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STRESS AND STRAIN ANALYSIS THAT OCCURS IN THE STRUCTURE OF A SECTION AND IN ITS LIFTING INSTALLATION, DURING THE LIFTING AND TURNING MANEUVERS

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ABSTRACT

During the shipbuilding processes carried out in the shipyards, there is a need to transport the sections of ship structure, from the place where they are built to the assembly location. When the shape and structure of the sections allow, they are built in an inverted position, and after finishing all the works that can be performed in this type of placement, the section will have to be turned to continue the section building process and subsequent the assembly. Loads that appear in the structure during these maneuvers are different from those that appear during the operation and from those for which calculations were made at the stage of the initial project. Therefore, it is necessary to calculate them and design a lifting / turning installation, which should also contain stiffening elements where required, in order to prevent both accidents and deformations or detachments that could occur at the section level. From this necessity appears the plan generically called "lifting plan" and which contains the installations, the schemes, the necessary instructions to remove the units from the section building hall, turn it to the gantry cranes and brought into the mounting position.

Keywords: lifting – turning sections, structural analisys.

1. INTRODUCTION

Lifting plans are often made within the construction yard because these components depend on the practice, infrastructure, instructions, standards and strategies imposed at the level of each yard. Although from one section to another very big differences can appear, the component of the lifting installations includes, in general, the same elements, chosen according to the structural particularities of the section:

- Lifting eyes - used to lift the subassemblies, sections and block of sections, are standardized at yard level. They are chosen depending on the results of the calculations

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performed, the rigidity of the structure, the thickness of the sheet on which it is positioned and the way in which the maneuvers will be executed.

- Stiffening elements are represented by:
▪ pipes, if the section has large openings and there is a risk of deformation at the time of lifting in the crane;
▪ brackets, for stiffening the structure of the area near the lifting eyes;
▪ profiles, to form false frames where the structure is weak.

2. OBJECTIVES PROPOSED TO BE SOLVED IN THE PAPER

In the first stage of the design process , the construction plans for the section are consulted, respectively the set of sections that make up the block to be lifted.

- checking and improving the lifting plan initially created in accordance with the results obtained from the analyzes.

The algorithm for creating a lifting plan, presented above, is often enough, but there are cases where the sections have more unusual shapes, the structure is weaker, which raises problems in the placement of the lifting eyes and the designing of correct lifting schemes, which not to induce deformations at the level of the structure during the execution of the maneuvers. Such problems often occur in stern, bow or large-opening sections, as well as in aluminum superstructures, that are built as big blocks and must be lifted to the ship.

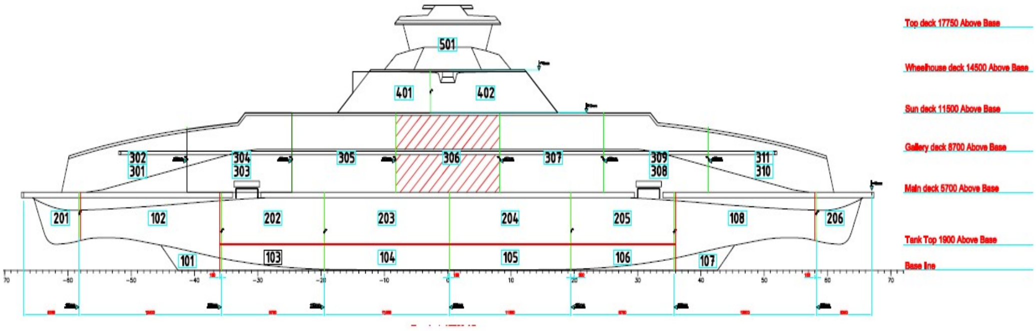
Also, taking into account the fact that the size and weight of the sections and blocks executed in the yard is constantly increasing, positioning the lifting eyes following the manual calculations sometimes is not enough, since there are softwares that present concrete analyzes and which help in making safe decisions.

Starting from those previously presented, the following were proposed:

- designing the initial lifting plan, starting from plan 2D construction plans of the section and following the steps presented;
- modeling the geometry of the section starting from the same 2D construction plans;
- model analysis for lifting and turning cases;

In this paper, was chose the case of a section located in the central area of a ferry built in the Damen Shipyards Galati, which due to large side openings can cause problems during the execution of maneuvers.

