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Strength Analysis with Variation of Construction Transverse Watertight Bulkhead On Ship Container 8842 DWT Using Finite Element Method

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Abstract **- Container ship are commonly employed in a variety of countries, particularly in archipelagic countries like Indonesia. It is a construction that is very important to consider when building a transverse watertight bulkhead ship because it serves as a compartment divider when the ship has a leak and also as a transverse strength of the ship. The purpose of this research is to see if various construction modifications of a transverse watertight bulkhead can bear the working load. The finite element method was employed in this study. Five different constructions of the transverse watertight bulkhead were used in this analysis. The highest stress value in the corrugated watertight bulkhead is 252.44 MPa, with a maximum deformation of 7.6433 mm, whereas the maximum stress value in the transverse plane watertight bulkhead with "angle stiffener" is 330.71 MPa, with a maximum deformation of 12,072 mm. on transverse plane watertight bulkhead with “Tee stiffener” The maximum voltage value of 301.56 MPa and value maximum deformation of 11,025 mm, on transverse plane watertight bulkhead with “bulb stiffener” maximum stress value of 331.98 MPa and value of maximum deformation of 13,421 mm, on transverse plane watertight bulkhead with “flat stiffener” maximum stress value is 484.94 MPa and value of maximum deformation of 16.13mm. According to the safety factor calculation, corrugated watertight bulkheads, transverse plane watertight bulkheads with "Angle stiffener," transverse plane watertight bulkheads with "TEE stiffener," and transverse plane watertight bulkheads with "Bulb stiffener" are all considered safe.**

Keywords: *Container; Transverse watertight bulkhead; Finite element method; Stress; Deformation.*

I. INTRODUCTION

In designing and designing ships, many aspects need to be considered to get optimal results, such as ship construction. Ship construction is one of the most important aspects of a vessel to support the safety of the boat in various environmental conditions. The condition of the ship's structure requires periodic checks to ensure the condition of the boat is better when it is operated so that it can anticipate more significant damage [1][2]. [A container ship or commonly called container ship is a type of ship that is often used in various countries, especially in archipelagic countries such as Indonesia.

This ship functions as a container carrier using the container being lifted or transferred to the ship using a crane and then arranged on the ship. [All ships have bulkhead construction. The bulkheads on the ship that are constructed need to be considered because each bulkhead has an important function and varies according to the location of the bulkhead [3], [4]. The bulkheads have various types, including rigid watertight bulkheads and corrugated watertight bulkheads, which of course have different advantages and disadvantages [5], [6]. The transverse watertight bulkhead construction of the ship must be made strong for various conditions to prevent damage such as flooding [7], [8]. The construction of bulkheads on ships is very important because if in the design or design the bulkheads are not made with the right process, there will be a risk of causing accidents to the ship [9], [10]. [Construction variations of corrugated transverse watertight bulkhead and stiffener with “TEE stiffener” profile are still categorized as safe, while for stiffener type “half bulb stiffener” and stiffener profiles with “TEE stiffener” and “angel stiffener” transverse watertight bulkhead are categorized as unsafe [11], [12].

II. METHOD

A. Research location and time

This research was carried out for it was carried out at Naval Architecture Laboratory in Kalimantan Institute of Technology due to the Covid-19 pandemic.

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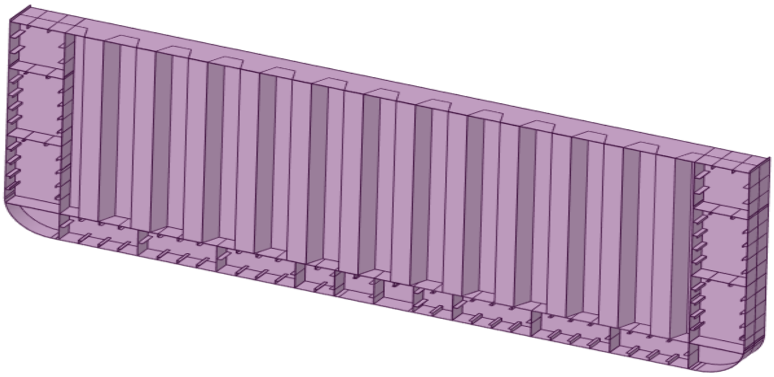

Figure 1 Corrugated watertight bulkhead 3D

B. Study of Literature

The steps taken in this research are looking for references related to the research that will be carried out in the research. To get the appropriate reference obtained from books, journals, the internet, and previous research that has been done. The results obtained in conducting a literature study are getting more accurate references and the research.

