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Numerical Investigation of the Laying of Airbag Arrangements on Launching Barges

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***Abstract*- Ship-launching technology is developing rapidly in an effort to reach a point of economic efficiency, time efficiency, security, and flexibility. On the one hand, risks to the process of launching ships using airbags are still present and can occur. Exploding airbags due to the inability to withstand the load has implications for structural damage. Excessive pressure on the airbags can cause structural deformation. This study aims to determine the effect of airbag pressure on the strength of the ship's structure. This study uses finite element-based software to analyze stresses and deformations in ship construction when interacting with airbags. From this study, it was found that the number of airbags used in the two-row layout and cross-over arrangement was 14, with the status of the airbags in terms of load distribution being safe (not broken). The maximum stress value obtained from the simulation on the two-row arrangement layout is 11.62 MPa when it is right in the frame and 9.83 MPa when it is between frames. As well as in the cross-over arrangement layout, the maximum stress is 20.24 MPa when in the frame and 13.84 MPa when in between frames. This phenomenon occurs because of the stress concentration in the frame.**

Keywords- Airbag, Barge, Ship Launch, Stress, Deformation

I. INTRODUCTION

In planning the launching of a ship, a naval architect is required to include variables that are appropriate or at least close to the actual conditions in the field. One of the most important variables is the accurate estimation of the ship's weight and launching equipment. Likewise with the center of gravity of the ship lengthwise from various points of view, such as the center of gravity at the end of the runway, the center of gravity at the front end of the skates, and so on [1]. Various kinds of docking, undocking, and launching technologies have been created to simplify, speed up, increase security, and minimize operational costs. In other words, the launch process is the last part of the repair process and new buildings at the shipyard, whose success is the shipyard's responsibility [2]. Launching a ship can pose risks when using airbags, including the ship's hull being broken due to only being concentrated on a portion of the airbags at the end of the runway, the ship capizing when launched due to overlapping of the airbag rotation, or other risks that can occur [3]. Another risk is the airbag exploding due to overpressure or the airbag not being able to withstand the load. The injuries suffered by the worker were caused by the splashing of sand caused by the bursting of the balloon. While the distance of the balloon burst was about 10 meters from the employees [4]. Studies on ship launching have been carried out. Alamsyah and Setiawan (2021) predict the launch of commercial ships using the end-launching method [1].

The study of the response of the ship's structure when it experiences a collision both during launch and under other conditions is very important to study because it has implications for the shape of the ship when it is in the water, which in fact significantly affects performance when operating. Wulandari et al. (2022) analyzed ship collisions using FE-based numerical simulations [5]. Alamsyah et al. (2021) investigated local stresses in the construction of ship decks using a finite element (FE)-based numerical simulation method [6]. Pawarah et al. constructed a river transportation mode with a load of container logistics [7]. Alamsyah et al. (2022) studied the response of the barge sideboard construction structure under the influence of lateral loads of coal [8]. Analyzing employs a variety of techniques. Although massively numerical simulation methods are spearheading the process because they provide results that significantly represent actual conditions, Liu et al. (2022) conducted a performance test on an unmanned underwater vehicle (UUV) using a numerical simulation method [9]. Alubokin et al. (2021) studied the flow and pressure structures of centrifuges using numerical simulation methods [10]. Khalid and Rahmad (2022) used a numerical simulation method to study the symptoms of the cavitation phenomenon in centrifugal pumps [11]. Yang et al. (2022) used the same method to

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study ship objects' turning and yawing behavior in calm water [12]. Wei & Tezdogan (2022) use the FE method with the help of OpenFOAM software to analyze hydroelastic phenomena on container ships [13]. Likewise, Pawar et al. (2022) studied the structural strength of crossing vessels using the FE method [14]. Alie et al. (2021) estimated the ultimate strength of the double-hull oil tanker cargo area using numerical analysis under the influence of hogging and sagging conditions [15]. Alie et al. (2022) modified the double bottom to determine the limit strength of the structure using numerical simulations under the influence of the global load of the structure [16]. Alie et al. (2020) studied structural damage to FPSO ships due to collisions [17]. Purba et al. (2020) studied the response of the jack-up construction structure during loadcase lifting [18]. Rizkiani et al. (2019) examined the limiting strength of VLCCs that experienced longitudinal bending moments in hogging and sagging conditions [19]. Alie and Latumahina (2019) studied the local construction of ro-ro ferries to determine their strength limit [20]. In this study, a numerical simulation approach was used using the ANSYS software [21].

II. METHOD

The research object is a 300-foot deck barge. Ship data is used to make ship models using the Maxsuf Modeler Advance software to make it easier to carry out data analysis to determine the number of airbags for the distribution of ship loading. Then, to calculate the power of the ship, they used finite element-based software. The ship modeling process employs actual construction dimensions as well as dimensions based on data obtained.

After modeling the line plan of the 300-foot barge, then calculating the approximate weight of the ship's hull using the Owen Huges method with the following equation 1 [22].

$$\rho g\int_0^L a(x)dx = g\int_0^L m(x)dx \quad (1)$$

Where:
a(x) = Immersed cross-sectional area (m^2)
m(x) = Mass distribution (mass per unit length) (ton/m)
ρ = Mass density of sea water (or fresh water, if appropriate) (ton/m^3)
g = Gravitational acceleration (m/s^2)
Δ = displacement (tons).

Furthermore, airbag data is adjusted to market airbag characteristics (YT-6 layer CB/T 3837-1998). Technical Requirements for Ship Upgrading or Air-Bag Launching (Shipbuilding Industry Standard, PRC): Qingdao Evergreen Maritime Co., Ltd. [23] which meets ISO 14409:2011 standards [24].

