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THE BORDURE INFLUENCE WITH FLAT-BARS AROUND THE TECHNOLOGICAL CUT OUTS OVER THE STRESS TENSION AT AN OIL-TANKER SHIP OF 49000 TDW

Anişoara - Gabriela Cristea
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: anisoara.cristea@ugal.ro

Diana Cătălina Ciulin
"Dunarea de Jos" University of Galati,
Faculty of Naval Architecture, Galati, Domneasca Street, No. 47, 800008, Romania,
E-mail: ciulin_diana@yahoo.com

ABSTRACT

The purpose of this paper consists in analysing the bordures influence with flat - bars around the technological cut outs on hot-spots stress. This static calculation was performed by the finite element method with Femap software as modeller and NX Nastran as solver. It is recommended the use of the bordures at the technological cut outs because the tensions decrease considerably, eliminating the risk of dangerous tensions.

Keywords: finite element method, deformations, static analysis, stress concentration, normal stress

1. INTRODUCTION

The study of this work refers to a ship that transports chemical compounds (chemical tanker ship) with 49000 tdw. All references to naval structures have this ship as target.

We select for this study the double-bottom structure where the floors frames are in detail analyzed. In general case, the frames have technological cut-hols for the piping passage from the ballast system, bilge-cables, etc.

These cut outs, usually of rectangular form, are used by strain concentration of tensions through their radius connections.

For the modelling and stress analysis surrounding the relief cut outs of one plate floor it was used the program with finite element Solid Works / COSMOS/M.

2. PRINCIPAL DIMENSIONS OF THE SHIP

The structure taken into consideration within the framework of this work is the structure of the double-bottom, over a hold length, of the oil tanker of 49000 tdw. This type of ship is built in longitudinal truss system.

The principal dimensions are presented in the table below (Tabel 1).

Using the Germanischer Lloyd program, Poseidon for the chemical tanker considerations as a study, it was realized the preliminary structural model, according to the rules of the local and general resistance. The cross section through this ship is presented in Fig.1.

Tabel 1 The geometric and material characteristics for the double-bottom structure

Length of water line at T, L_{WL}	182.85 m
Length between perpendiculars, L_{pp}	175 m
Breadth, B	32.2m
Scantling draught, T	12 m
Depth, D	18 m
Block coefficient, c_B	0.823
Young Module, E	2.1E+5MPa
Poisson coefficient, υ	0.3
Steel density, ρ	7.85E-6 kg/mm^3
Yield point, R_{eH}	235 N/mm^2
Breaking strength, R_m	360-480 MPa

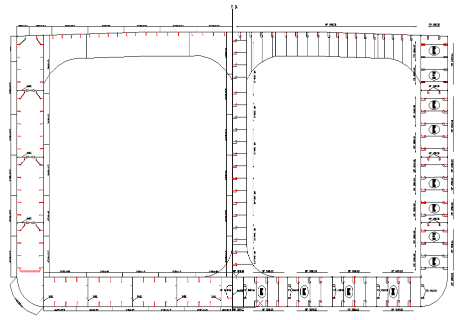

Fig. 1a) Cross-section area at the amidships section

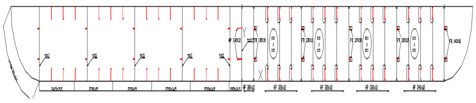

Fig. 1b) Detail of the structure analyzed area

3. MESH STRUCTURE

In general, this kind of structure is composed of: bottom floor, double-bottom, floor plate, side mounts, stiffeners and double-bottom stiffeners.

The hull structure considered in the 3-D hold model includes three cargo tanks of the parallel mid-body, as shown in Figure 2.

The global coordinate system of the finite element model is defined as follows:
X-axis: Longitudinal, positive from aft to fore;
Y-axis: Transverse (athwart ships), positive toward portside;
Z-axis: Vertical, positive upwards;
Origin: Base-line.

The following units are used for analysis
- Length: millimeters (mm);
- Pressure: Megapascals (N/mm);
- Mass: kilogramme (kg);
- Stress: (MPa).

The analyzed model has been reduced at the double-bottom and tank plate and it has been extended over a storage length.

The processing and interpretation of the results can be made very easily with various facilities of post processing, as stress maps, displacements maps, graphics, etc.

In order of the numerical analysis, the double-bottom structures must be meshed with finite elements.

The choice of the finite element depends on the geometry structure and the degree of the precision required by the application.

