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3D-FEM Strength Analysis for the Influence of Corrosion over Deck Plating of a Oil Tanker Ship

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Abstract - ***The subject of this study is to identify the influence of corrosion over deck plating of a VLCC. The main deck of the ship was affected by pitting, firstly initiated by coating breaking following by scratching and spill of various aggressive liquids. Strength analysis was performed using 3D-FEM tools over three cargo hold model. Yielding ratio criteria was used as checking criteria.***
Keywords - **corrosion influence, three cargo hold model, 3D-FEM numerical analysis, VLCC**

I. Introduction

The vessel selected for this study is a VLCC (very large crude carrier) with double hull. The main characteristics of the ship are presented in Table 1.

Table 1. Main characteristics of the ship

Length between perpendiculars	L_{BP}	324	m
Breadth	B	60	m
Draught	T	21	m
Depth	D	29	m
Service speed	v_s	16	knots
Displacement	Δ	360000	t
Block coefficient	c_B	0.86	

The size of the selected vessel is justified by the fact that in our days some VLCC are transformed into FPSO (floating production storage and offloading) or FSU (floating storage unit) ships and during conversion the 3D-FEM strength analysis is to be carry out to verify the strength of the hull structure. The structural assessment is to verify that the acceptance criteria specified are complied with. The model extends over three cargo tank lengths about midship. Coarse mesh model has been modelled including all main longitudinal and transversal structural elements.

During the lifetime the ships are affected by corrosion for this study we considered that the main deck of the ship was affected by pitting, was firstly initiated by coating breaking following inappropriate storage of items on deck, scratching when moving items and spill of various aggressive liquids.

The deck plating was divided per longitudinal strakes and per frame spacing. These area have typically 4.8x3m, and each area was divided in 2x3 items. The locations were the deck plating is affected by pitting is presented in Figure.2. In some locations have been found substantial corrosion or even corrosion above the rule allowable corrosion margin, the maximum wastage was 30 %.

The ship is longitudinally stiffened, the transverse frame spacing is 800 mm and the longitudinal stiffener spacing is 940mm except from specific locations. The ship scantling was made according to Bureau Veritas Rules[1] using Mars 2000 software. In figure Figure.3 is presented the midship section of the selected ship.