In Figure 1 is presented the position of section chosen to be studied along the ship. Figure 1b shows the construction position of the section chose (marked with red in Figure 1a).



a)

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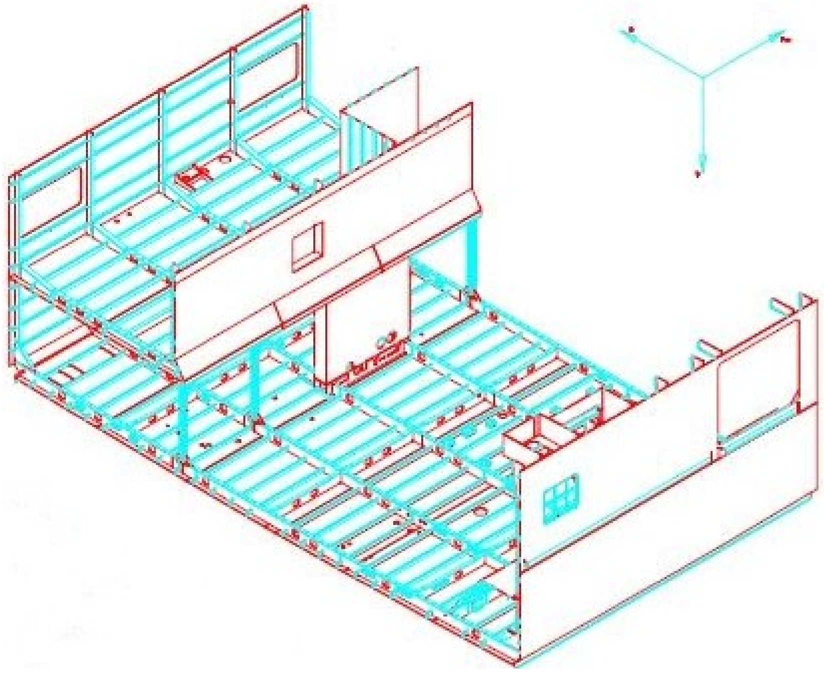

b)
Figure 1

3. LIFTING EYES POSITIONING AND CALCULATIONS

In the first stage of the study was necessary to establish weight of the section who is 48.126,0 kg. The coordinates of gravity center was found:

$X = 29\,\text{mm}; Y = 653\,\text{mm}; Z = 9906\,\text{mm}$

Knowing the intercostal distance of the ship, the frame at which the center of gravity is can be calculated as follows:

$X : a_0 = FR0 + 29\,\text{mm}$

The possibilities of lifting and returning are evaluated, taking into account the infrastructure of the area in which the maneuvers are to be executed, but also the structure of the section.

Chossing the right scheme, the distribution of the forces on the lifting eyes can be calculated, also the maximum load on each lifting eye:

$F_{1max} = 24.063,5\ \text{kgf} = 235,98\ \text{kN}$

Lifting and turning will be done with 4 lifting eyes of 15 tons force and 2 lifting eyes with a capacity of 30 tons force.

In Figure 2a, b it is mention the position of the lifting eys (on maneuvres) without stiffening elements and 2c with this elements mounted.

Figure 2a shows the initial position of section to be lifted with lifting eys positioned, and Figure 2b shows the position in upside down position.

Depending on the place where the ship is assembled (in the hall, on the slipway or in the dry dock), the installation in question will be carried out, taking into account the position of the ship in relation to the position of the lifting systems.

This maneuver will be performed with two bridges or cranes, using the lifting eyes mounted on the Main Deck.

