A Bulk Carrier Hatch Block Analysis with Finite Element Method

Serdar Turgut INCE, Ozgur DEMIR, Seyfettin BAYRAKTAR, Tamer YILMAZ

Department of Naval Architecture and Marine Engineering, Yildiz Technical Universit, Istanbul, 34349,Turkey

Abstract The production process based on experience was switched modern manufacturing treatment that found on knowledge, counting and advanced engineering applications as well as other areas at the ship building industry that the importance of the analysis process has been increased.

In the present study, the natural frequency and structural strength analysis of the hatch block of a bulk carrier are performed with finite element method. Computer aided design (CAD) model of the ship's structures is prepared by means of a commercial CAD software. Pre and post-processing including all analysis are done with MSC.PATRAN and MSC.NASTRAN.

Keywords: Finite element method, stress analysis, natural frequency.

1. Introduction

Ships are the vehicle that made for a identified task to operate at sea. Usually ships work under rough conditions and migbt be influenced by many diiferent dynamic loads. Therefore, several engineering analyses should be be made form primary design stage to the launching process. Some special considerations should be concentrated on computational fluid dynamics (CFD), vibration, structural strength analysis, etc. Altough some basic analyses have been performing well, in the present some fundamental aspects needs to be used most commonly such as vibration and strength analysis. Especially finite element method (FEM) could be mentonioned as uncommon at shipping industry, in practice. Generally, from rules of the classification society on which depend ships is benefit. This approximate calculation is different from the real model and includes several acceptances, so that this calculation is effect negatively ship's lifetime.

In this study, structural strength and natural frequency analysis was achieved for the bulk carrier which is about 50 m and obtaind data then were compared with the material yield being used in the structure.

2. Primary Design of the Ship Structure

Design process in shipbuilding industry is under control of classification societies and international rules.

Simulation that is used the primary design of ship structure was calculated with the Class Rules for steel vessel of Turkish Lloyd. Main dimensions of the ship is given in Table 1. As it can be seen, ship used for the analyses is a bulk carrier with B=7.485 m, D=3.599 m, T=3.00 m. The block coefficient of the ship is 0.794.

Table 1: Main dimensions of the ship.

$L_{over\ all}$	47.450 m
$L_{waterline}$	44.194 m
$L_{betweenperpendiculars}$	43.000 m
B	7.485 m
D	3.599 m
T	3.000 m
CB	0.794

According to the ship's dimensions listing in Table 1, the hatch is 14 m in length. Three-dimensional (3D) CAD model of the hatch structure is generated with a CAD package of SolidWorks. The modeling of the frame that is conveyor element of the ship is started by creating CAD geometry. Firstly, the skeleton of the ship is composed by modeling of the full frames. Then, the surfaces surrounding the internal and external skeleton are formed through making surface process. Figure 1 shows the stages of created CAD models.

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Fig. 1: 3-D CAD model of the hatch structure phases.

3. Finite Element Separation Process

Finite element separation process is practiced with MSC.SOFY and MSC.PATRAN commercial softwares. During the finite element separation process of the steel plates that modeled as surface; 4 (Quad) and 3 (Tria) nodes elements were used.

The ship created as sub-assemblies is completed by means of finite element net in MSC.SOFY. In the Finite element net, hatch structure of ship, includes approximately 46 038 quad, 779 tria and totally 46817 elements. The model is made very detailed both element number and different element that is included in the finite element net model.

Before the natural frequency and structural strength analysis of the ship, physical properties of materials, thickness's and beam profile properties are defined with MSC.PATRAN

During the analysis a most commonly used material in the shipbuilding industry, St42 steel has been used (Table 2).

Table 2: Characteristics of the used material.