The global mesh size is 1/6 of the regular distance, the regular distance being 830mm. The mesh is made of quad and triangle elements in the area of the tank plate.

In figure 2 is presented the mesh finite element model used in study.

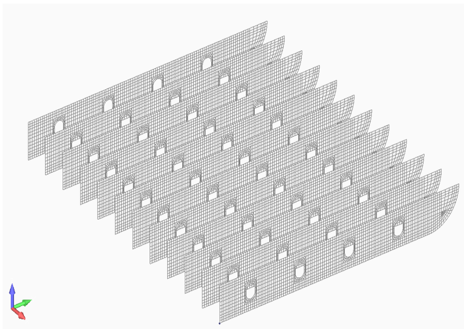

Fig. 2 Floor plates

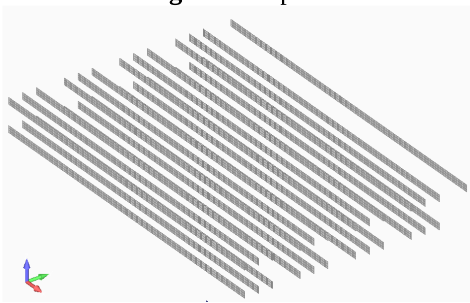

Fig. 3 Longitudinals

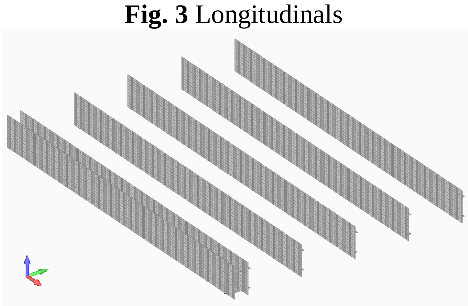

Fig. 4 The central support and lateral support brackets

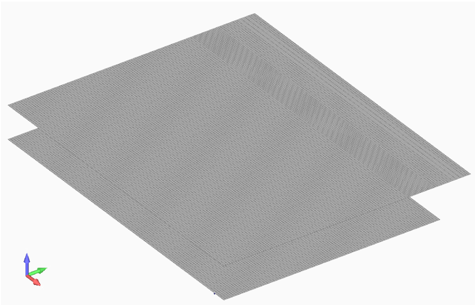

Fig. 5 Double-bottom table and table floor

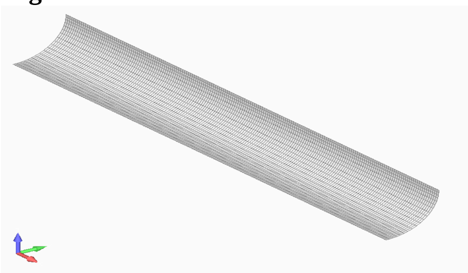

Fig. 6 Table plate

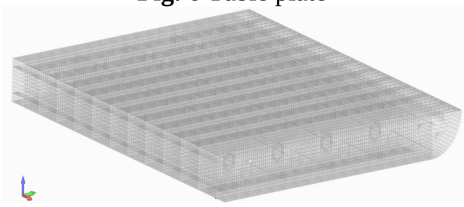

Fig. 7 Meshed double-bottom structure

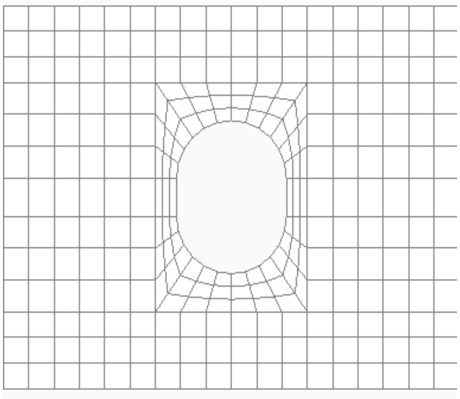

Fig. 8 Cut out detail

4. LOADING THE STRUCTURE

4.1 Boundary conditions

To model the physical bearing points and the instructions with the adjacent structures, it is necessary for a series of displacements and rotations of the finite element model to be default. In order not to affect the accuracy of modelling by blocking the displacements and rotations, the bearing points must be placed at relatively large distances from the numerical area concerned or to be replaced with elastic connections. At the ships analysis structures, the boundary conditions are taking into account the symmetry planes and the distribution of the loads, in order to obtain a real structural model.