Calculations must be made on the quantity of airbags and their spacing prior to using pneumatic airbags to launch ships. The following formula can be used to determine how many pneumatic airbags are required for ship launching :

$$N = K_1 \frac{Wc \times g^2}{C_B \times R \times L_d} + N_1 \quad (2)$$

Where,
K_1 = $\frac{1.2}{1,3}$;
Wc = Launching weight of ship and launching device (ton);
g = Gravity 9.81 m/s^2;
C_B = Block coefficient;
R = Airbag Load capacity per unit length (ton/m);
L_d = Airbag Effective length (m);
N_1 = Additional airbags are required.

The distance between the airbags must not exceed 6 meters. Or it can be checked using the formula.

$$\frac{L}{N-1} \leq 6 \quad (3)$$

$$\frac{L}{N-1} \geq \frac{\pi D}{2} + 0.5 \quad (4)$$

To calculate the average load distribution received by each airbag lengthwise (q), the ship can be calculated using the formula:

$$q = \frac{P}{S} \quad (5)$$

TABLE 1.
DIMENSION OF DECK BARGE 300 FT

Dimension	value	Unit
LOA	91.44	meters
LPP	91.44	meters
B	24.99	meters
H	5.48	meters
T	4.66	meters
DWT	10450	tons

Next, it is necessary to know how much load each airbag can accommodate in tons (P1) with the formula:

$$P_1 = q \times x \quad (6)$$

After that, the actual average load distribution received by each airbag (q1) can be calculated by the following equation:

$$q_1 = \frac{P_1}{B} \quad (7)$$

Where:
P = construction weight;

S = length of ship supported by airbags; x = distance between airbags;
B_1 = effective length of the row arrangement of airbags;
B_2 = effective length of the cross-over arrangement of airbags;
q_{bc} = bearing capacity.

In conditions where $q_1 > q_{bc}$, the airbag does not burst. In contrast, when $q_1 > q_{bc}$, the airbag ruptures.

The next step is to model the structure of the 300-foot barge using initial data derived from midship construction drawings and profiles, as shown in Figure 1, using space claim software. The shape and arrangement of ship construction analyzed are as follows: 1) a ship model made only in the parallel middle body with a construction length of 21945.6 mm or equivalent to 0.23 LPP of the ship; 2) the ship construction components being modeled are components that play an important role in the longitudinal strength of the ship, such as A36, deck plates with a thickness of 14 mm, side plates with a thickness of 11 mm, bottom plates with a thickness of 12.5 mm, transverse bulkhead plates, and elongated In this study, two types of material were used, namely A36 steel and [25] for construction, and rubber for airbags.

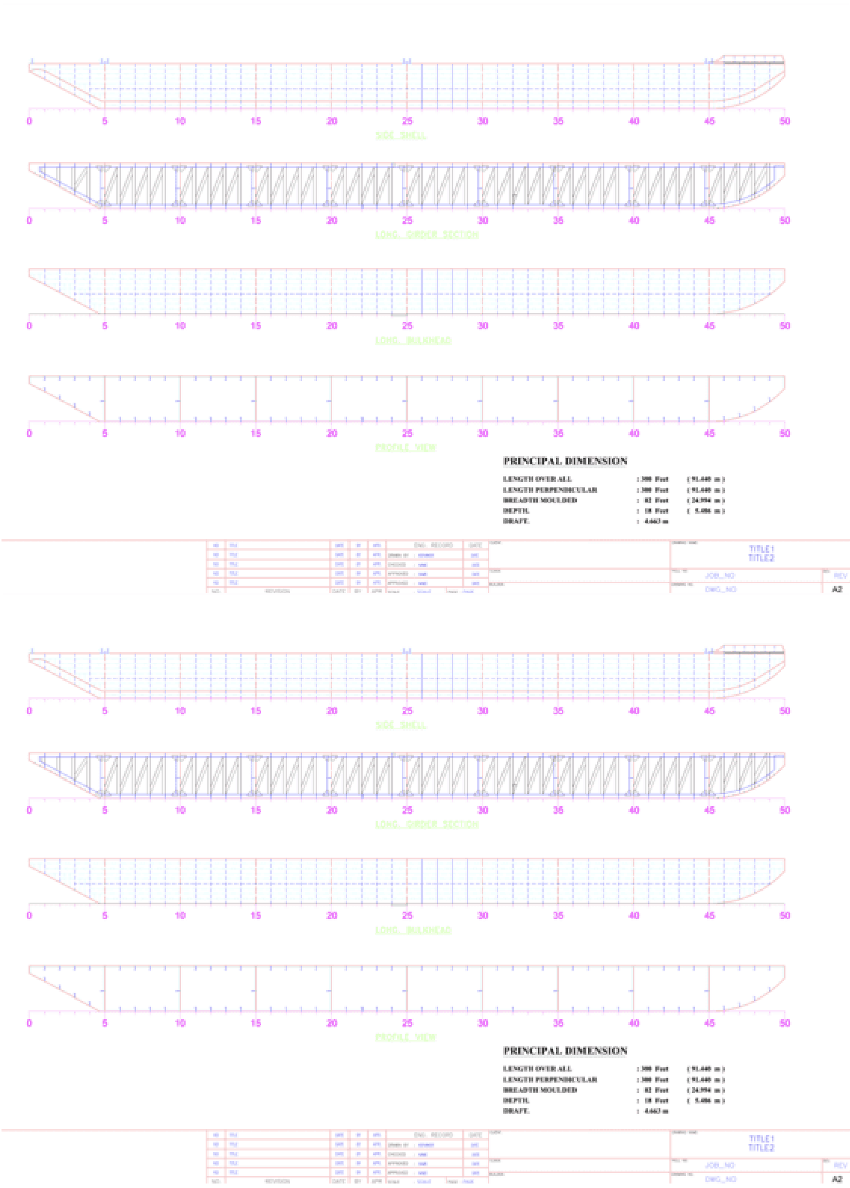

Figure 1. GA of deck barge

TABLE 2.
TWO ROW ARRAGEMENT AIRBAG

Characteristic	**Value**	**unit**
External diameter D_1	1.5	m
Effective height	0.8	m
Load capacity per unit length	143.03	kN/m
Maximum length	13	m
Effective length	10	m
Working pressure	0.13	MPa