Material model	Linear elastic
Elasticity Module	210 000 MPa
Poisson Ratio	0.3
Density	7800×10^{-12} ton/mm^3

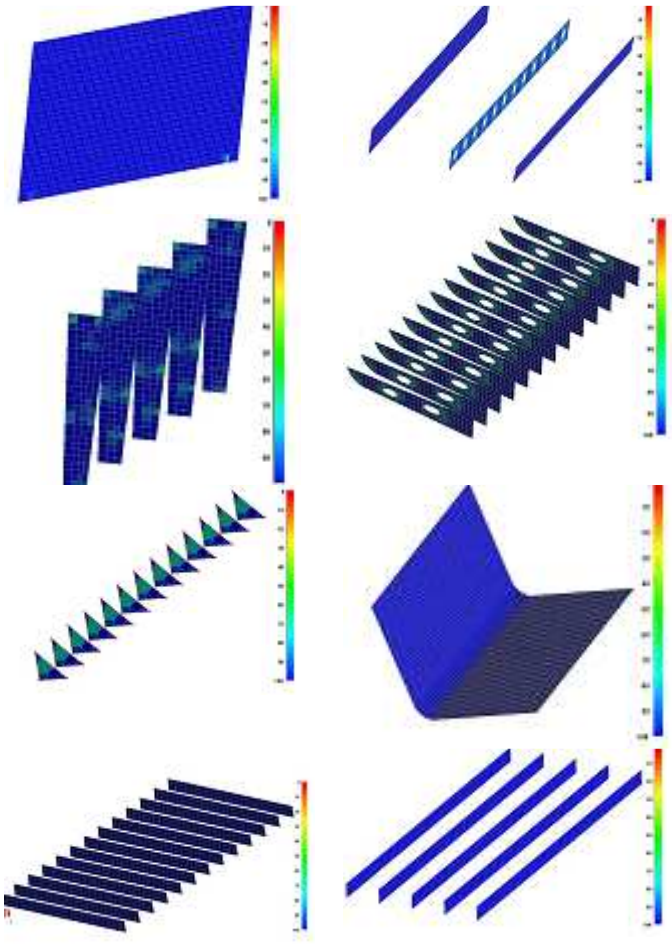


Fig. 2: Mesh structures generated for the elements.

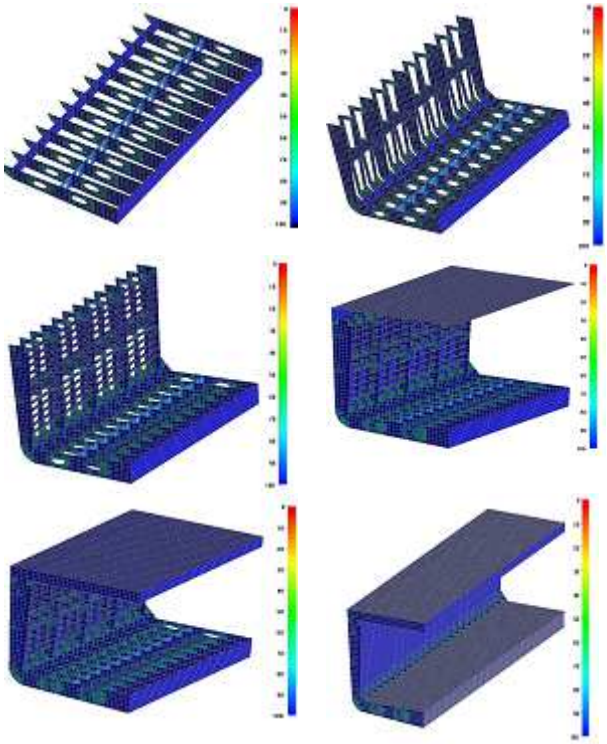


Fig. 3: Intersected surfaces are stitch to each other.

