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ON A RIVER-BARGE NUMERICAL STRENGTH ANALYSIS IN HEAD DESIGN WAVE LOADS

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ABSTRACT

The FEM approach is a well-established computational technique for solving the governing equations of structural mechanics under various loadings. To delve deeper into the FEM approach, we focus on the floating structure of a river barge. This study aims to determine a structure's structural capacity by applying admissible stress criteria following the DNV rules. The structural analysis involves a comparative study of stress levels from the equivalent design wave loads for two river-barge operational conditions, light, and full cargo cases.

Keywords: river-barge**,** FEM analysis, global-local strength, design wave loads.

1. INTRODUCTION

The FEM approach is recognized as a highly effective computational technique for solving the mechanical equations of structures under various loading scenarios.

To delve deeper into the FEM application for the ship's strength analysis, we have selected the floating structure of a 1400 tdw river-barge, by the ANR album [1]. The Shipyard Drobeta Turnu Severin and Shipyard Orsova built the river-barge.

The river-barge structure was initially designed by the RNR / ANR rules [1] and was re-designed by the DNV rules [2].

The river-barge has one hatch and deck, two transversal bulkheads, and longitudinal bulkheads, defining the single cargo-hold.

Table 1 presents the main data of the 1400 tdw [1] river-barge.

Table 1 The river-barge main data [1]

L_{PP}[m]	68.20
L_{max}[m]	71.00
B [m]	11.60
H [m]	2.70
T_{light} [m]	0.506
T_{full} [t]	2.257

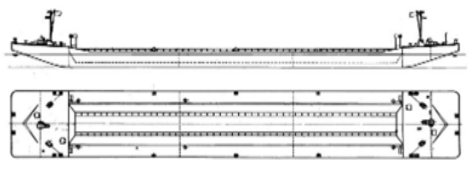


Fig.1 River-barge 1400 tdw [1].

2. RIVER-BARGE SCANTLING

The scantling of the river-barge is acquired using the Poseidon [2] program by DNV (Figs. 2-3).

In the initial phase, following the structural scantling results, CAD river-barge model is obtained using the Rhinoceros [3] program (Fig.4). Subsequently, the surfaces are imported layer by layer in the Femap [4] program, using the *.stp* file extension.

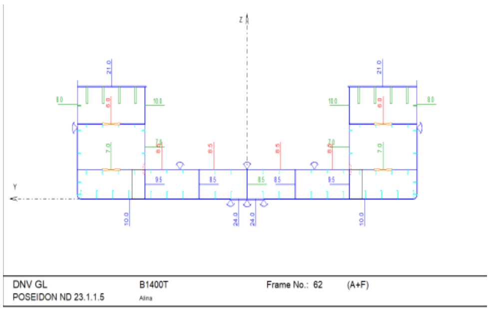


Fig. 2 Plates thickness - Scantling results

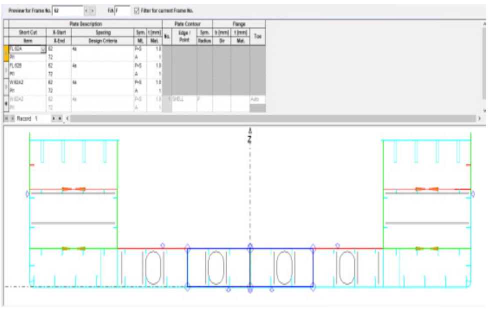


Fig. 3 Hull structure - Plates view

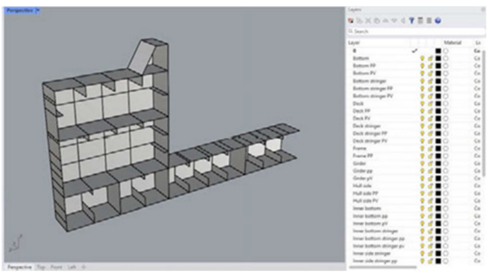


Fig. 4 River-barge, 3D-CAD model, detail

3. RIVER-BARGE FEM

The FEM river-barge model obtained by Femap [4] program (Fig.5), consists of: 72960 nodes, and 78976 elements, 406 triangles, and 78372 quads.