TABLE 3.
CROSS ROW ARRAGEMENT AIRBAG

Characteristic	**Value**	**unit**
External diameter D_1	1.5	m
Effective height	0.8	m
Load capacity per unit length	143.03	kN/m
Maximum length	19.5	m
Effective length	18	m
Working pressure	0.13	MPa

The next step is airbag modeling according to the data and airbag layout that have been predetermined for the launch of the two-row layout and the cross-over arrangement. Applying a convergence test to the acquired solutions is one of the suggestions for figuring out how many elements in a finite element analysis have acceptable solution accuracy. For instance, in a stress analysis of a component, a certain size or number of parts are utilized in the first analysis, and the answer is produced by filling out the model that was employed. The stress value at a specific area is then compared to the outcomes of the earlier study when the analysis is repeated with a larger number of pieces. If the stress levels between the two analyses differ significantly, the analysis is repeated with more elements until the difference is deemed acceptable. In the modeling, the face of the launch pad where the airbag is installed is provided a fixed support. The model is being loaded by the weight of the materials used in its creation in comparison to the gravitational force of 9806.6 mm/s2. The program on the model has computed the building weight automatically.

III. Results and Discussion

Various stages were carried out in this study, as follows.

A. Arragement of Airbags

Equation 2 must be used to determine the quantity of airbags and the spacing between them necessary for pneumatic airbag ship launching. Figures 2 and 3 display the amount of pneumatic airbags required for ship launching based on the type of placement. Figure 2 shows the placement of a two-row arrangement of airbags with a value of K1 = 1.2; Wc = 2136 tons; R = 143 kN/m; N1 = 9 pcs; Ld = 10 m; and the number of airbags is 24 pcs. Figure 3 shows the placement of the Cross Over Arrangement type airbag, which has a value of K1 = 1.2, Wc = 2136 tons, R = 143 kN/m, N1 = 3 pieces, Ld = 18 m, and the number of air bags is 14 pieces.

B. 3D Modeling of barge

Then, a 3D model of ship construction is obtained using ANSYS software [21] as shown in Figure 4. In this study, two types of materials were used, namely A36 steel for construction and rubber for airbags. Airbag modeling is matched to predefined airbag data and layouts for launch two-row layouts and cross-over arrangements. so that the airbag modeling is obtained as shown in Figure 5. Then in Figure 6, there is a ship construction model that has been combined with an airbag support.

C. Study Independent of Mesh

Model convergence or independent mesh studies are carried out in order to find the true stress. The convergence of the model is outlined in the form of a curve shown in Figure 7. Figure 7 shows the result of model convergence. I found the right mesh size to be 205 mm. The mesh size is used in both models. This is done so that the results of the solutions generated by the application are close to the actual results. The meshing process is shown in Figure 8.