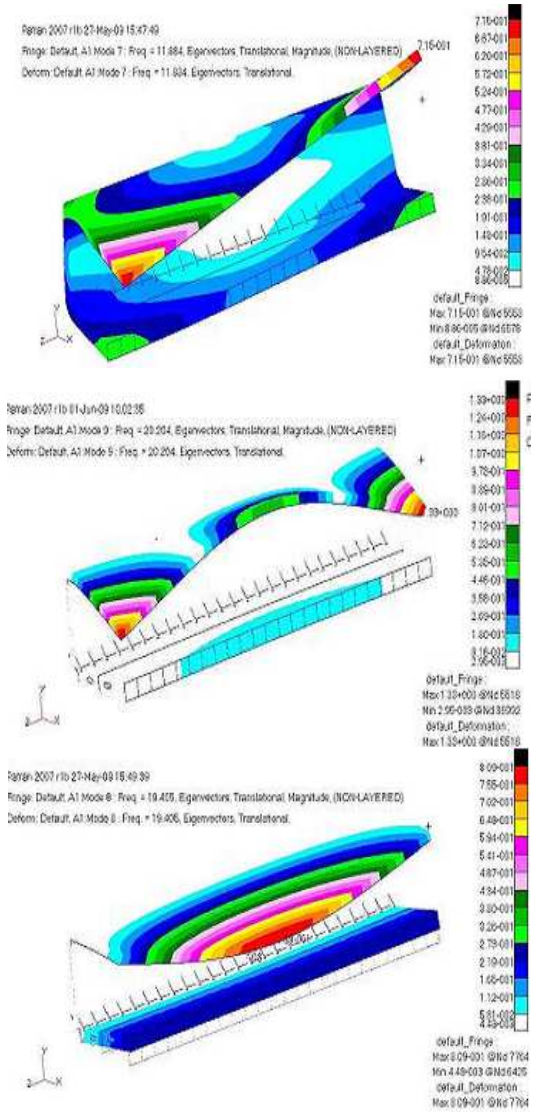
4. Natural Frequency and strength Analysis of Hatch Structure of the Ship

Natural frequency analysis is carried out with MSC.NASTRAN. Obtained natural frequencies values are shown in Table 3. Mod shapes of natural frequencies values obtaining with natural frequency analysis are also shown in Figure 4.

Table 3: Natural frequency analysis result.

Mode	Frequency	Mode	Frequency
1	1,18E+01	8	4,23E+01
2	1,94E+01	9	4,23E+01
3	2,02E+01	10	6,18E+01
4	2,24E+01	11	6,28E+01
5	2,78E+01	12	6,74E+01
6	3,77E+01	13	6,77E+01
7	4,04E+01	14	8,23E+01

Ship structure analysis was initialized with natural frequency analysis. The main goal of the natural frequency analysis is to understand whether frequency of the the coercive force which effect ship structure found any natural frequency belonging ship structure or not. Main machinery, auxiliary machinery, and other equipment frequency interval will have been determined with natural frequency results of ship structure.