The most important steps conducted in this phase of the study are: defining the material, specifically Grade A Steel and establishing the properties by incorporating the plate thicknesses and profile dimensions determined in the scantling phase. At the same time, the necessary boundary conditions are applied for each loading case.

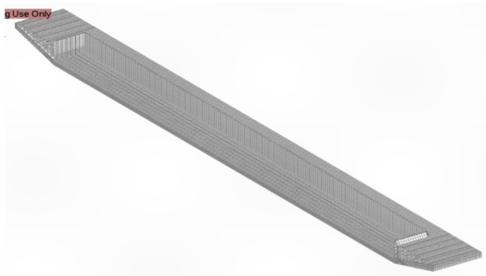


Fig. 5 River-barge, FEM model

4. RIVER-BARGE LOADING CONDITIONS

For the light loading (T=0.506 m), 13 wave cases have been computed, still water, wave height H_w=0.10, 0.20, 0.30, 0.40, 0.50, 0.60 m, hogging & sagging (Fig.6).

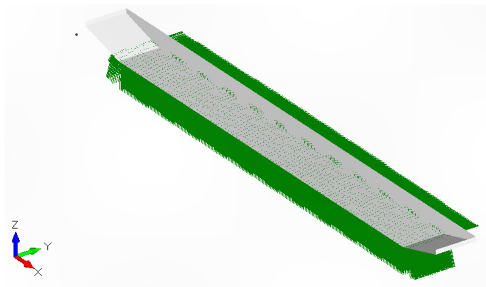


Fig. 6 Hogging H_w= 0.60 m, light, wave load pressure

For the full loading (T=2.257 m), the same 13 loading cases were used, H_w=0-0.6 m sagging & hogging (Fig.7).

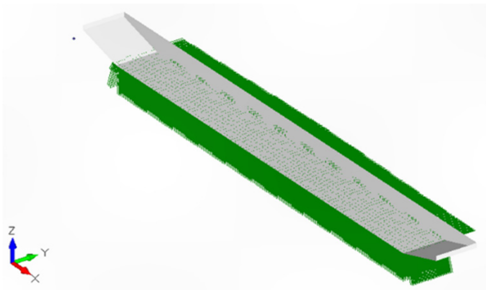


Fig. 7 Sagging H_w= 0.60 m, full cargo, wave load pressure

5. RIVER-BARGE FEM ANALYSIS FOR THE LIGHT CASE

For the light river-barge case, the wave load scenarios have three primary subcases: still water, hogging waves (Figs. 8-9), and sagging waves (Figs. 10-11).

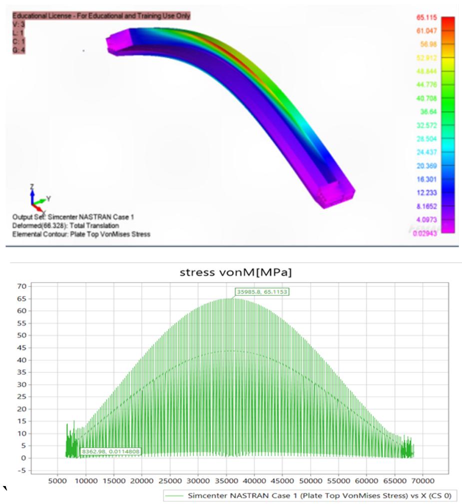


Fig. 8 Von Mises stress [MPa], Light, H_w=0.60m, hogging.