The loads that are taken into consideration in the ships analysis structures may be classified after:

- static loads of cargo ship weight and hydrostatic pressure at the calm water balance;
- dynamic loads induced by hall waves;
- loads resulted from the cargo's operation on the board;
- loads that appear in extreme situations as: ship collision, failure, etc.

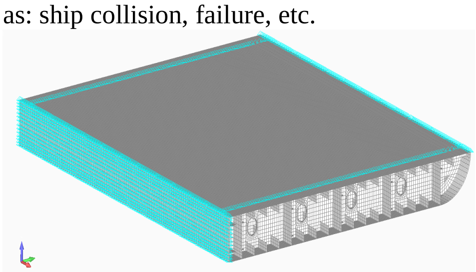

Fig. 9 Boundary conditions

In the model 3D FEM case for this structure, the following border conditions were considered:

Tabel 2 Boundary conditions

Area	Translations			Rotations		
	Ux	Uy	Uz	Rx	Ry	Rz
PD		X		X		
Forward/Aft			X			
Bilge tablea∩ Double Bottom-Table			X			
PD∩Floor plate	X					

4.2 Loading conditions

Considering the full loading case in the next conditions:

- Still water
- Hogging
- Sagging

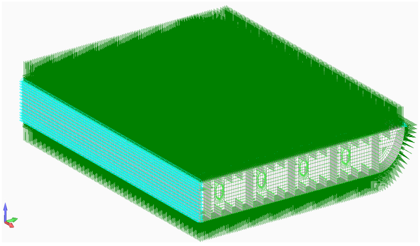

Fig. 11 Boundary conditions

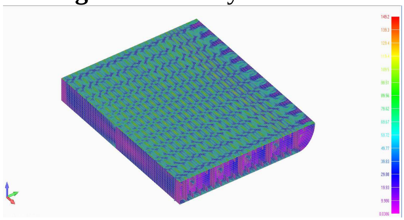

Fig. 12 Global stress (VonMisses), in case of the bordering lack

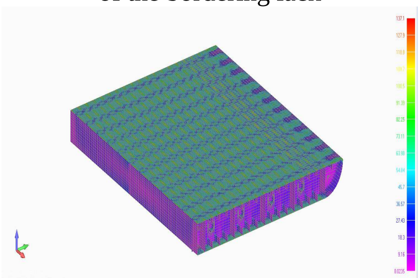

Fig. 13 Global stress (VonMisses), in the bordering case

In order to obtain comparative results of the tensions, between the cut outs case without flare and the cut outs with flare, there were selected a number of 4 elements on the radius connection of the cut outs. (Fig. 14 a,b).

As a result of the numerical calculations done, the results obtained were centralized in tables in which was analyzed the voltage variation on the element depending on the loading charge.

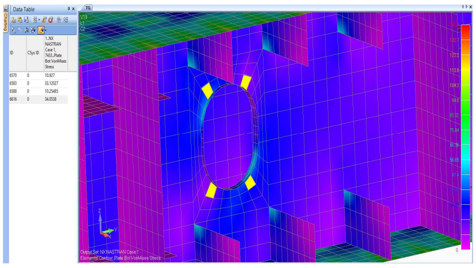

Fig. 14a) Knots arrangements taken in analysis

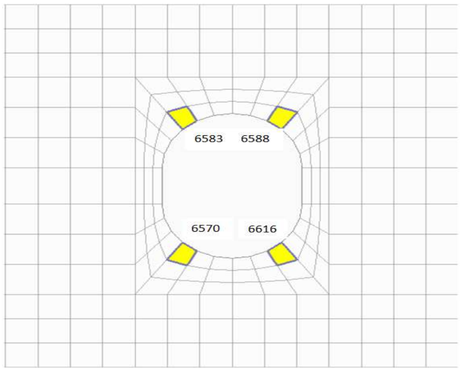

Fig. 14 b) Knots arrangements taken in analysis

L.C. 1: Still water

✓ Cargo pressure, p_{tk}, is:

$$p_{tk} = \rho g z_{tk}, [kN/m^2]$$

where:

z_{tk} - vertical distance the highest point of the merchandise in the tank, [m];

z_{tk} =D - h_{DF}=18-2=16[m];

P - 0.9, density of the merchandise in the tank [t/m^3];

g - 9.81, gravitational acceleration [m/s^2];

✓ Sea water pressure, p_s, is:

$$p_s = \rho_{sw} g T, [kN/m^2]$$

where:

ρ_{sw} - 1.025, density of sea water, [t/m^3];

T - draft, [m];

g - 9.81, gravitational acceleration, [m/s^2].

