COMPARATIVE STUDY OF THE CUTTING SHAPE FROM THE REINFORCED ELEMENTS ON THE SHIP BODY STRUCTURE

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ABSTRACT

In order to achieve a lighter ship hull, solutions are required regarding the mass reduction of the structural elements, which are part of the ship hull. In the development of the ship hull, besides the shell, there is another series of system elements, the transverse and longitudinal frames, which ensure the rigidity, the strength and the stability of the ship. Depending on the building system of the ship hull, these structural elements have a more or less preponderance in the total mass of the ship. In this study paper using Finite Elements Method will be presented a comparative study of different cutting forms through the reinforced frame elements, which are a part of the structure of the ship hull. On the end will be some conclusions regarding the opportunity of adopting one form or the other.

Keywords: ship hull, structural elements, cuttings forms, FEM simulation.

1. INTRODUCTION

The ship hull is a complex structure which consists mostly of steel, constructed on either a longitudinal or a transversal structure system.

The construction of a ship hull consists of the following components: shell and framing. The structure in turn can also be reinforced (usually with T-profile) or/and not reinforced (mostly with bulb profile). Because of their huge weight, just in case they don't need to secure the tightness of a tank or fuel tank, reinforced structural elements have relief cutouts. These are technological cutouts (through which can pass pipes, ventilation ducts, cable routes etc) made with the purpose to lighten the weight of the ship hull in order to ensure an optimal transported mass report between the weight of the shipment and the weight of the ship itself.

Usually, the cutouts form have an eliptical or circular shape.

In this research paper we will study the influence of the cutout shapes based on the resistance and the weight of the structural element.

2. CONCEPT

One of the major demands of the shipowner concerning the ship is she to be as light as

possible so the weight of the shipment to be as big as possible. In this case, various solutions are still being looked upon regarding the weight optimisation of the structural elements of the ship.

In this paper, it will be studied a series of technological cutout shapes in the reinforced structural elements. Based on this analysis it will be proposed a constructive option for the reinforced frame structural elements of the hulls with double bottom. It will be studied the shapes of the plate floor cutouts, the ones which can ensure the lightest weight taking into account the endurance conditions imposed by the naval classification societies.

Figure 1 – a, b, c present structural shapes of the plate floor cutouts from the double bottom of a tanker. As you can see, the cutouts are circular and rectangular. There are two types of rectangurar shapes.

a) model 1

b) model 2

c) model 3

d) model 4
Figure 1
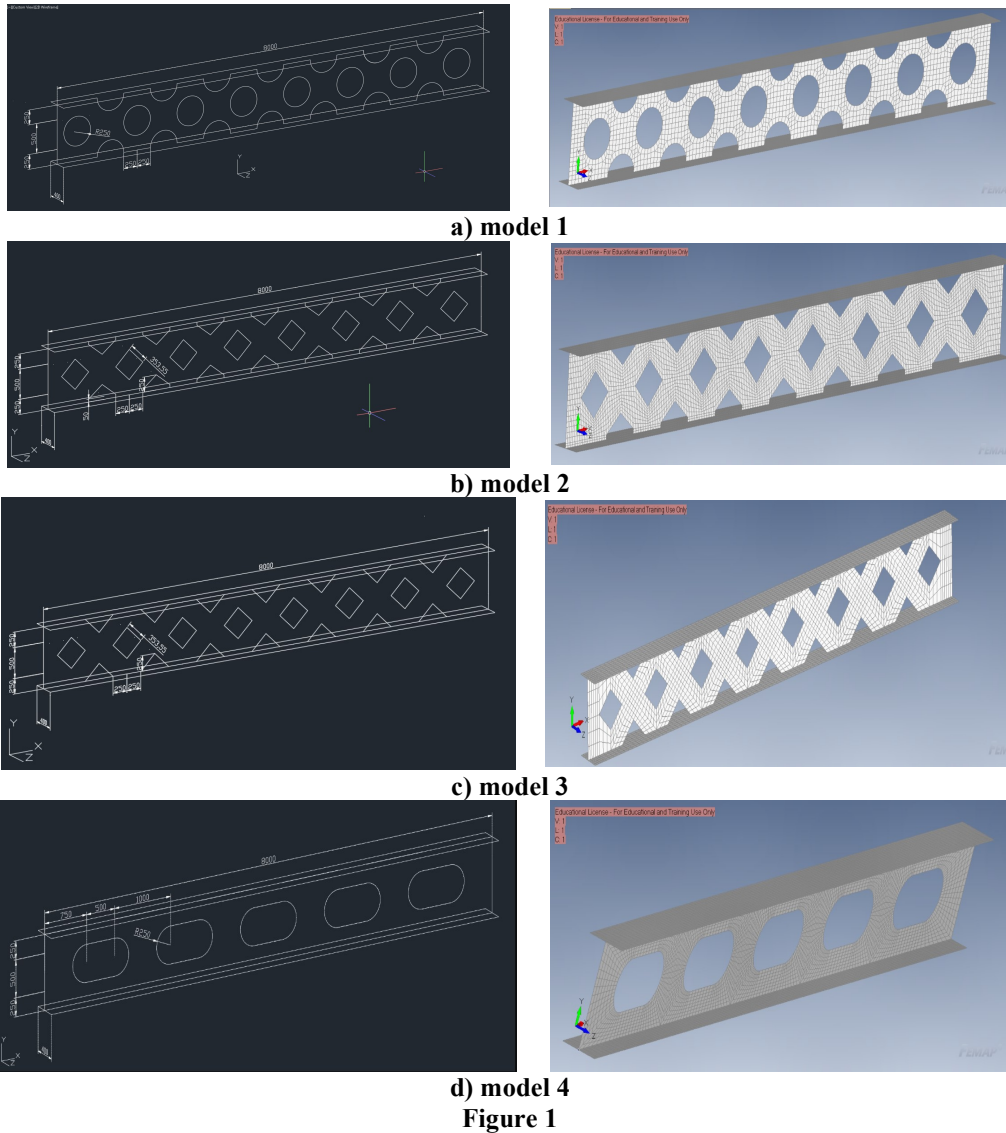
3. MESH STRUCTURE, CONSTRAINTS, LOADS