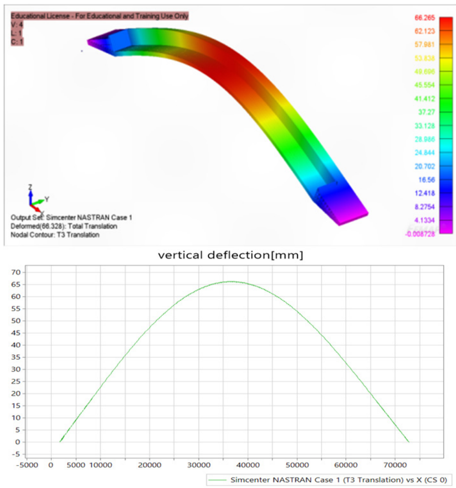


Fig. 9 Vertical deflection [mm], Light, H_w=0.60m, hogging.

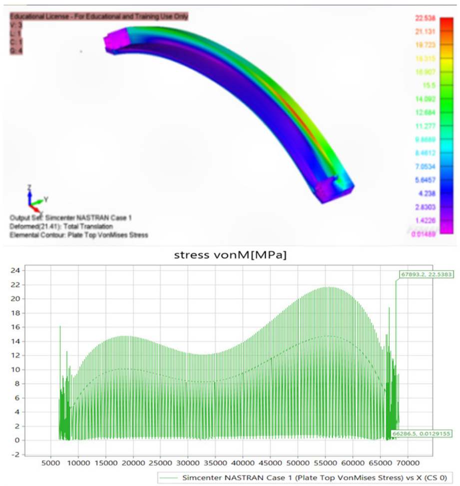
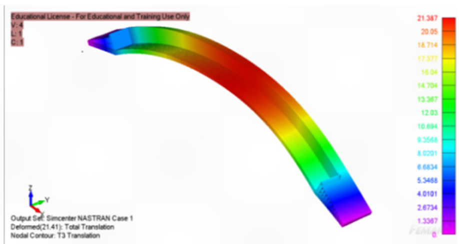


Fig. 10 Von Mises stress [MPa], Light, H_w=0.60m, sagging.



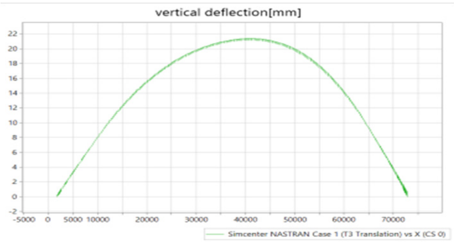
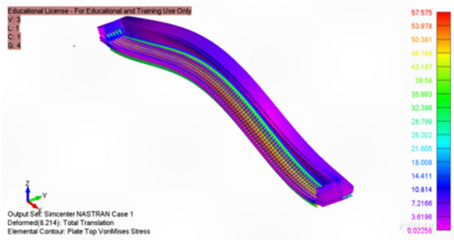


Fig. 11 Vertical deflection [mm], Light, H_w=0.60m, sagging.

6. RIVER-BARGE FEM ANALYSIS FOR THE FULL CASE

For the full cargo river-barge case, the wave load scenarios also have three primary subcases: still water, hogging waves (Figs. 12-13), and sagging waves (Figs. 14-15).



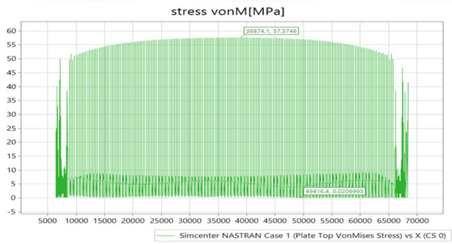
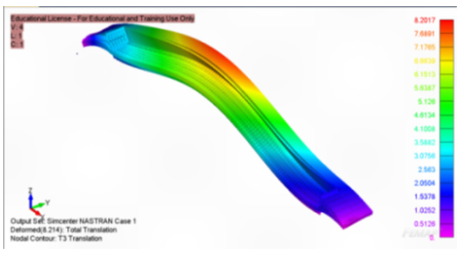


Fig. 12 Von Mises stress [MPa], Full cargo, H_w=0.60m, hogging.