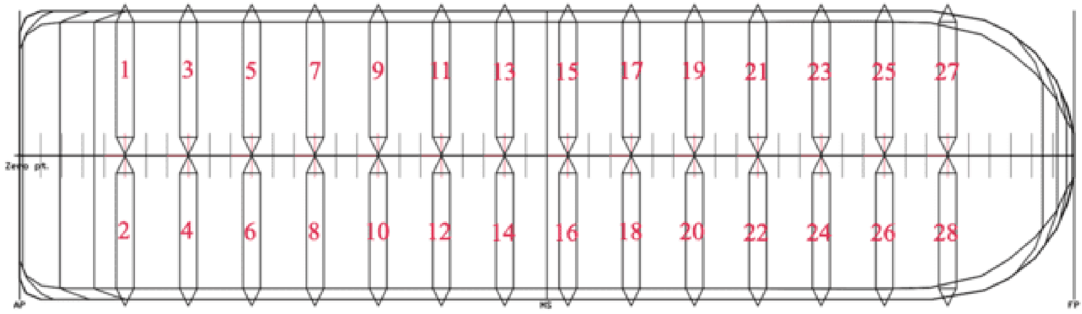

Figure 2. Two Row Arrangement

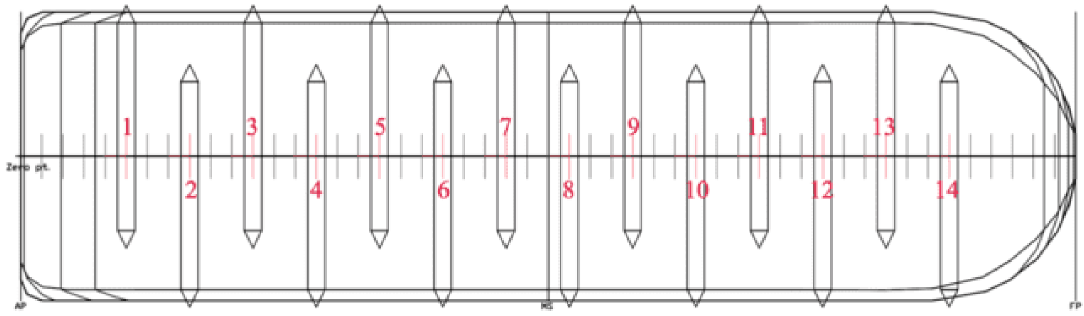

Figure 3. Cross Over Arrangement

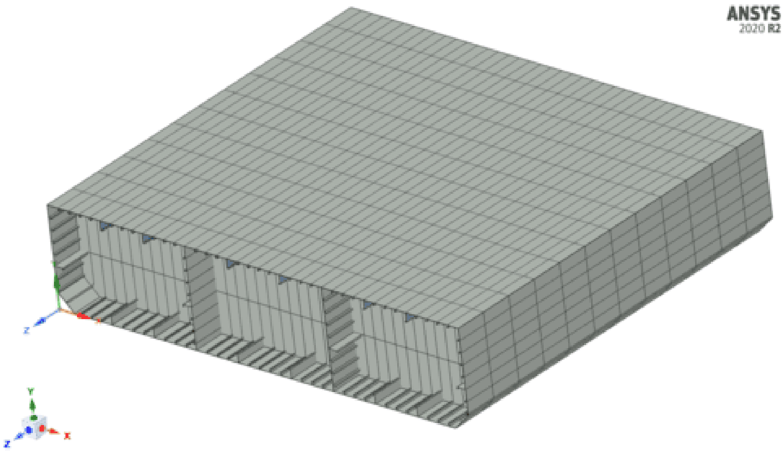

Figure 4. Construction Modeling with Hull Bulkheads and Skin

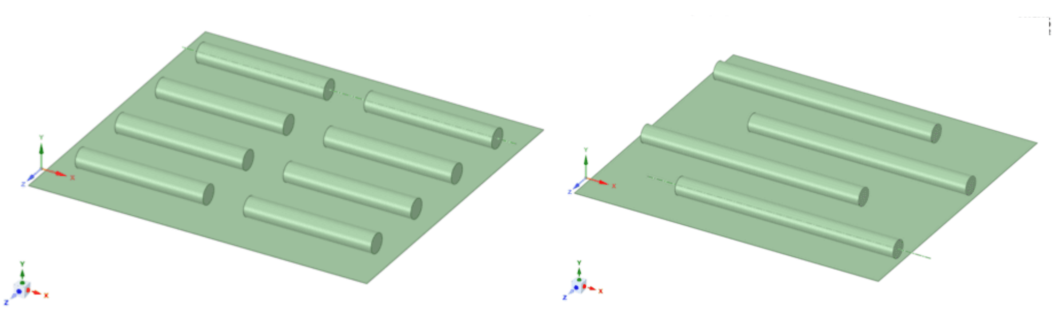

Figure 5. Airbag layout modeling, two-row arrangement, and crossover arrangement

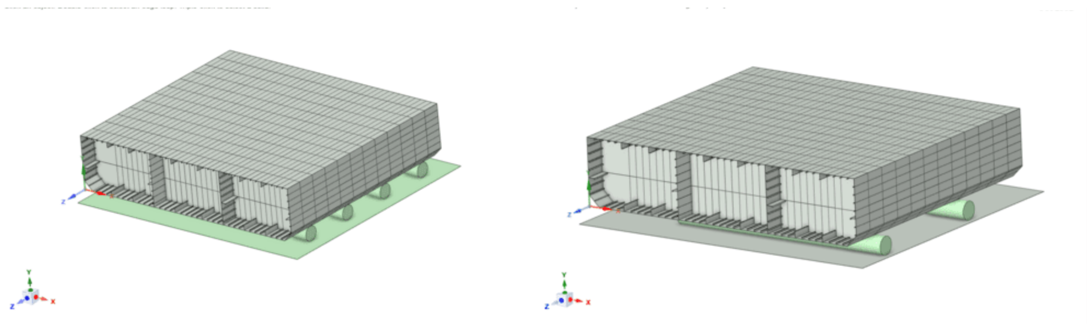

Figure 6. Airbag layout and construction modeling

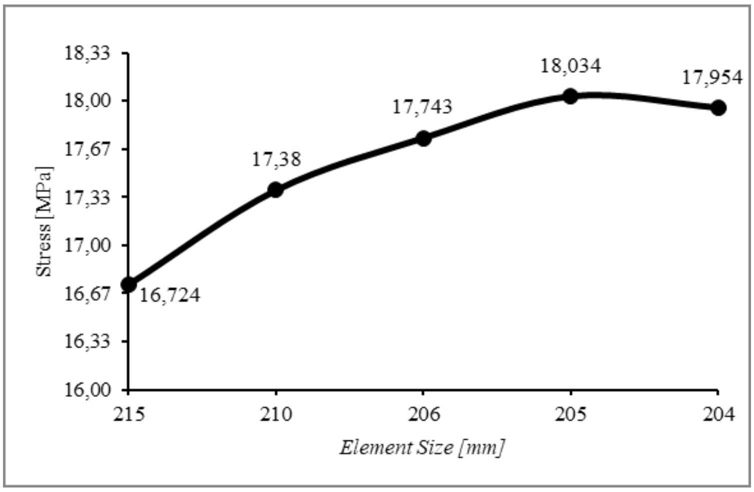

Figure 7. Model convergence curve

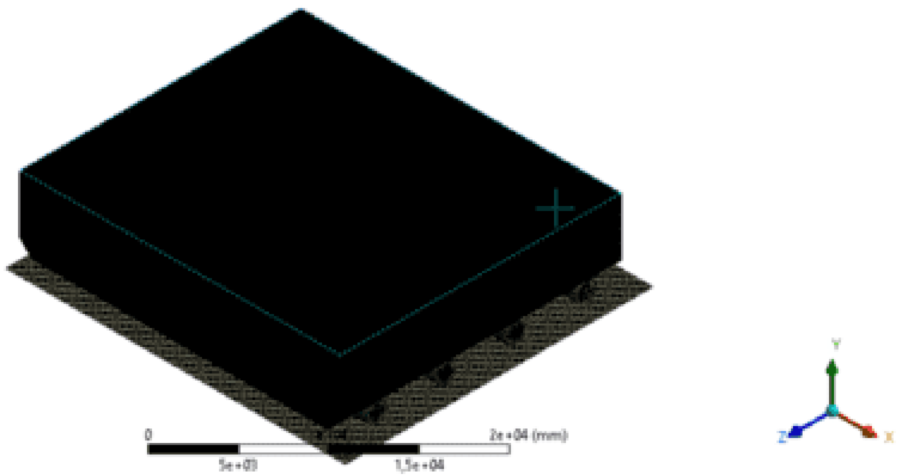

Figure 8. Mesh of 3D model

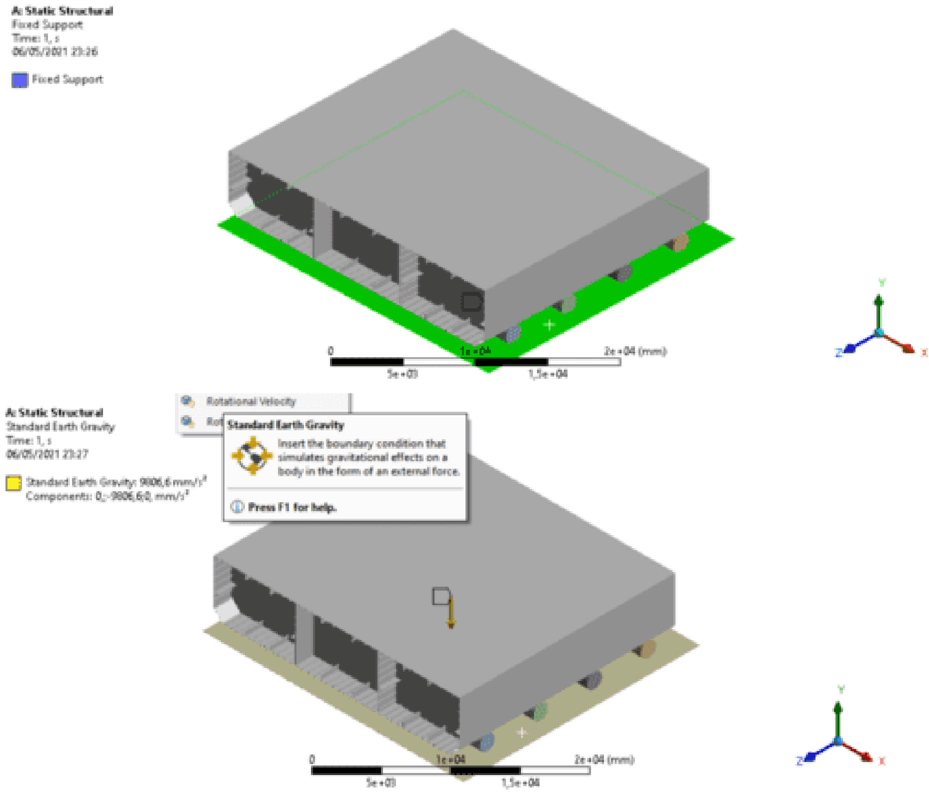

Figure 9. Mesh of 3D model

D. The Boundary of Condition of Model

The input of the boundary conditions in the form of supports and forces on the model is shown in Figure 9. Figure 9 shows the input of boundary conditions in the form of supports and a construction load of 245.8 tons. It is known that in a two-row arrangement and a cross-over arrangement, the type of airbag placement in each uses a simulation when the airbag is above the frame and when the airbag is between the frames.

E. Stress and Deformation of Model

The simulation results are shown in Figures 10, 11, 12, 13, 14, 15, 16, and 17. The recapitulation of the maximum stress analysis results for the construction and the maximum deformation is shown in Table 4.

Table 4 shows the stress and deformation values that occur in the barge structure during the launching process using airbags. The greatest stress is detected during the laying of cross-over arrangement type airbags, with the type of load located on the frame at 20.24 MPa. Meanwhile, the smallest stress occurs during the placement of the two-row airbag arrangement with the type of load between the frames of 9.83 MPa. The deformation value is directly proportional to the construction stress value, with the deformation value being 0.3–0.7 mm. From Table 4, it can be seen that the maximum stress occurs in the loadcase airbag right on the frame. This applies to all types of airbag placement, namely the two-row arrangement and the cross-over arrangement. This phenomenon occurs because of the stress concentration located on the frame [26][27][28].