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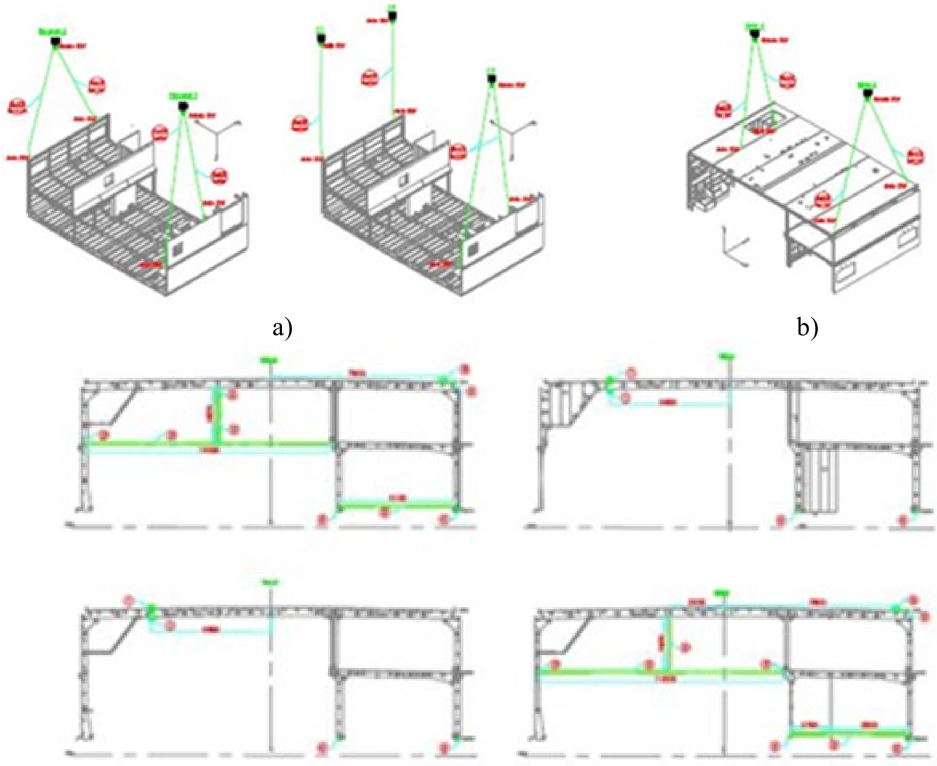


a) b)

c)

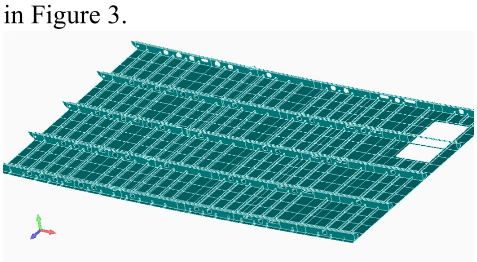
Figure 2

4. FEM MODELING OF THE LIFTING OPERATION

In order to be able to perform a Finite Element Analysis of a structure, the decisive step to be taken is to develop the calculation model of that structure. For the transition from the real structure to its calculation model, there are no general methods to ensure the elaboration of a unique model, which approximates, with a predetermined error, the structure to be modeled. In general, it is possible to develop several models for a structure, all correct, but with different performances.
In this case, the model for performing the structural strength analysis of the section during the execution of the maneuvers was developed based on its 2D construction plans and the results obtained in previous chapters, effectively synthesizing all available information on the structure.

4.1 Section structure discretisation

The section (few parts of them) was divided on layers which summary is presented in Figure 3.



a) main deck

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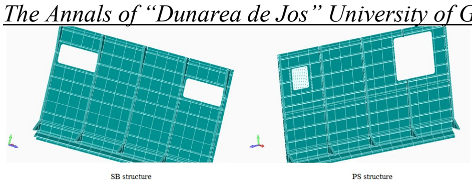
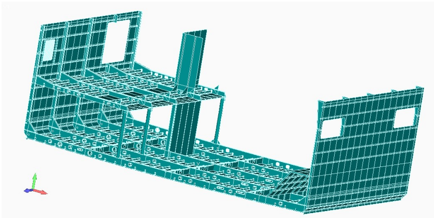


b) sides



c) section structure
Figure 3

The calculation model of the structure subjected to finite element analysis consists of points, curves and surfaces. At this stage, the model is a continuous one, with an infinity of points, and by discretization we pass from this structure to a discrete model, with a finite number of nodes.
The discretization process results in the division of the structure model into a certain number of finite elements. They are connected by common nodes, which are the vertices of quadrilaterals, when working with QUAD elements, such as this one, or triangles, where discretization is done using TRI elements.
In principle, the dimensions of finite elements can be as small as possible, but always be finite, the transition to the limit where their dimensions tend to zero is not possible [9].