E. Model Making

The next step after obtaining basic data on the size of the vessel is to create a model using CAD software. The created model is placed in the middle of the ship at a height of 1240 mm in the three-dimensional form shown in Figure 1 and Figure 2.

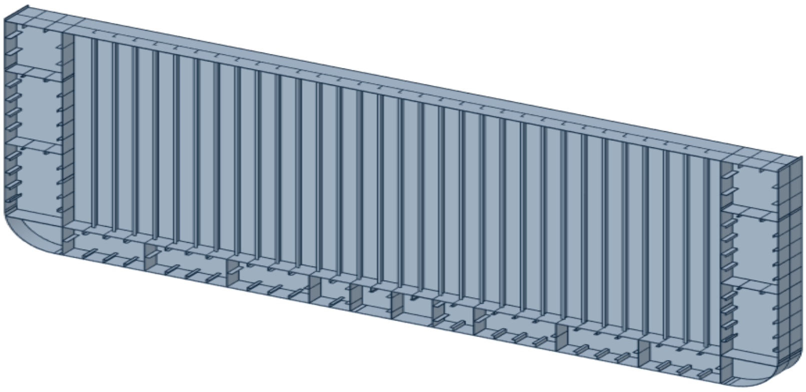

Figure 2**.** Transverse watertight bulkhead 3D

C. Data Analysis

Data analysis was performed at the initial stage when the model was designed using CAD software and then exported to finite element method software [11][12]. Once the model is complete, add models, meshes, input loads, pedestals, etc. It is then run using the software used and the results are obtained in the form of output data that can be used as non-observation results, such as stress and disease-type results [17].

D. Main Dimension of Ship

The vessel size data for this study using containers can be found in Table 1.

III. Results and Discussion

A. *Load Calculation*

In this study, the assumed load is the ship's load in flooding conditions, the base load, the side load below the waterline, and the side load above the waterline.

B. *Shipload in flooding condition*

The flooding condition or seawater entering the compartment is placed in the loading and unloading space where the load acts as pressure [13], [14]. [In determining the magnitude of the working force due to flooding conditions (Pcf) the IACS approach formula (UR-S17 – UR-S20) can be used [4], [15].

TABLE 1
MAIN DIMENSION *CONTAINER*

LOA:	98.9	m
LBP:	92	m
B:	23.5	m
H:	10	m
T:	6.5	m
Deadweight:	8842.2	Ton
Vs:	11	Knot

C. *Side load above the draft water line*

$$Ps = Po \, . \, C_F \, \frac{20}{10 + Z - T} \quad (kN/m^2) \quad (1)$$

$$Po = 2{,}1 \, . \, (C_b + 0{,}7) \, . \, Co \, . \, C_L \, . \, f \quad (kN/m^2) \quad (2)$$

results are shown in the table 2.

F. *Calculation of Modulus of Variation of Transverse Watertight Bulkhead Construction*

The profile modulus calculation is based on BKI volume II Section 11 using the following formula:

TABLE 2
LOAD CALCULATION RESULTS

Load	Quantity	Unit
Pcf	90.50	[kN/m2]
Ps below	65.68	[kN/m2]
Ps above	37.65	[kN/m2]
PB	87.12	[kN/m2]

Which:

Co =*Wave coefficient*
Cb = *Block coefficient*
f = *probability factor*
C_L = *length coefficient*
Crw = *service range coefficient*
T = The vertical distance from the baseline to the draft line
Z = The vertical distance from the load center to the baseline
Cf = *Distribution factors*

D. *Side load below the draft water line*

$$Ps = 10 \, . \, (T - Z) + Po \, . \, C_F \, . \, (1 + z/T) \quad (kN/m^2) \quad (3)$$

E. *Ship's base load*

$$P_B = (10 \, . \, T) + (Po \, . \, C_F) \quad (kN/m^2) \quad (4)$$

By using the assumed load approach formula, the

$$W = Cs \, . \, a \, . \, \ell^2 \, . \, p \quad (\mathbf{cm^3}) \quad (5)$$

Which:

W = *Modulus*
Cs = *Coefficients*
a = *spacing of stiffeners* [m]
ℓ = *unsupported span* [m]
p = *g x h* [kN/m^2]
h = *The distance from the center of the structure to a point 1 m above the side bulkhead deck, in the case of a collision bulkhead, to a point 1 m above the top edge of the side collision bulkhead in the case of a collision bulkhead*

W = 481,417 (cm^3)

G. *Transverse Bulkhead Watertight with Angle Stiffener*

After a minimum modulus calculation with a surface area of 51 cm2. Then the profile can be determined as follows:

Selection of profile:

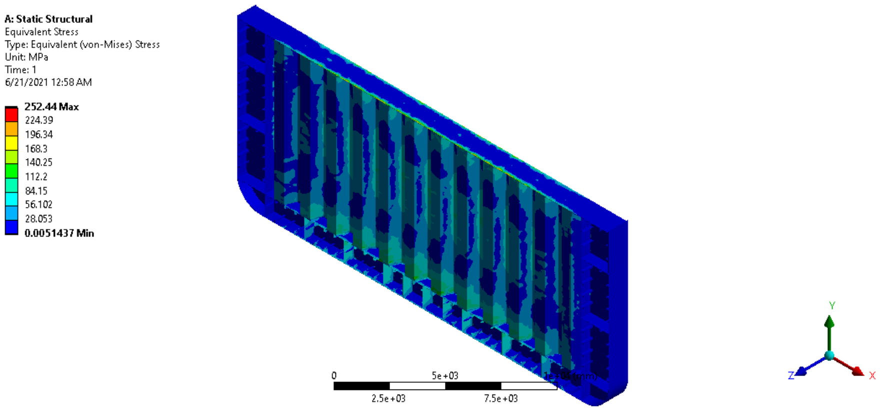

Figure 3. Corrugated Maximum Stress Result

Modulus = 600 (cm^3)
Dimension = L 250 x 90 x 16

H. *Transverse Bulkhead Watertight with Bulb Stiffener*

After calculating the minimum modulus of the area of 51 cm2. The profile can be determined as follows:
Selection of profile:
Modulus = 600 (cm^3)
Dimension = Bulb 280 x 13

I. *Transverse Bulkhead Watertight with Flat Stiffener*

After calculating the minimum modulus of the area of 51 cm2. The profile can be determined as follows:
Selection of profile:
Modulus = 490 (cm^3)
Dimension = I 300 x 17

J. *Transverse Bulkhead Watertight with TEE Stiffener*

After calculating the minimum modulus of the area of 51 cm2. The profile can be determined as follows:
Selection of profile:
Modulus = 609,339 (cm^3) Conform
Dimension = T 250 x 14 Face 120 x 14

K. *Analysis Results*

Analysis of the results using finite element software is the maximum stress and strain. The maximum stress values for the construction variations are as follows:
Based on figure 3, the maximum stress value in the corrugated watertight bulkhead construction in the loading space flooding condition that occurs is 252.44 MPa which occurs at node 53727.

Figure 4 shows the deformation values of the corrugated bulkhead structure in the flooded loading area is 7.6433 mm which occurs at node 26083. Figure 5 shows the maximum pressure (maximum stress) during the construction of the transverse watertight bulkhead with "angle stiffener" under the condition of flooding is 330.71 MPa which occurs in node 17425.

Figure 6 shows the deformation value in the transverse plane watertight bulkhead construction with "angle stiffener" in the loading space flooding condition is 12.072 mm which occurs at node 9774. Figure 7 shows the maximum stress value for the transverse plane watertight bulkhead construction with “TEE stiffener” under loading space flooding conditions is 301.56 MPa which occurred at node 19932. Figure 8 shows the deformation value of the transverse plane watertight bulkhead construction with “TEE stiffener” under flooding conditions of 11.025 mm which occurs at node 10625. Figure 9 shows the maximum stress value in the transverse plane watertight bulkhead construction with "bulb stiffener" in the loading space flooding condition is 331.98 MPa which occurs at node 73532. Figure 10 shows the deformation value of the transverse plane watertight bulkhead construction with "Bulb stiffener" in the loading space flooding condition is 13,421 mm which occurs at node 49046. Figure 11 shows the maximum stress (maximum stress) in the construction of the

