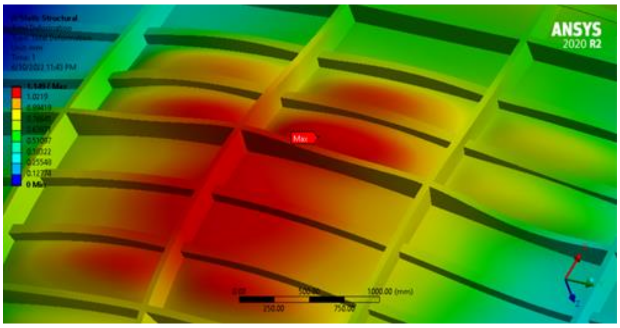
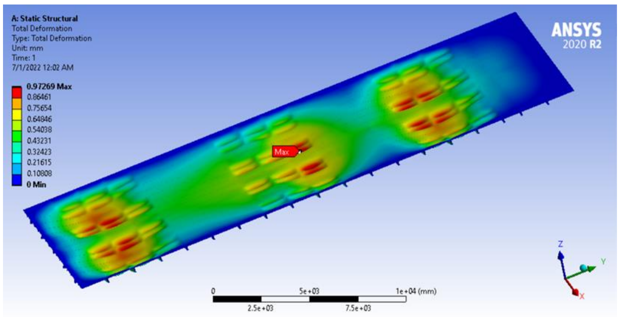


(b)

Figure. 3. Results of running total deformation Angle Bar

Figure 3 shows the deformation value in the construction of the ship's deck with the actual and centralized load in the form of vehicle wheel area using an Angle Bar profile of 1,1497 mm which occurs at node 141360.



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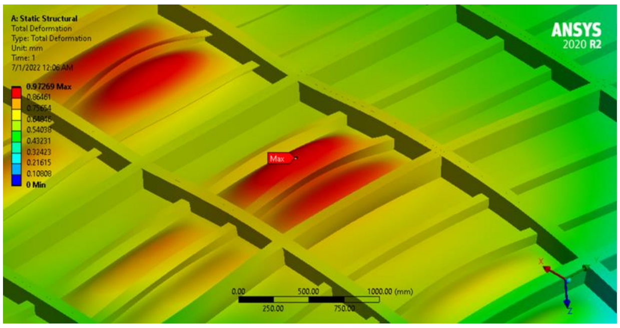
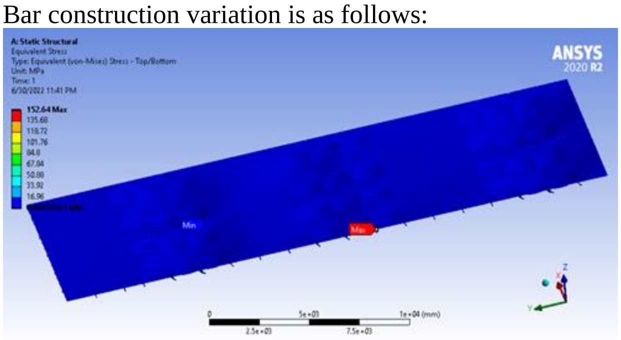


(b)

Figure. 4. Results of running total deformation Tee Bar

Figure 4 shows the deformation value in the construction of the ship's deck with the actual and centralized load in the form of vehicle wheel area using a Tee Bar profile of 0,97269 mm which occurs at node 146459.

The maximum stress value for the Angle Bar and Tee Bar construction variation is as follows:



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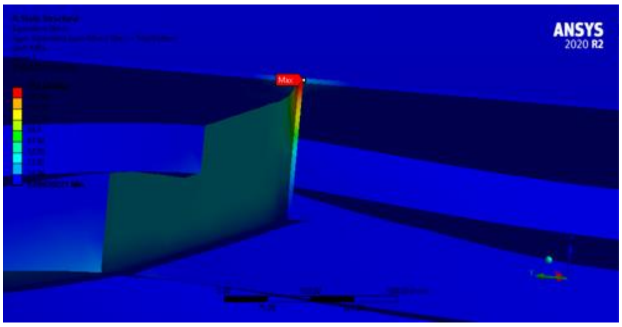
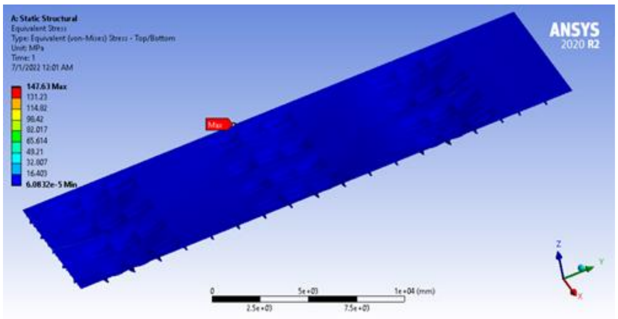


(b)

Figure. 5. Results of running maximum stress Angle Bar

Based on Figure 6 shows the maximum stress value (equivalent maximum stress) on the deck construction of the Angle Bar variation that occurs is 152,64 MPa which occurs at node 141360.



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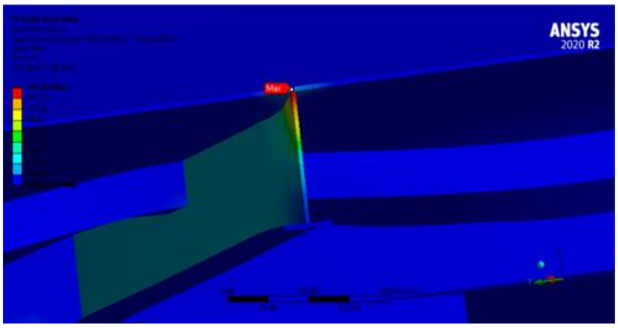
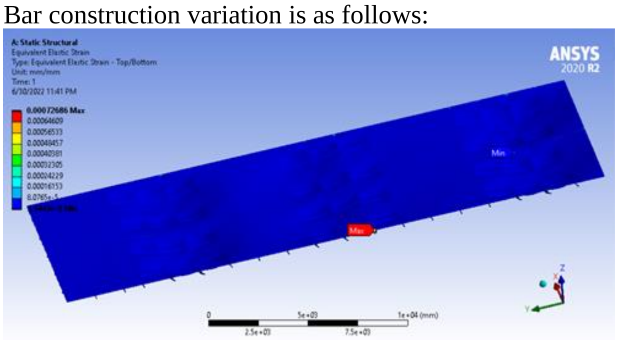


(b)

Figure. 6. Results of running maximum stress Tee Bar

Based on Figure 6 shows the maximum stress value (equivalent maximum stress) on the deck construction of the Tee Bar variation that occurs is 147,63 MPa which occurs at node 146459.

The maximum strain value for the Angle Bar and Tee Bar construction variation is as follows:



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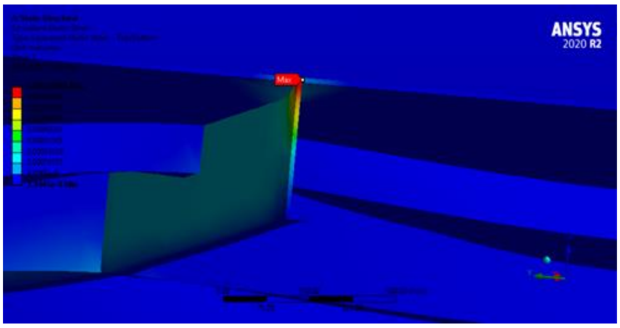

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Figure. 7. Results of running maximum strain Angle Bar

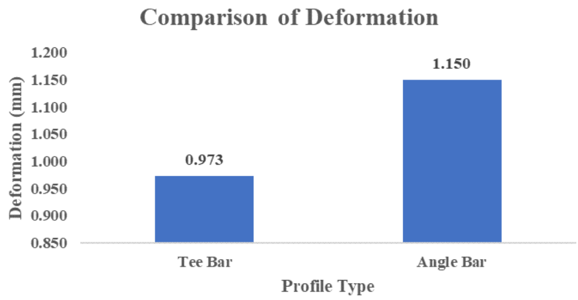
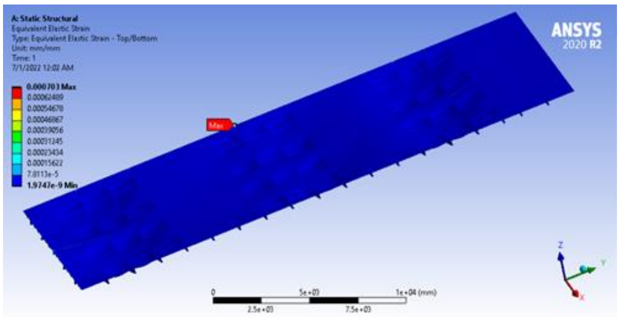