4.2 Boundary condition

In order to model the physical bearing points, the interactions with the adjacent structures, in the case of local analysis, or to balance the model, in case a global analysis is performed, it is necessary that a series of displacements or rotations of the finite element model be predetermined.
In this case, the boundary conditions will be applied on the position where the lifting eyes will be mounted, taking into account the axis around which the rotation will be performed in case of returning the section

4.3 Loads

Since the goal is a test of the structure's strength under the influence of its weight, we use the load acceleration in order to apply gravity to all structure components, depending on the postion in which will be mentain in the crane.
Thus, the section structure was analyzed in the following cases:
Case 1 - Lifting the section from the section building workshop
a. Only with the help of lifting eyes
b. With lifting eyes and stiffening elements
In this case, the section will be raised in an inverted position, therefore the gravitational acceleration will act in the direction of the Z axis.
Case 2 - Maintaining the section in only two lifting eyes, during the turning maneuver
a. Only with the help of lifting eyes
b. With lifting eyes and stiffening elements
In this case, the gravitational acceleration will act down the vertical of the gravity center and it will decompose alog Y and Z directions on the angle that this vertical line makes with the Y axis.
Case 3- Lifting the section for positioning
a. Only with the help of lifting eyes
b. With lifting eyes and stiffening elements
In this case, the section will be raised in normal position, therefore the gravitational acceleration will act in the opposite direction of the Z axis.

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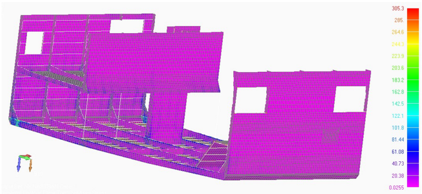
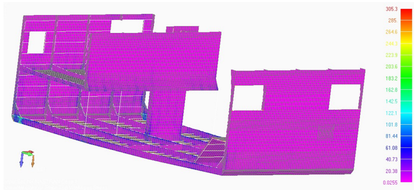
5. RESULTS

The results in stresses VonMises obtained for the 3 cases analyzed are shown in the images in figure 4.

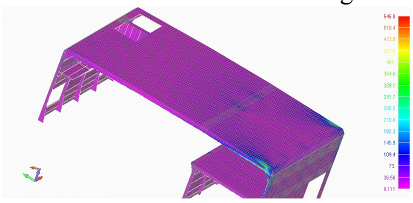


Case a) only with lifting eyes

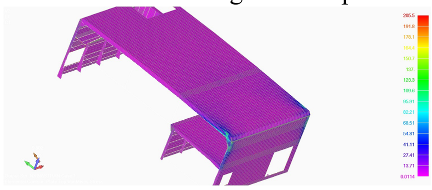


Case a) with lifting eyes and stiffening elements

Results for Case 1 - Lifting the section from the section building workshop

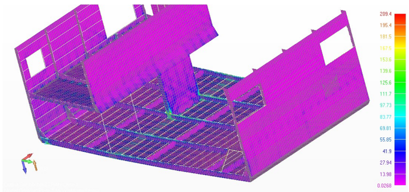


Case a) only with lifting eyes

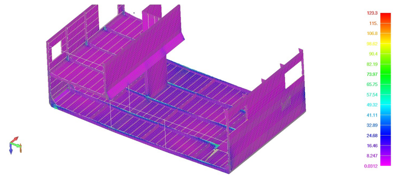


Case b) with lifting eyes and stiffening elements

Results for Case 2 - Maintaining the section in only two lifting eyes, during the turning maneuver



Case a) only with lifting eyes

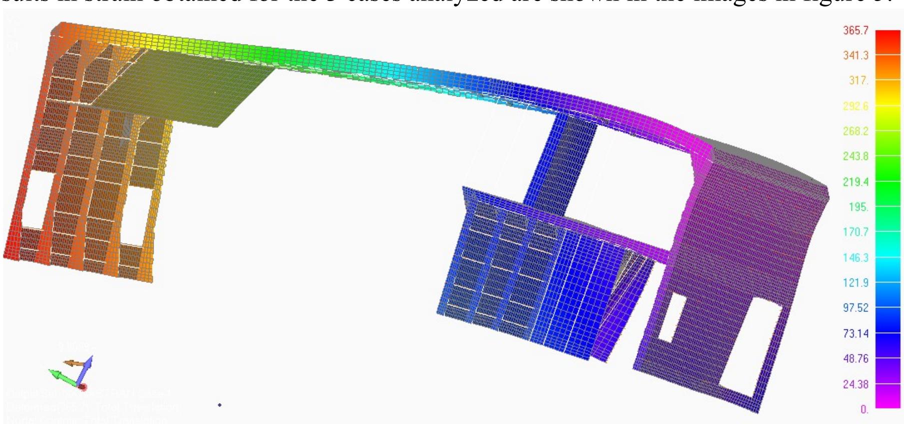


Case b) with lifting eyes and stiffening elements

Results for Case 3- Lifting the section for positioning

Figure 4

The results in strain obtained for the 3 cases analyzed are shown in the images in figure 5.