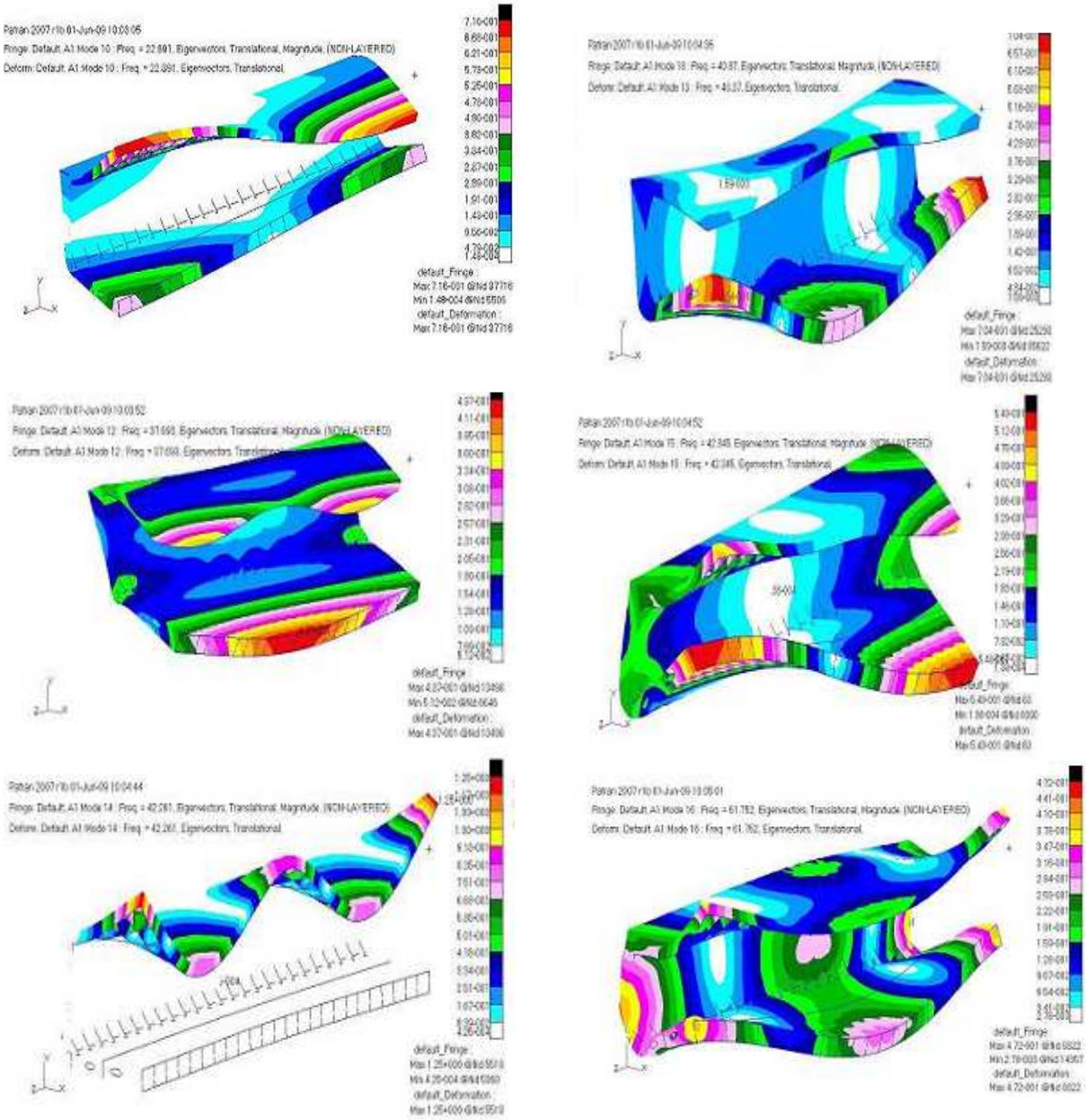


Fig. 4: Natural frequency modes shapes.

5. Stress Analysis for Calm Water and No-Load Conditions

Boundary conditions should be applied to system in order to realize analysis of calm water and no load case. Symmetry boundary conditions were performed for strength analysis of no load state. However, the hydrostatic lifting up forces that effected ship hatch structure was defined a function and it was carried out the surfaces that were under water on ship. Prepared ship hatch model was run analysis with MSC.NASTRAN. Results of analysis for calm water and no load case is shown in Figure 5 and Figure 6.

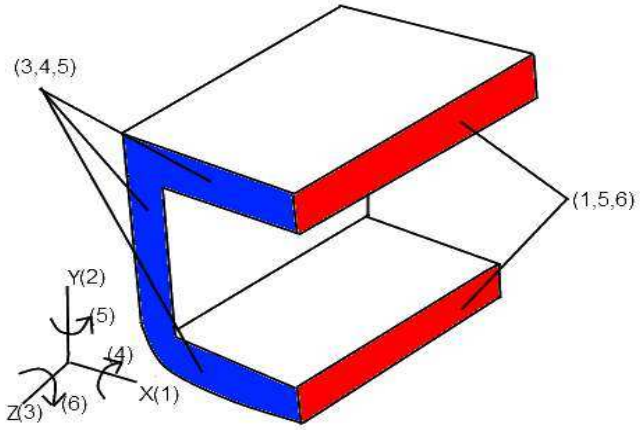


Fig. 5: Fixed boundary directions.