To determinate the behaviour of the four structural figures we used the finite element analysis program, FEM simulation (the version for educational purposes). The chosen structures have been meshed using the plate elements QUAD as shown in **Figure 1 – a, b, c, d**. For the first structure it has resulted a great number of elements presented in **Table 1**.

Table 1

Model	Elements no	Nodes no
1	3060	3403
2	7744	8391
3	3000	3319
4	7008	7384

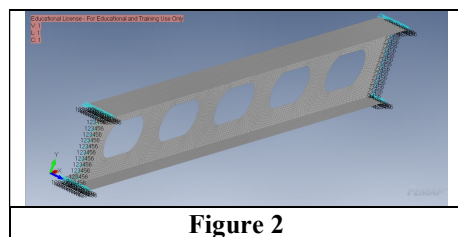The structures constraints (fixed) are presented in **Figure 2**.

Figure 2

This boundary condition simulates the fixing of the plate floor with the longitudinal reinforced structural elements, as if it were a longitudinal watertight bulkhead.

The load is a surface pressure on a 400x8000 mm area given by the 8000 mm oil column.

In **Table 2** are presented the masses of the four chosen cutouts forms.

Table 2

| Model	Mass (kg)
1	901.092
2	969.475
3	983.212
4	955.334

A first conclusion can be drawn regarding mass of the structures. The model 1 (circular cutouts) has the lightest mass of all.
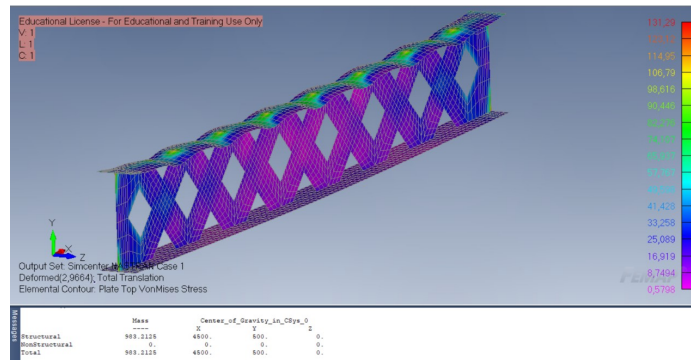
4. STRESS AND DEFORMATION ANALYSIS

For the analysis of the stress and deformation state, the meshed structure was calculated using the FEM simulation software FEMAP. After the analysis, the stress state (VonMises) conclusion for the four figures is presented in **Figure 3**.
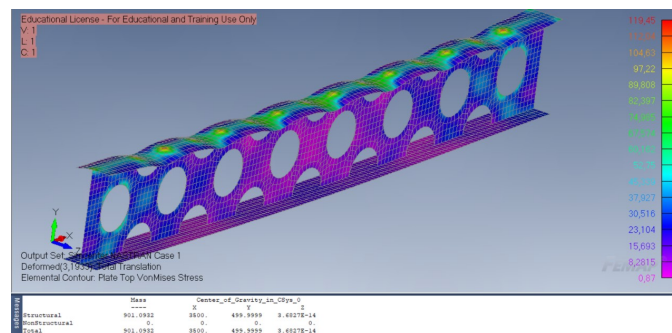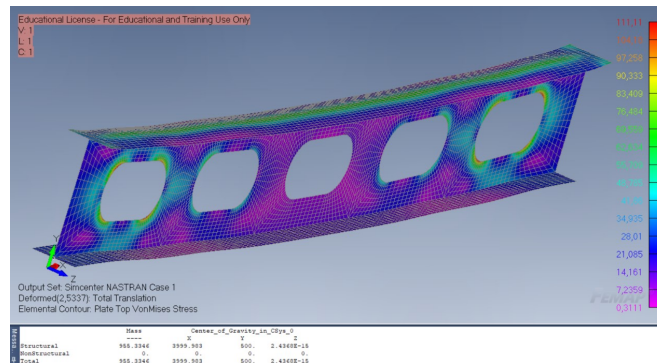