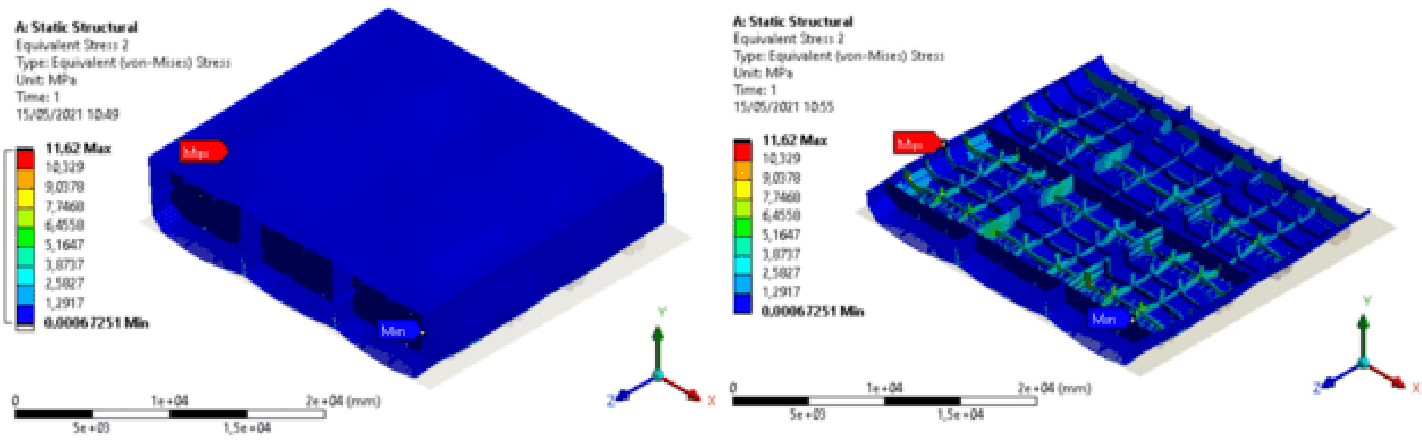

Figure 10. The maximum stress for placing the two-row arrangement of airbags is right under the frame.

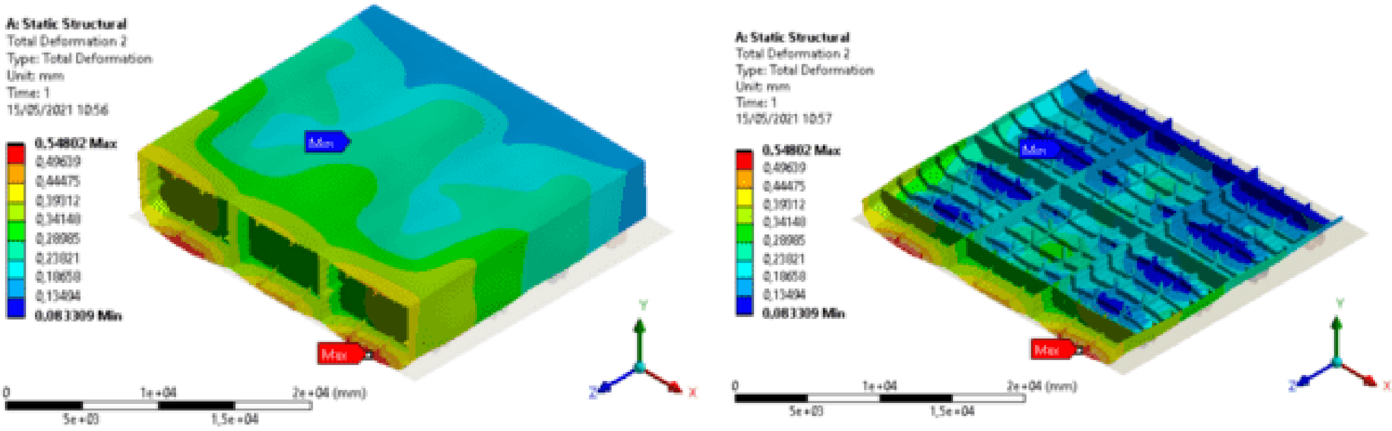

Figure 11. The maximum deformation caused by the placement of the two rows of airbags is just below the frame.

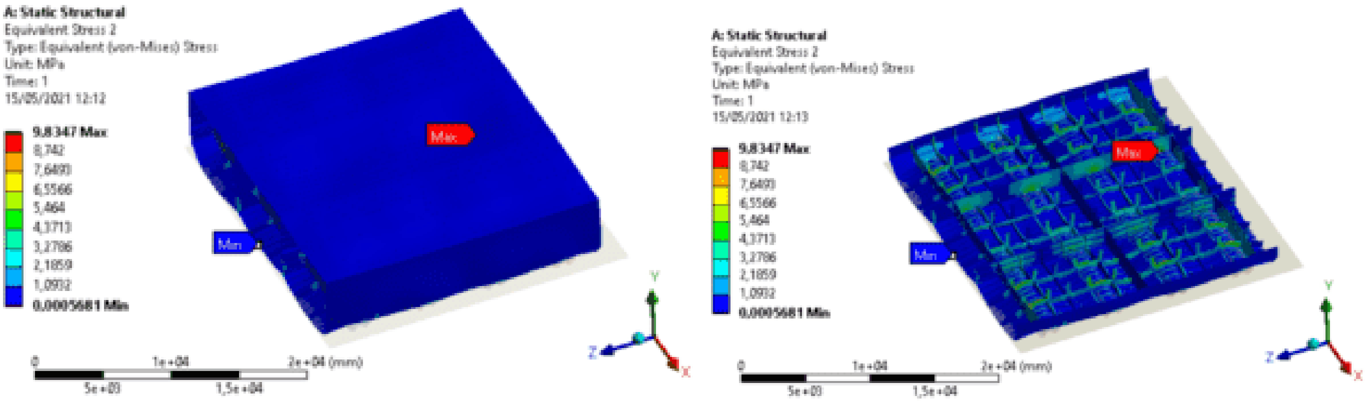

Figure 12. The maximum stress for placing airbags in a two-row arrangement is right between the frames.