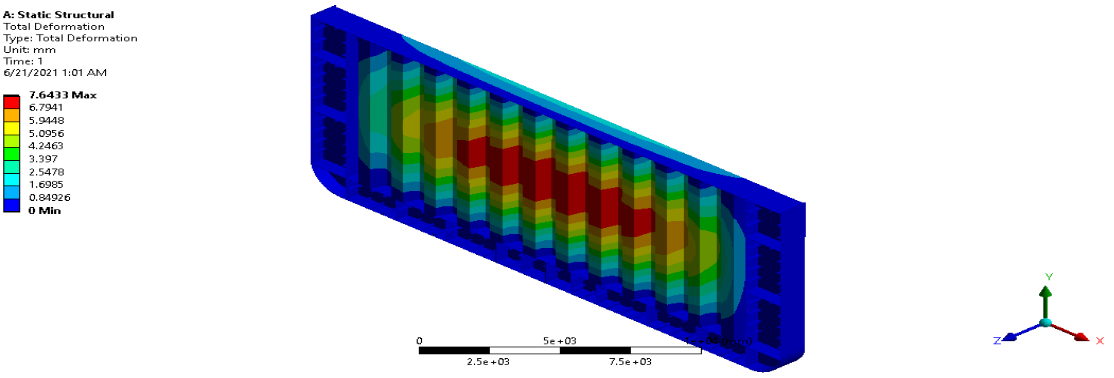

Figure 4 Corrugated Maximum Deformation

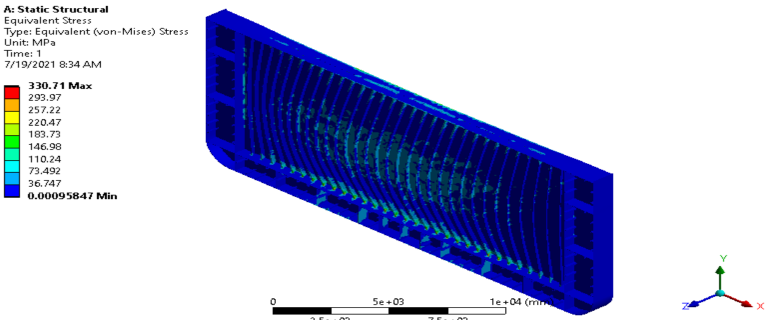

Figure 5. Angle Stiffener Maximum Stress

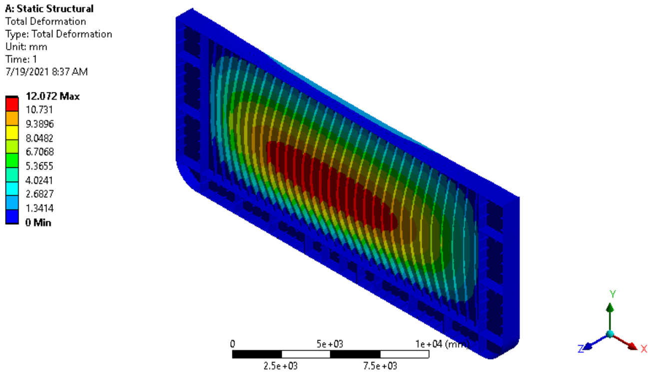

Figure 6. Angle Stiffener Maximum Deformation

transverse plane watertight bulkhead with "flat stiffener" under the condition of the loading space flooding is 484.94 MPa which occurs in node 14652. Figure 12 shows the deformation value in the transverse plane watertight bulkhead construction with "flat stiffener" in the loading space flooding condition is 16.13 mm which occurs at node 12995.