Table 3 Von Mises tensions table thickness 16mm with technological cut out bordered / unbordered

L.C. 1: Still water

ELEMENT ID	Bordered	Unbordered	Differences
	(MPa)	(MPa)	(%)
6570	10.927	19.251	55.17%
6583	33.120	42.883	25.69%
6588	10.254	19.994	64.40%
6616	34.053	46.979	31.90%

L.C 2: Hogging

✓ Sea water's pressure:

$$p_{cv} = \rho_{sw} g(T + \frac{h_w}{2}),[kN/m^2]$$ where:

ρ_{sw} - 1.025, density of sea water, [t/m^3];
g - 9.81, gravitational acceleration, [m/s^2];
h_w - wave height.

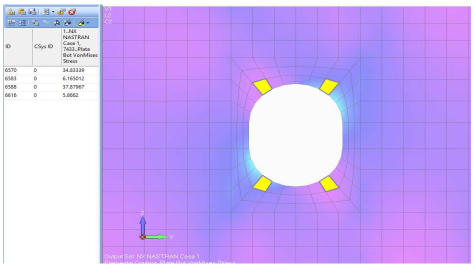

Fig.16a) Hogging - Unbordered cut out

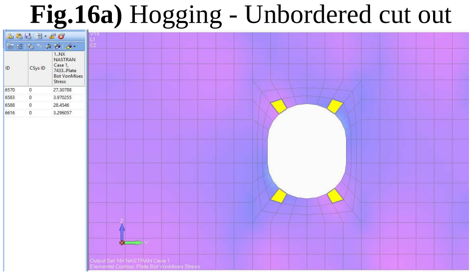

Fig. 16b) Hogging - Bordered cut out

L.C 3: Sagging

✓ Sea water's pressure:

$$p_{cv} = \rho_{sw} g(T - \frac{h_w}{2}),[kN/m^2]$$

Table 4 VonMises tensions table thickness 16mm with technological cut out bordered/ unbordered

L.C. 2: Hogging

ELEMENT ID	Bordered	Unbordered	Differences
	(MPa)	(MPa)	(%)
6570	27.307	34.833	24.22%
6583	3.970	6.165	43.31%
6588	28.454	37.879	28.42%
6616	3.296	5.866	56.10%

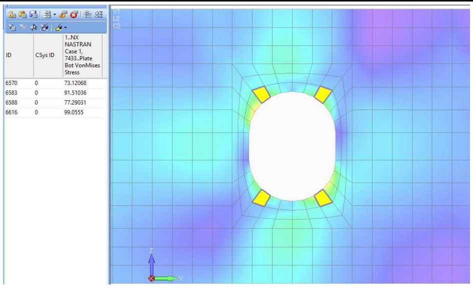

Fig. 17a) Sagging - Unbordered cut out

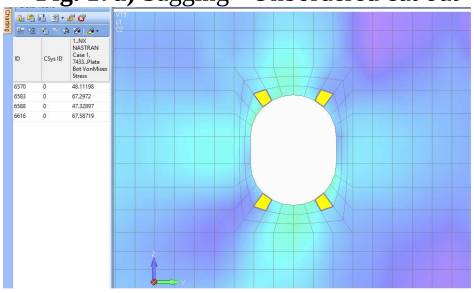

Fig. 17b) Sagging - Bordered cut out

Table 5 VonMises tensions table thickness 16mm with technological cut out bordered/ unbordered

L.C. 3: Sagging

ELEMENT ID	Bordered	Unbordered	Differences
	(MPa)	(MPa)	(%)
6570	48.111	73.120	41.26%
6583	67.297	91.510	30.49%
6588	47.328	77.290	48.08%
6616	67.587	99.055	37.77%

4. CONCLUSIONS

The results interpretation is just partial because this model contains only tensions and deformations requested by the local stress, without taking into consideration the stress local bending of the ship that introduces additional tensions, especially structural elements of the double-bottom.

From the analysis of the results obtained the following may be concluded:

It is recommended the use of borderes at the technological cut outs because the tensions decrease considerably, eliminating the risk of dangerous tensions. As it appears from the tables above, pressures drop in the cut outs technological area, reducing the risk of apparition and propagation of the cracks in those areas.

The calculation methodology presented can be successfully used for the stress tension calculation in the double-bottom ships structure.

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