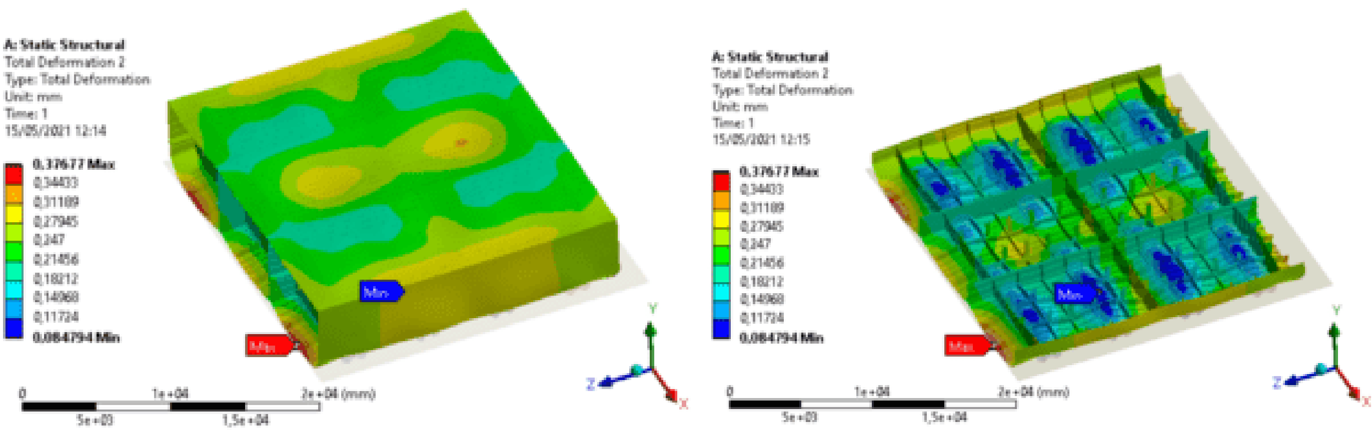

Figure 13. The maximum deformation is caused by the placement of the two rows of airbags right between the frames.

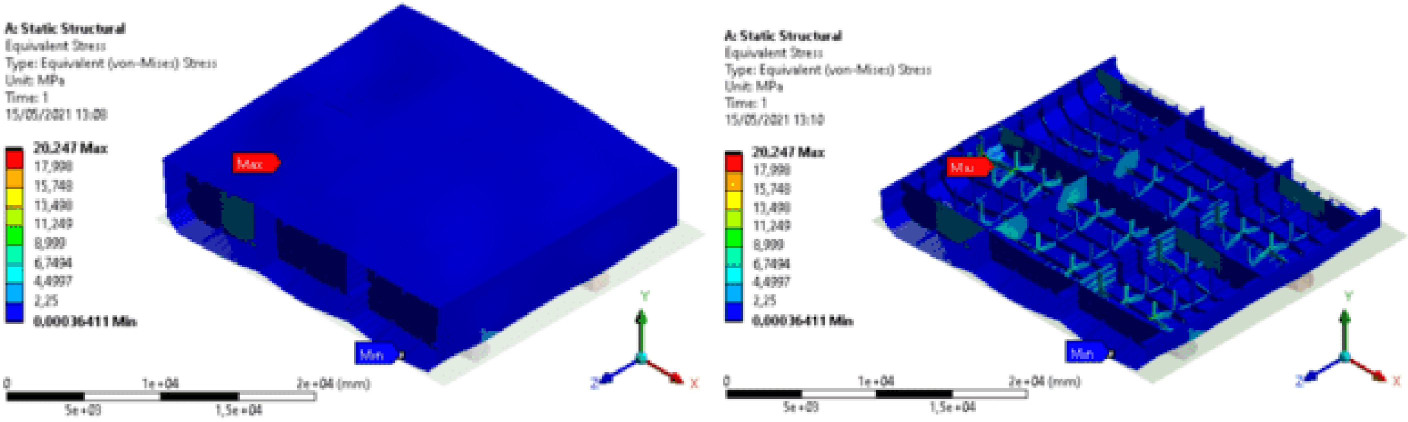

Figure 14. The cross-over arrangement airbags are placed with the most stress just below the frame.

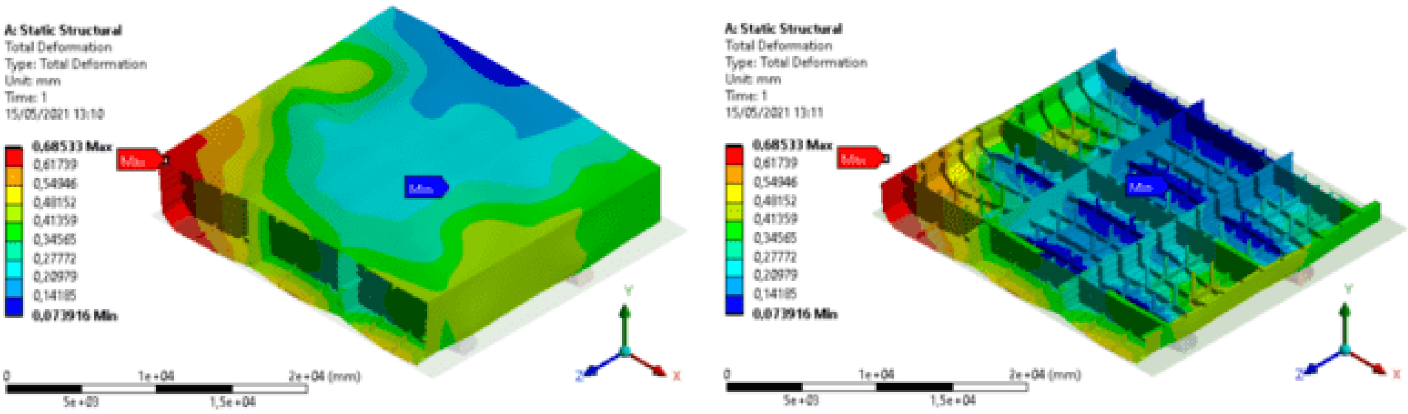

Figure 15. The maximum deformation of the cross-over airbag placement is just below the frame