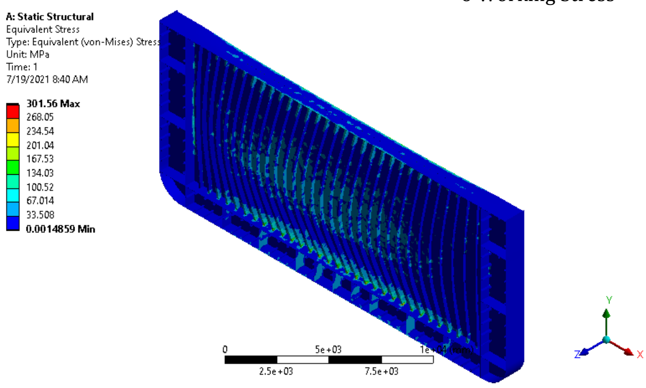

Figure 7. TEE Stiffener Maximum Stress

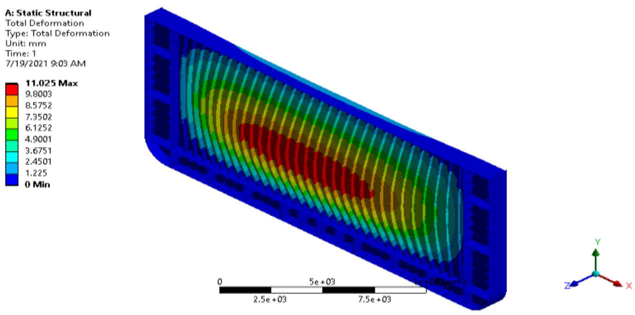

Figure 8. TEE Stiffener Maximum Deformation

L. Safety Factor Calculation

The safety measures aim to show the capacity of the construction to protect the work. The material is KI-A36 steel. Based on the analysis results, compare the material stress results with the maximum simulation using the following equation:

$$SF = \frac{\sigma \text{ Yield Stress}}{\sigma \text{ Working Stress}} \quad (6)$$

Then the resulting table as follows:

Based on the table, the safety factor values are obtained with various construction variations with material safety standards. If the value of the safety factor is more than 1, the construction is said to be safe.