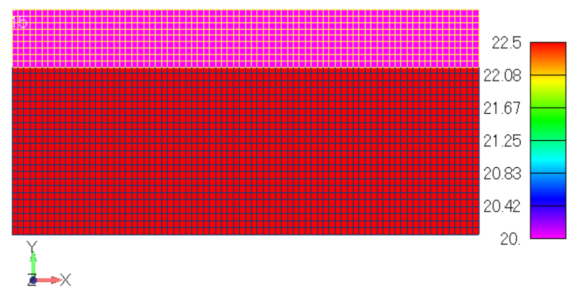

Figure.1. Thickness of deck plating as built

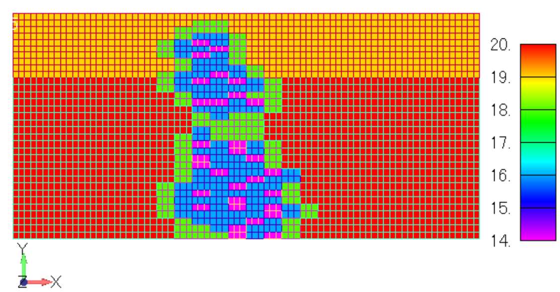

Figure.2. Thickness of deck plating affected by corrosion

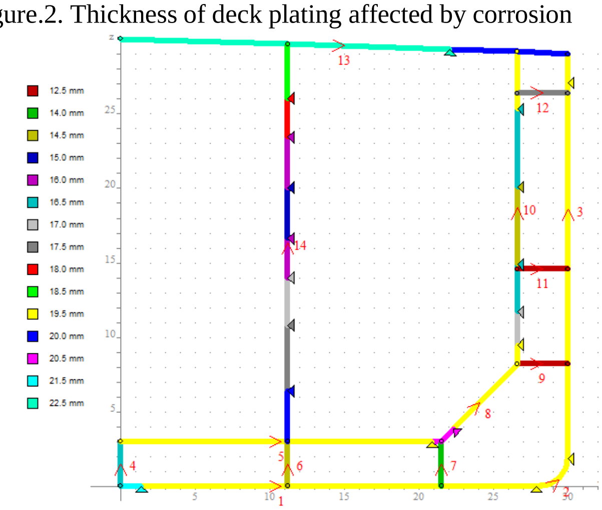

Figure.3. Midship section

II. Methodology

In order to study the strength of the selected vessel the 3 cargo hold 3D-FEM model was built in FEMAP according to CSR Rules [2] for double hull oil tankers. Hereafter are presented the main steps for the strength analysis [4].

The 3D-FEM mesh of the ship hull structure

The first step of the strength analysis includes the generation of the 3D-FEM hull model. The mesh can be generated automatically, using auto-mesh options that are usual included in the FEM programs or it can be done manually. In the 3D-FEM model, all structural members have been modelled according to their original shape using the following types of elements:

- plate element defined by three / four nodes, each with six degrees of freedom;
- bar elements defined by two nodes, six degrees of freedom per node;

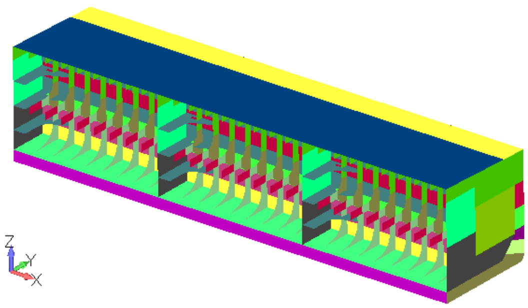

Figure.4. 3 Cargo holds 3D-FEM model

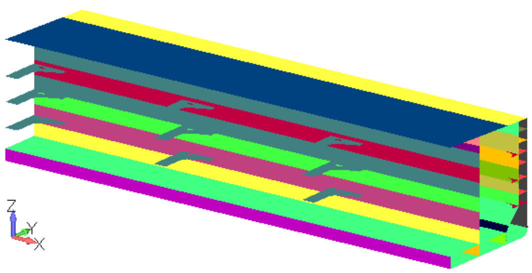

Figure.5. 3D-FEM model: longitudinal structures

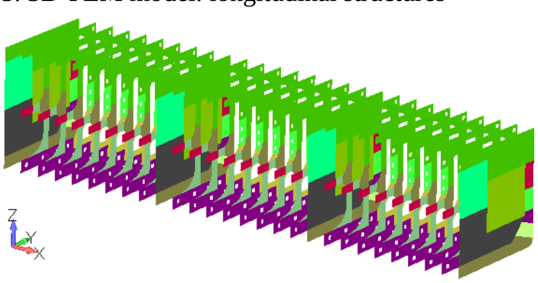

Figure.6. 3D-FEM model: transverse structures

In the Table 2 are presented the characteristics of the materials used for 3D-FEM model

Table 2. Material characteristics

Young modulus		206000	N/mm^2
Poison coefficient		0.3	
Transversal modulus		79231	N/mm^2
Density		7850	Kg/m^3
Yield limit	AH32	315	N/mm^2
	AH36	355	N/mm^2

The boundary conditions of the 3D-FEM model

The next step of analysis includes the generation of the boundary conditions for the 3D-FEM hull model. Due to the symmetry of the ship structure the model was developed only in one side with symmetry conditions in center line.

Two rigid elements (shown in Figure.7) were added at the fore end and the aft end of the model having the master node in the neutral axis of the ship. For all the nodes in center line the symmetry boundary condition is applied.

The boundary conditions applied to the 3D-FEM model are presented in the Table 3. The TX, TY and TZ are the translation along X, Y and Z axis and the RX, RY and RZ are the rotations around X, Y and Z axis.