a) model 1 stress
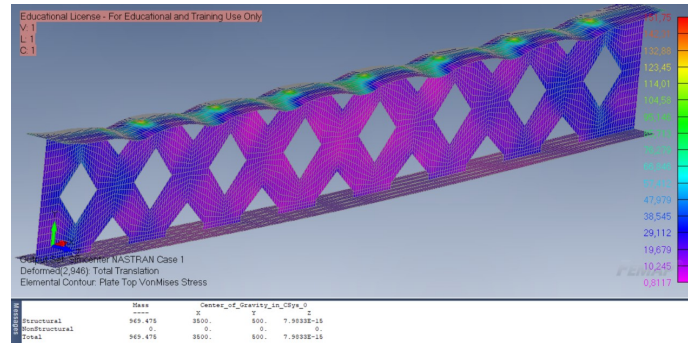
b) model 2 stress

c) model 3 stress

**d)** model 4 stress
Figure 3 Von Mises stress state

From **Figure 3 – a, b, c**, there can be observed the maximum stress for every model. These are presented in **Table 3**.
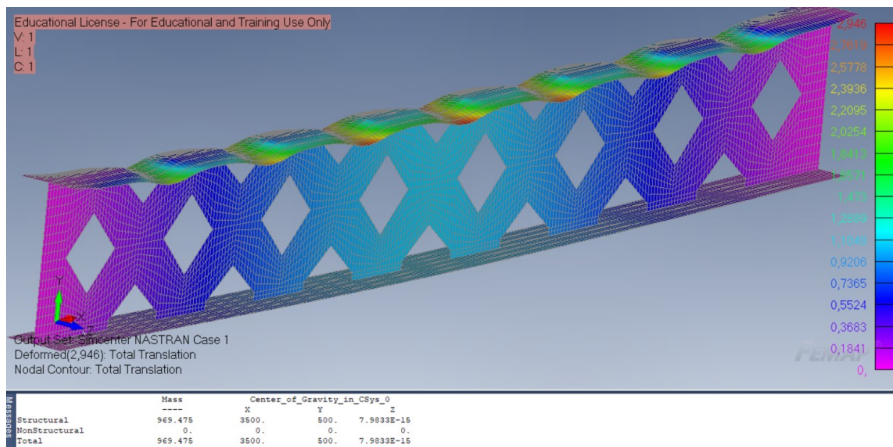
Table 3