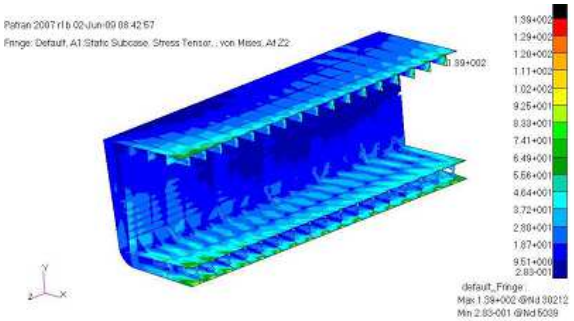


Fig. 6: Stress distributions for unloaded state.

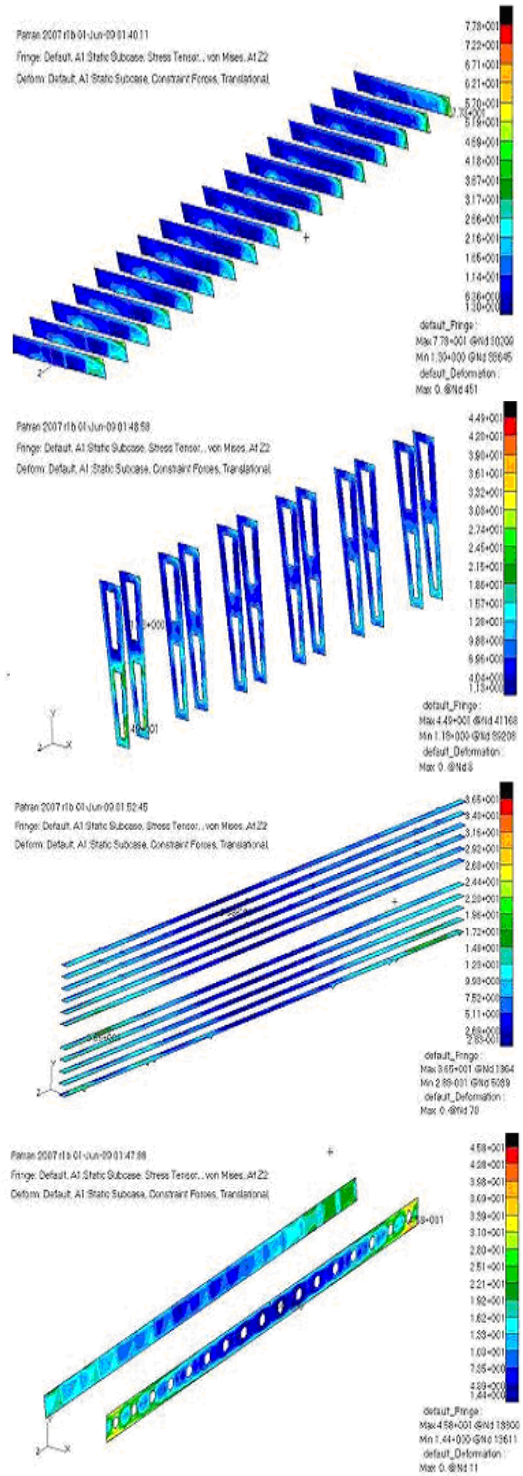


Fig. 7: Stress distribution of the vessel elements.

6. Stress Analysis for Calm Water and Loaded Conditions

Boundary conditions must be applied to system in order to realize analysis of calm water and load case. Symmetry boundary conditions were performed for strength analysis of load state. However, the hydrostatic lifting up forces that effected ship hatch structure was defined a function and it was carried out the surfaces which were under water on ship. Bulk carrier load that is in hatch structure was practiced system as total load. Results of analysis for calm water and load case is shown in Figure 8 and Figure 9.