Table 3. Boundary conditions applied to 3D-FEM model

Boundary condition	TX	TY	TZ	RX	RY	RZ
Center line		X		X		
Aft node	X	X	X	X		X
Fore node		X	X	X		X

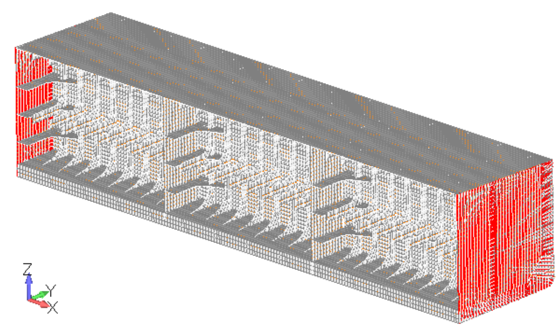

Figure.7. Two rigid elements situated in the aft and fore extremity of the model

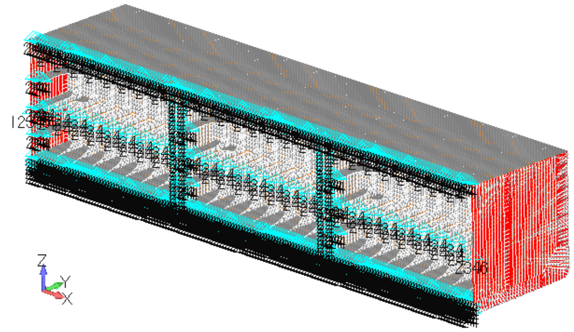

Figure.8. Boundary conditions applied to the model

The loading conditions and the numerical analysis

This third step of the strength analysis contains the modeling of the loading conditions and the effective numerical structure analysis of the 3D-FEM model. Four load cases were selected for this analysis. The model was loaded with still water bending moment (SWBM) and total wave bending moment, SWBM+VWBM, were VWBM represents the vertical wave bending moment, both for sagging and hogging conditions.

The vertical wave bending moment for hogging and sagging conditions are calculated according to Bureau Veritas Rules[1].

$$M_{WV,H} = 190 \cdot F_M \cdot n \cdot C \cdot L^2 \cdot B \cdot c_B \cdot 10^{-3}$$

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$$M_{WV,S} = -110 \cdot F_M \cdot n \cdot C \cdot L^2 \cdot B \cdot (c_B + 0.7) \cdot 10^{-3}$$

were:
F_M - represents the distribution factor,
C - represents the wave parameter,
n - represents the navigation coefficient;

The Table 4. contains the values of the moment applied for each analysis case for the two master nodes.

Table 4. Bending moment values for two master nodes

	NDaft [kNm]	NDfore [kNm]
SWBM - Hogging	- 7252730	+ 7252730
SWBM - Sagging	+ 6637163	- 6637163
SWBM + VWBM - Hogging	- 17869290	+ 17869290
SWBM + VWBM - Sagging	+ 17869283	- 17869283

The numerical results evaluation

At this step of the strength analysis based on 3D-FEM model are obtained the stress and deformations, and also the prediction of the higher risk domains.

The yielding ratio was used as checking criteria.

The yielding ratio is calculated according to Bureau Veritas Rules using eigen program codes [3].

$$YR = \frac{\sigma_{VM}}{\sigma_{Master}};$$

$$\sigma_{Master} = \frac{R_y}{\gamma_R \times \gamma_M};$$

$$R_y = \frac{235}{k};$$

$$\sigma_{VM} = \left(\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau^2\right)^{1/2};$$

where k is the material coefficient and γ_R, γ_M are partial safety factors.

III. Numerical results

The numerical analysis is focused on the deck strength of a VLCC ship. The yielding ratio is used as a checking criteria, according to chapter II with the yielding ratio smaller than unit the strength criteria is verified.

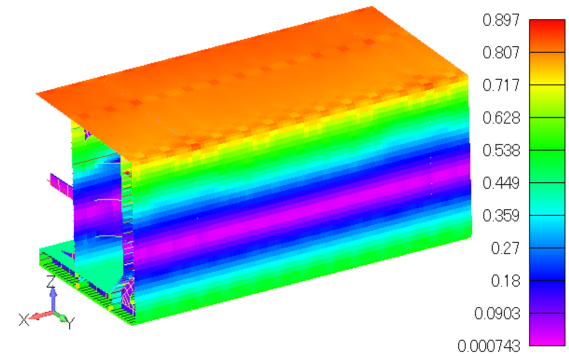


Figure.9. Yielding ratio distribution over central tank of the ship. Envelope for all loading conditons. As built model.