Figure. 9. Deformation Comparison Chart

TABLE 3.
COMPARISON OF THE MAXIMUM DEFORMATION IACS

No.	Model	Simulation Deformation (mm)	Maximum Deformation (mm)	Description
1.	Angle Bar	1,1497	8	Fulfill
2.	Tee Bar	0,9726	8	Fulfill

Based on Figure 7 shows the maximum strain value (equivalent elastic strain) on the deck construction of the Angle Bar variation that occurs is 0,00072686 which occurs at node 141360.



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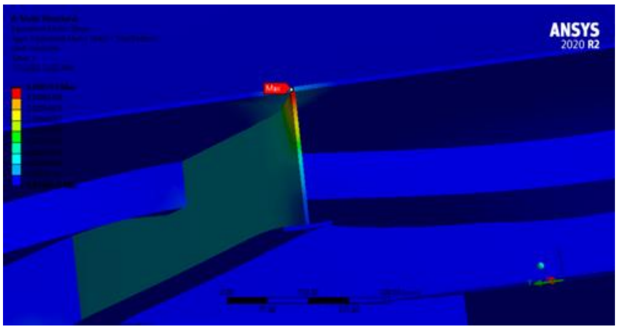

(b)

Figure. 8. Results of running maximum strain Tee Bar

Based on Figure 8 shows the maximum strain value (equivalent elastic strain) on the deck construction of the Tee Bar variation that occurs is 0,000703 which occurs at node 146459.

Based on the analysis, the results of the Total Deformation acting on each element of the ship's deck structure, taking into account the variations in the type of profile that occur in each case are obtained, the comparison curve of the material deformation value in Figure 11 is as follows:

In Figure 9, the maximum deformation value with the actual and concentrated load on the surface of the vehicle wheels is 5.535569E-03 MPa on the variation of the deck construction using the "Angle Bar" profile of 1.1497 mm while on the variation of the deck construction using the profile the “Tee Bar” is 0,97269 mm. The comparison of the maximum deformation value of the analysis with the maximum deformation limit based on IACS No. 47 Shipbuilding and Repair Quality Standard [12] can be seen in Table 3.

Calculation of stress values in finite element-based software requires data in the form of actual and centered loading values on the surface of the vehicle wheels, providing support and also the availability of models or constructions that have been designed on the finite element method-based software that is owned by each loading variation.

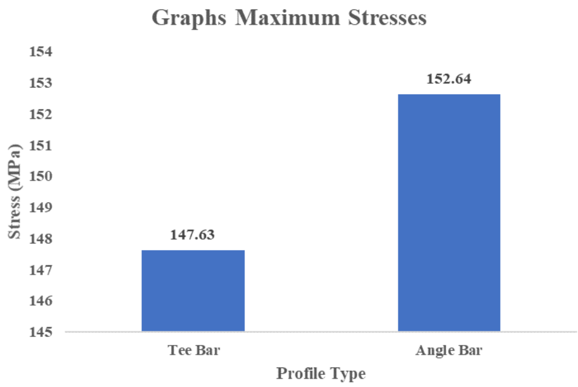

Figure. 10. Equivalent Stress Analysis Chart

In Figure 10, the maximum stress value with the actual and cantered load on the surface of the vehicle wheels is 5,535569E-03 MPa on the variation of the deck construction using the "Angle Bar" profile of 152,64 MPa while on the variation of the deck construction using the profile the “Tee Bar” is 147,63 MPa.