Model	Max stress
1	119.45
2	151.75
3	131.29
4	111.11

Given the results the lowest maximum stress is obtained for the first model. The maximum stress doesn't exceed the admissible maximum stress of the steel AH36 (315 MPa).
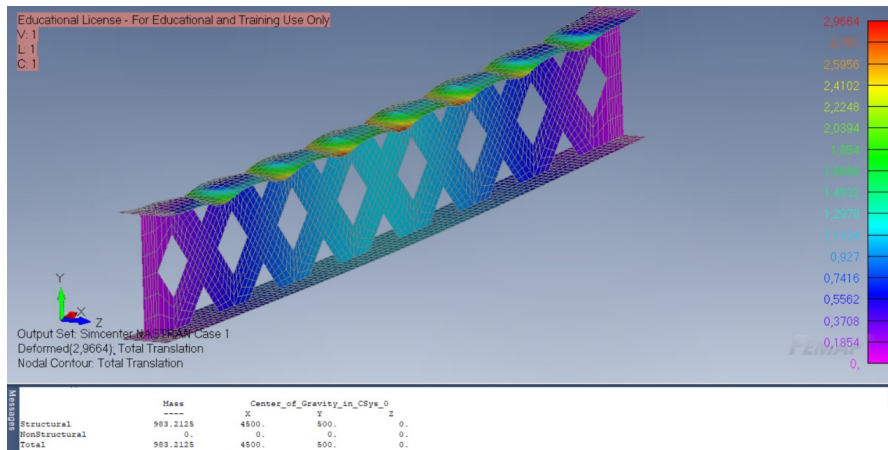
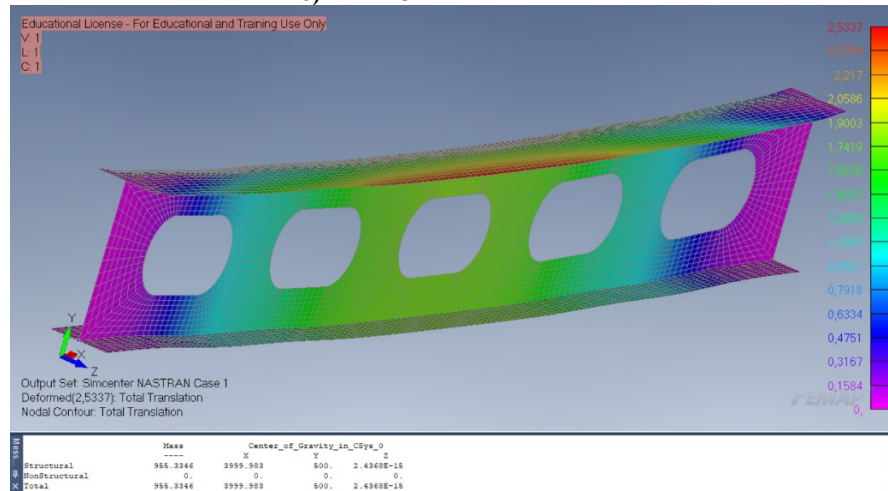In **Figure 4** it is presented the variation of the deformation of the four chosen structures.
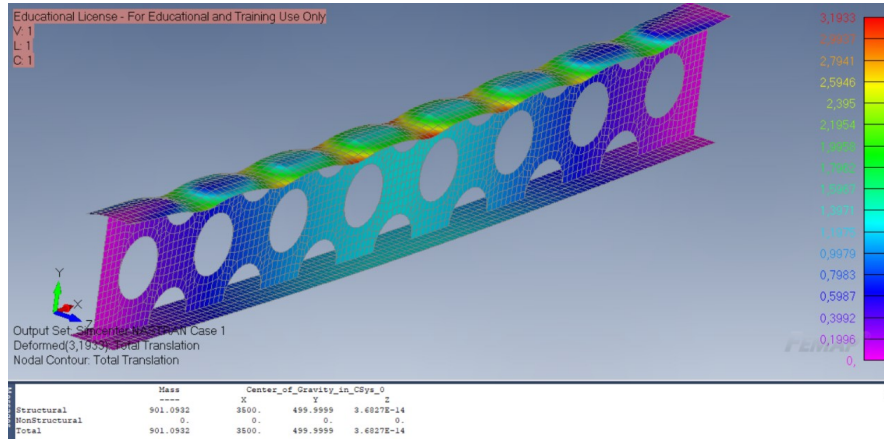
a) model 1 total deformation

b) model 2 total deformation

c) model 3 total deformation

d) model 4 total deformation
Figure 4

The resulting maximum deformations for every structure can be seen as presented in **Figure 4 – a, b, c, d**. They are also presented in **Table 4**.

The maximum translations are found on the edges of the double bottom plates. This it is normal because of the structures dimension chosen. If the structures is enlarged to front respectvelly aft part of the ship this deformation will be smaller. It concerns the translations from the middle lenght of the structure. It can be observed that these are around 1.58 mm.

Table 4

Model	Deformation max (mm)	Max deformation on the middle of the structure (mm)
1	3.19	1.39
2	2.94	1.28
3	2.96	1.29
4	2.53	1.58

5. CONCLUSION

From the data analysis presented in Tables 2, 3, 4, we can conclude that from the four chosen structures, the first one (model 1) has the most advantages. These benefits are:

1.   Mass is lower with 7.59% than the structure 2, with 9.11% than the structure 3 and with 6.02% than the structure 4.

2.   Maximum stress is lower with 27.04% than the structure 2, with 9.91% than the structure 3 and with 7.51% bigger than the structure 4. But on the structure 4 we can see some local effects on the corner of the cuttings which it can be a crack intialisation.

3.   Analysing the deformations also we can see than the figure 1 obtained deformations at the middle lenght of the structure are higher with 7.91% than the figure 2, with 7.19% higher than the figure 3 and with 13.67% smaller then the structure 4.

From these advantages presented above, we can conclude that using the first structure (model 1) for the reinforced frame of the double bottom plates or double hull it is more beneficial, especially regarding the quantity of the material used at the construction of those structural elements.

The final conclusion can be taken after an economical study which it must be done. This study is necessary to see and put in balance the material economy versus the manpower price.

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