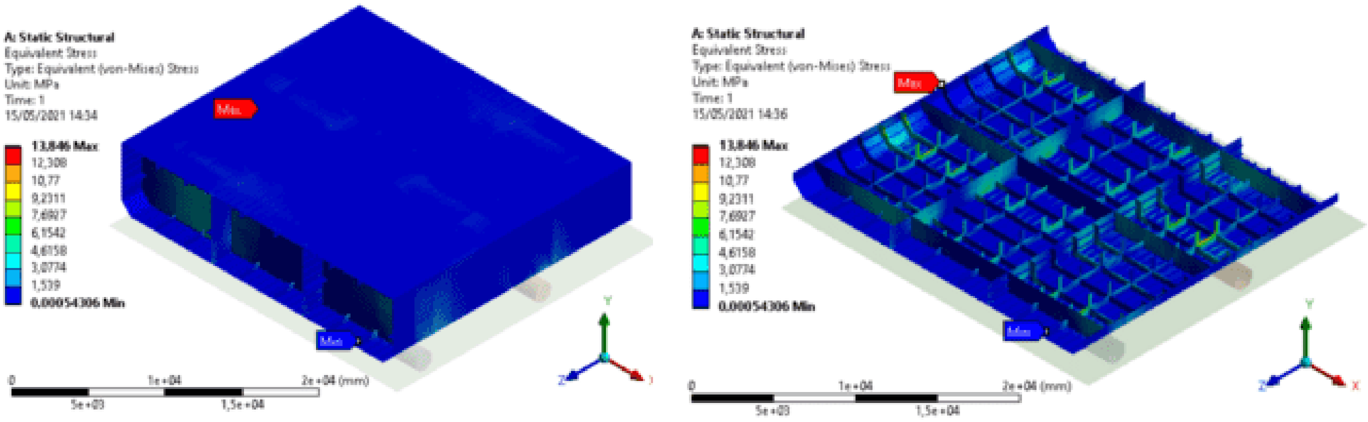

Figure 16. The maximum stress for placing the cross-over arrangement airbags is right between the frames.

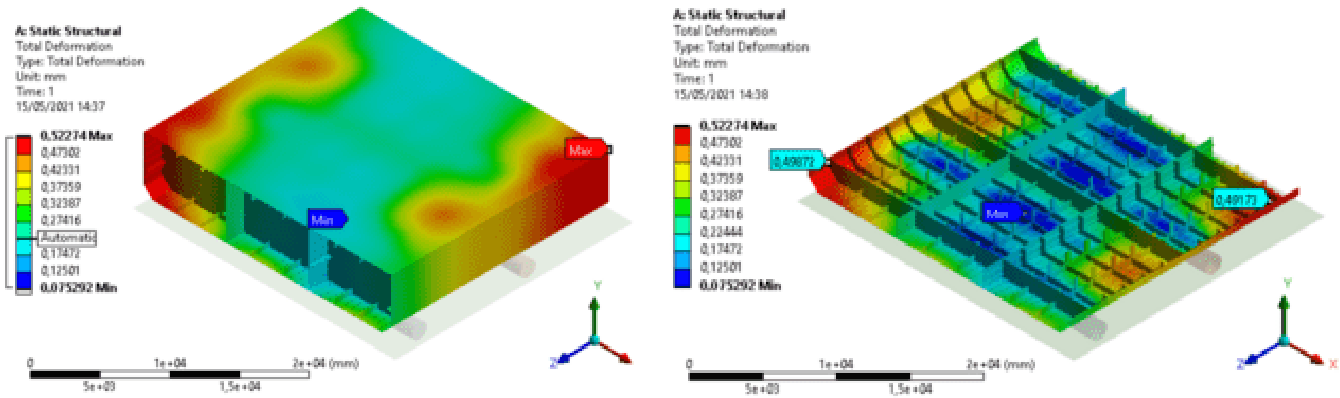

Figure 17. The maximum deformation of the cross-over arrangement airbag placement is right between the frames.

TABLE 4.
STRESS AND DEFORMATION OF THE BARGE STRUCTURE

Arragement of airbag/loadcase	max. Stress (MPa)	max. deformati (mm)
Two row arragement		
- load at girder	11.62	0.54
- load at between girder	9.83	0.37
Cross over arragement		
- load at girder	20.24	0.68
- load at between girder	13.84	0.52

IV. CONCLUSION

The two row and cross-over arrangement layouts have 14 and 28 airbags, respectively, with a distance of 5.49 m between the airbags. The status of the airbags in the two-row layout and the cross-over arrangement of the loading is safe—not broken or unable to withstand the weight of the ship's construction. From the results of this simulation, it was found that greater stress occurs in the bottom area of the ship, which is in direct contact with the airbags. The maximum stress that occurs in ship construction globally is still in a state of meeting or below the allowable stress. Then the deformation resulting from the simulation states that greater deformation occurs in areas that are not supported by airbags.

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