The calculation of the strain value in finite element-based software requires data in the form of actual and centered loading values on the vehicle wheel surface, providing support and also the availability of models or constructions that have been designed on the finite element method-based software that is owned by each loading variation.

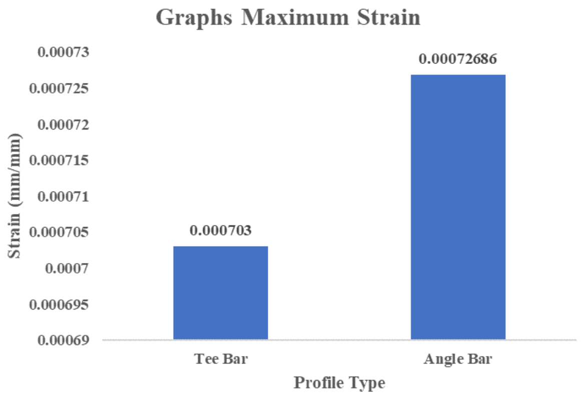

Figure. 11. Equivalent Elastic Strain Analysis Chart

In Figure 11, the maximum strain value with the actual and cantered load on the surface of the vehicle wheels is 5,535569E-03 MPa on the variation of the deck construction using the "Angle Bar" profile of 0.00072686 mm/mm while the variation of the deck construction that uses the "Angle Bar" profile is 0,00072686 mm/mm. using the “Tee Bar” profile of 0,000703 mm/mm.

D. Calculation of Safety Factor

Calculation of safety factor aims to show the ability of the construction to the compressive load and the working tensile load. In this research, the material used is KI-A36 steel. Based on the results of the analysis carried out, a comparison is made between the yield stress of the material and the maximum stress acting on the structure. Where for the safety factor based on the material criteria the value should not be FS>1. by using the equation:

$$FS = \frac{\sigma yield}{\sigma working} \quad (7)$$

σ is the yield stress of the material (N/mm^2), σ working stress is the maximum stress acting on the structure (N/mm^2) and FS is the safety factor (FS>1)
Then the resulting table is as follows:

TABLE 4.
CALCULATION OF MATERIAL CRITERIA SAFETY FACTOR

No.	Model	Maximum Simulation Stress (MPa)	*Yield* Strength (MPa)	*Safety Factor*	Information
1.	*Tee* Bar	147.63	355	2,405	Safe
2.	*Angle* Bar	152.64	355	2,326	Safe

TABLE 5.
CALCULATION OF BKI SAFETY FACTOR

No.	Model	Maximum Simulation Stress (MPa)	*Permissible* BKI (MPa)	*Safety* Factor	Information
1.	*Tee* Bar	147.63	250	1,693	Safe
2.	*Angle* Bar	152.64	250	1,638	Safe

For the allowable stress according to BKI Vol. II Rules for Hull 2017 Section 10 A. 2. The permissible stress should not exceed 180/k, where the value of k can be found in table BKI Vol. II Rules for Hull 2017 Section 2 A. 2.1. Then the data is generated as follows [11]:

Based on Tables 3 and 4, it is obtained that the safety factor value is based on the allowed regulation for the limit of the allowable stress value based on the material criteria and BKI rules. If the value of the safety factor is more than 1, the construction is said to be safe.

IV. Conclusion

The value of material deformation that occurs on the ship's deck with a variation of "Angle Bar" is 1.1497 mm and the value of material deformation that occurs on the deck of a ship with a variation of "Tee Bar" is 0.97269 mm. The maximum stress value acting on the ship's deck with the "Angle Bar" profile variation is 152.64 MPa and the maximum strain value is 0.00072686 mm/mm. The maximum stress value acting on the ship's deck for the "Tee Bar" profile variation is 147.63 MPa and the maximum strain value is 0.000703 mm/mm.

The Safety Factor value based on the material criteria on the ship's deck is obtained by comparing the yield stress value of the material and the maximum stress value must be greater than 1, then the deck construction with the "Angle Bar" profile variation is 2,326 and for the "Tee Bar" profile variation 2,405 are categorized as safe. Meanwhile, the Safety Factor based on BKI rules for the variation of the "Angle Bar" profile is 1,638 and for the variation of the "Tee Bar" profile 1,693 is categorized as safe.

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