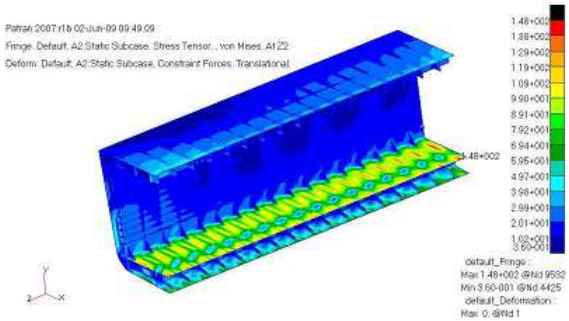
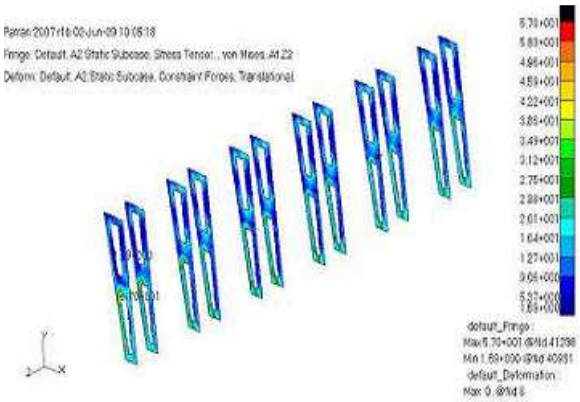
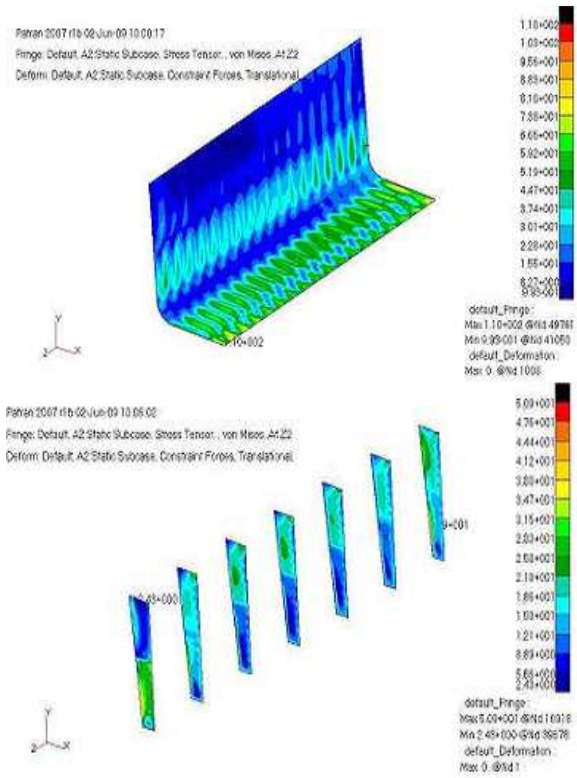


Fig. 8: Stress distribution for loaded state.





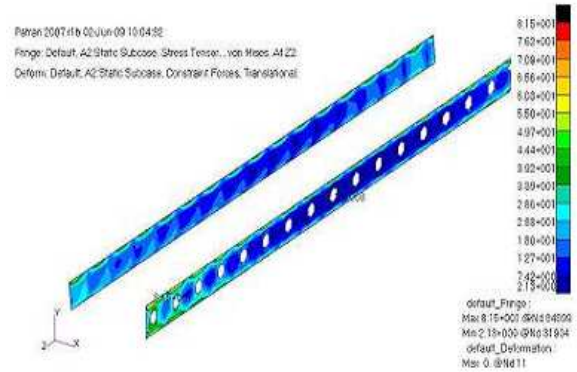


Fig. 9: Stress distribution of the vessel elements.

3. Results and Discussions

The first structure analysis of the ship was strength analysis for calm water and no load case. Using the model, physical properties of St42 steel are found as follows;

Yield stress (σ_{Yield}) : 250 MPa

Tensile stress ($\sigma_{tens.}$): 412 MPa

Highest stress value obtainsed form analyses is foudn as 139 MPa. This value is lower than yield stress of steel. As a result of that, the structure is safe all area for stress.

Highest stress value that obtains results of analysis was measured as 148 MPa for load case. Also this value is under yield stress of steel. So, also for the load case is safe all structural elements.

4. Conclusions

Finite element method has been used for a bulk carrier ship to identify the structural analysis. Simulations has been performed with two different cases, loaded an unloaded. For these two conditions, obtained values have been found lower than the yield stress of the used steel.

6. References

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