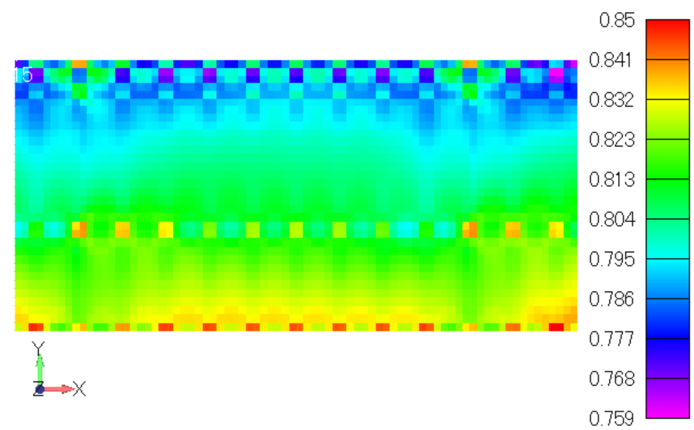


Figure.10. Yielding ratio distribution over main deck of the ship. Envelope for all loading conditons. As built model

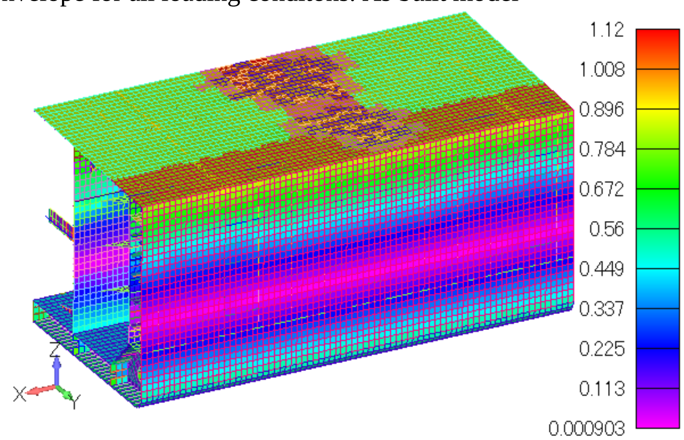


Figure.11. Yielding ratio distribution over central tank of the ship. Envelope for all loading conditons.Corroded model.

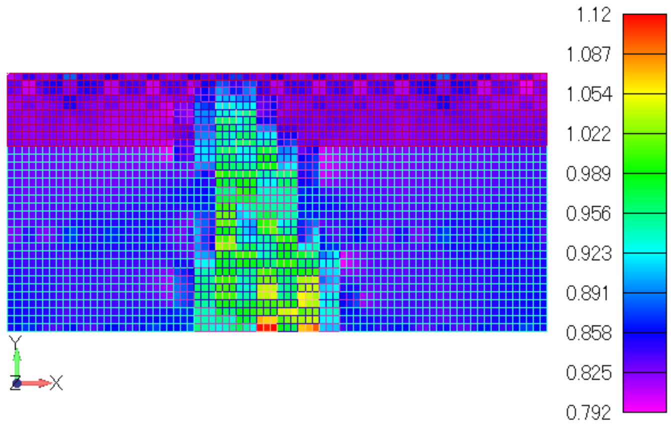


Figure.12. Yielding ratio distribution over main deck of the ship. Envelope for all loading conditons. Corroded model.

Figures Figure.9. and Figure.11. presents the yielding ratio distribution over the middle cargo tank of the ship for as built model and for corroded model.

Figures Figure.10. and Figure.12. presents the yielding ratio distribution over the main deck for as built model and for corroded model.

For as built model the maximum yielding ratio is 0.897 and for model affected by pitting the maximum yielding ratio is 1.12.

Hereafter are presented the spots where the yielding ratio is greater than unit for the deck affected by pitting.