Results for Case 1 - Lifting the section from the section building workshop

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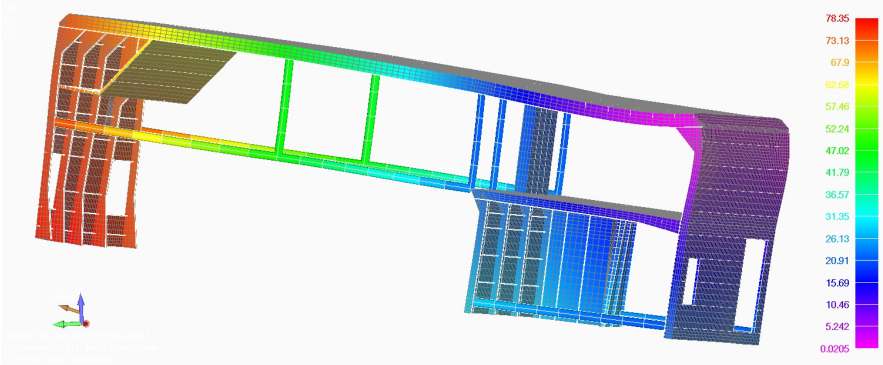
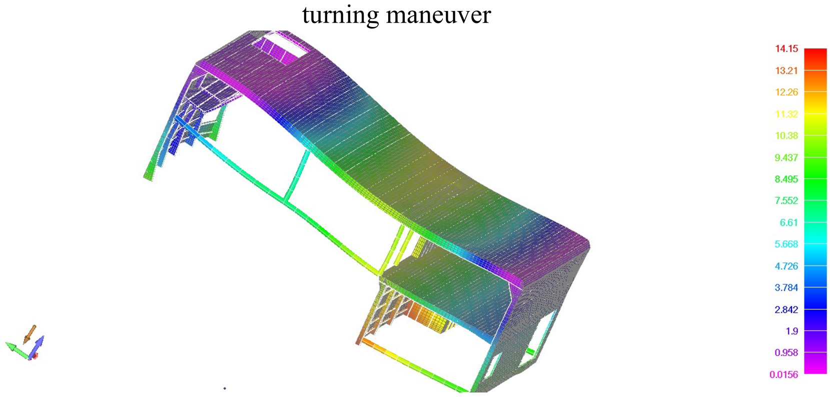


Results for Case 2 - Maintaining the section in only two lifting eyes, during the turning maneuver



Results for Case 3- Lifting the section for positioning

Figure 4

The resulting and centralized values are presented in the table below.

Case	Option	Max Stress [MPa]	Max Deformation [mm]
1	without stiffening elements	305.3	32.2
	with stiffening elements	154.5	11.7
2	without stiffening elements	546.8	365.7
	with stiffening elements	205.5	78.3
3	without stiffening elements	209.4	49.2
	with stiffening elements	123.3	14.1

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6. CONCLUDING REMARKS

It is highlighted the fulfillment of all the proposed objectives, achieving, the design of the lifting plan, the modeling of the structure and their analysis.

Coming to the aid of the current practices of each yard regarding the realization of lifting plans, this type of analysis can be introduced to provide a more accurate picture of the stresses and strains that may occur during maneuvers, avoiding possible accidents and saving time for plates straightening.

One of the important aspects for performing such maneuvers is the structural strength of the section, which must meet the safety criteria. The results obtained from the numerical analyzes with finite elements allow the evaluation of the states of stress and deformation that manifest in the structure of the section, as well as the verification of the resistance criterion in relation to the yielding limit of the material. Also, by identifying the areas where stresses or deformations manifests itself in worrying values, improvements can be made to the lifting planes by means of stiffening elements, in order to avoid field failures and reduce material costs.

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