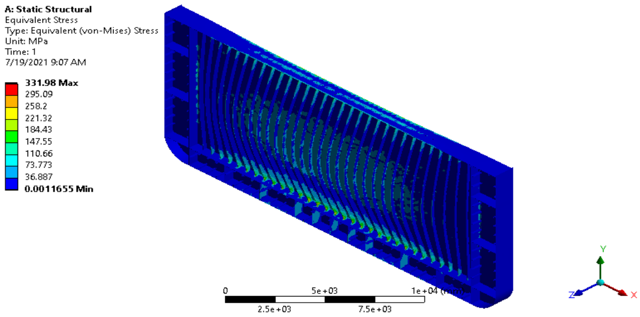

Figure 9. Bulb Stiffener Maximum Stress

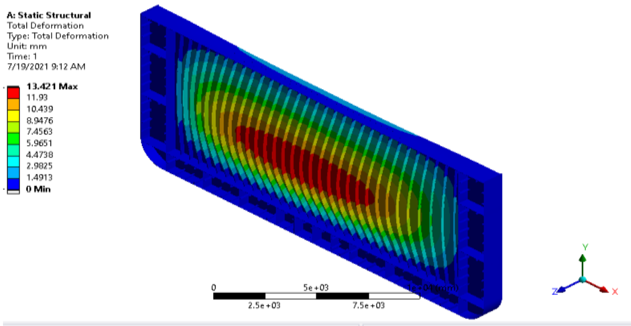

Figure 10. Bulb Stiffener Maximum Deformation

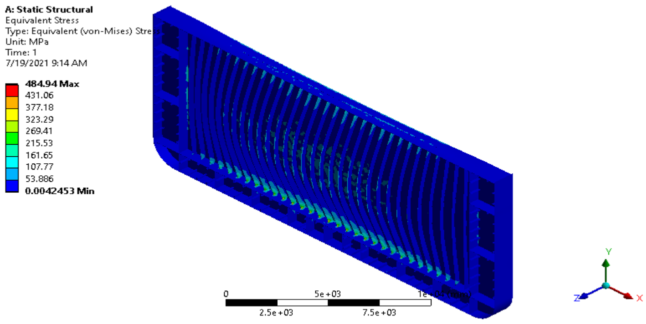

Figure 11. Flat Stiffener Maximum Stress

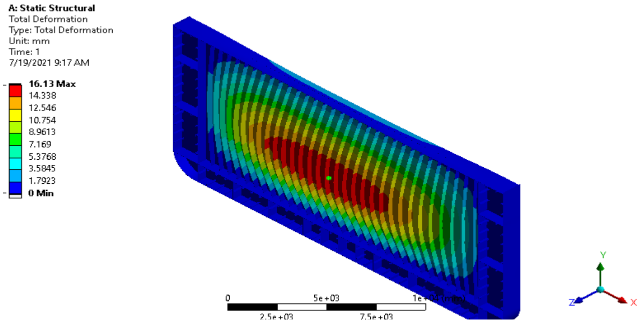

Figure 12. Flat Stiffener Maximum Deformation

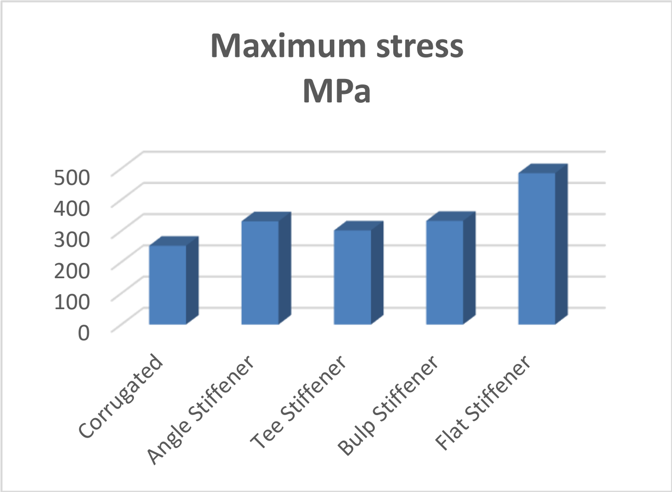

Figure 13. Maximum Stress Analysis Diagram

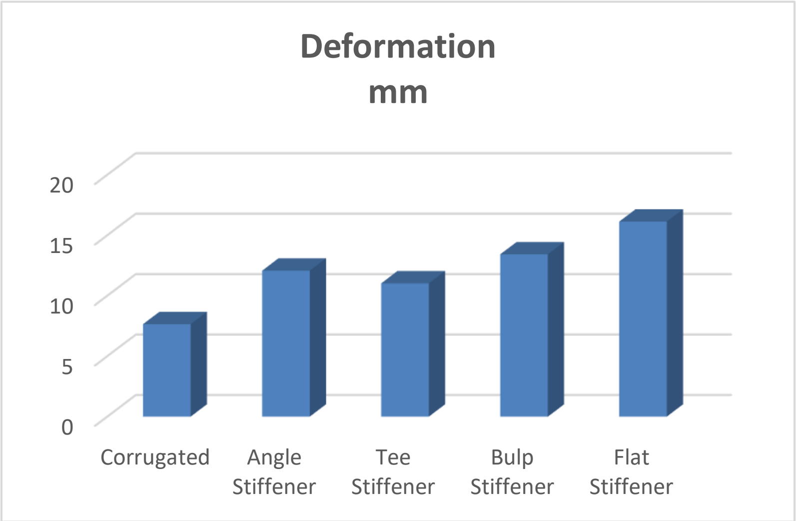

Figure 14. Deformation Maximum Analysis Diagram

TABLE 3.
SAFETY FACTOR CALCULATION

No	Model	Maximum Stress (MPa)	Yield Strength Material (MPa)	Safety Factor	Remarks
1	Corrugated	252.44	355	1.41	Safe
2	Angle Stiffener	330.71	355	1.07	Safe
3	Tee Stiffener	301.56	355	1.18	Safe
4	Bulp Stiffener	331.98	355	1.07	Safe
5	Flat Stiffener	484.94	355	0.73	Not Safe

IV. CONCLUSION

The maximum stress value in the analysis, namely the corrugated watertight bulkhead is 252.44 Mpa; transverse plane watertight bulkhead with "angle stiffener" of 330.71 MPa; transverse planet watertight bulkhead with "TEE stiffener" of 301.56 MPa; transverse planet watertight bulkhead with "bulb stiffener" of 331.98 MPa; and transverse plane watertight bulkhead with "Flat stiffener" of 484.94Mpa.

The maximum deformation value in the analysis is the corrugated watertight bulkhead of 7.6433 mm; transverse plane watertight bulkhead with "angle stiffener" of 12,072 mm; transverse planet watertight bulkhead with a "TEE stiffener" of 11,025 mm; transverse planet watertight bulkhead with a "bulb stiffener" of 13,421 mm; and transverse plane watertight bulkhead with a "flat stiffener" of 16.13 mm.

In calculating the safety factor by comparing the material yield stress with the maximum stress, the construction variations of the corrugated watertight bulkhead, transverse plane watertight bulkhead with "angle stiffener", transverse plane watertight bulkhead with "TEE stiffener", and transverse plane watertight bulkhead with "bulb stiffener", categorized as safe because the value obtained on the safety factor is more than 1. Meanwhile, the construction variation of the transverse plane watertight bulkhead with a "flat stiffener" is categorized as unsafe.

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