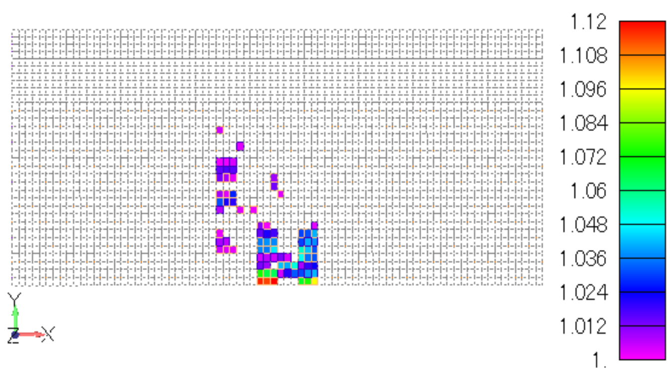
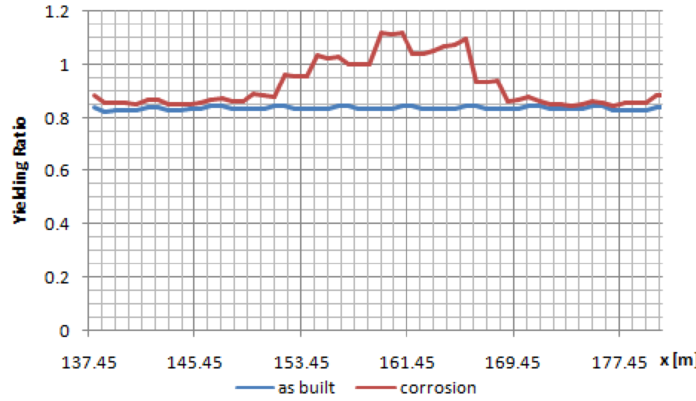


Figure.13. Yielding ratio greater than unit on main deck of the ship. Envelope for all loading conditons. Corroded model.

For the spots where strength criteria in not fulfill the repair should be done by welding-up pits or by inserts.
Other experimental alternative may be applied, for example composite reinforcement.

IV. Conclusion

The diminution of deck thickness is related to accidental contact of deck plating with chemical products and mechanical abrasion due to storage of metallic objects directly on deck followed by wastage due to environment factors. Due to the wastage the deck strength was affected. Hereafter are presented the differences between the maximum yield ratio values along deck.



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References

i. *BV, Bureau Veritas Rules for Classification of Steel Ships, 2014.*

ii. *CSR, Common Structural Rules for Double Hull Oil Tankers, 2008.*

iii. *Jagite, G.; Domnisoru, L., Ship Structural Analysis with Femap API program codes. Naval Architecture Faculty, Galati, Romania, 2014;*

iv. *4.Domnisoru, L., The finite element method applied in shipbuilding. Bucharest: The Technical Publishing House,2001;*

v. *5.Domnisoru, L., Structural analysis and hydroelasticity of ships. University "Dunarea de Jos" Press, Galati, 2006;*

vi. *6. Hughes, O.F., Ship structural design. A rationally-based, computer-aided optimization approach. New Jersey: The Society of Naval Architects and Marine Engineering, 1988;*

vii. *7. Bathe, K.J., Finite Elementen Methoden. Berlin: Springer Verlag, 1990;*

viii. *8. Guedes Soares, C., Special issue on loads on marine structures. Marine Structures 12(3):129-209, 1999;*

ix. *9. Servis, D.; Voudouris, G.; Samuelides, M.; Papanikolaou, A., Finite element modeling and strength analysis of hold no. 1 of bulk carriers. Marine Structures 16:601-626, 2003;*

x. *10. Lehman, E., Matrizenstatik. Hamurg: Technischen Universitat Hambourg - Hamburg, 1994;*

xi. *11. Lehman, E., Guidelines for strength analysis of ship structures with the finite element method. Hamburg: Germanischer Lloyd Register, 1998;*

xii. *12. Ioan, A.; Popovici, O.; Domnisoru, L., Global ship strength analysis. Braila: Evrika Publishing House, 1998;*

xiii. *13. Rozbicki, M.; Das Purnendu, K.; Crow, A., The preliminary finite element modeling of a full ship. International Shipbuilding Progress. Delft 48(2):213-225, 2001;*