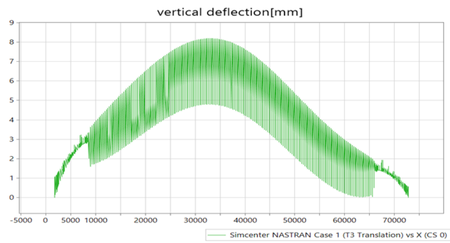
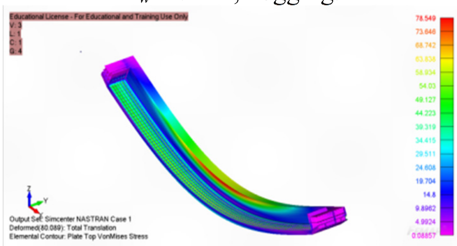


Fig. 13 Vertical deflection [mm], Full cargo, H_w=0.60m, hogging.



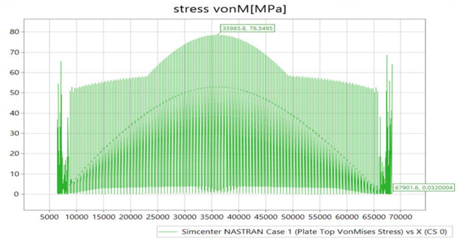
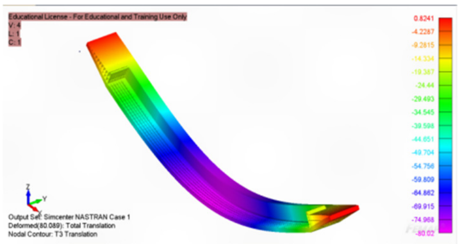


Fig. 14 Von Mises stress [MPa], Full cargo, H_w=0.60m, sagging.



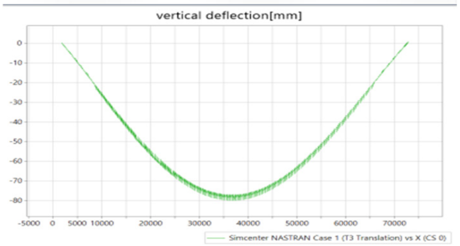


Fig. 15 Vertical deflection [mm], Full cargo, H_w=0.60m, sagging.

7. RIVER-BARGE STRESS FEM RESULTS

Tables 2 and 3 summarize the von Mises stress results obtained for all the loading cases, including light and full cargo cases.

Table 2 River-barge, Von Mises stress [MPa].

Loading Case	Light	Cargo	%
Still water	40.79	58.23	42.75
Sagging S010	36.43	58.72	61.20
Sagging S020	32.09	60.54	88.70
Sagging S030	28.12	63.37	125.34
Sagging S040	25.18	66.94	165.81
Sagging S050	23.15	74.18	220.41
Sagging S060	22.54	78.55	248.56

Table 3 River-barge, Von Mises stress [MPa].

Loading Case	Light	Cargo	%
Hogging H010	45.09	58.08	28.82
Hogging H020	49.28	57.95	17.60
Hogging H030	53.38	57.84	8.35
Hogging H040	57.39	57.74	0.60
Hogging H050	61.31	57.66	-5.95
Hogging H060	65.12	57.58	-11.58

8. RIVER-BARGE FREEBOARD

In Table, 4 the freeboard is checked for full case, without coaming. In the case of wave height H_w>0.40 m (full cargo), it is necessary to add a supplementary coaming of at least 0.1 m.

Table 4 River-barge, Freeboard [m] without supplementary coaming, Full case.

Loading Case		Freeboard [m]		
		Aft	Mid	Fore
1	SW	0.248	0.248	0.248
2	S0.10	0.198	0.298	0.198
3	H0.10	0.298	0.198	0.298
4	S0.20	0.148	0.348	0.148
5	H0.20	0.348	0.148	0.348
6	S0.30	0.098	0.398	0.098
7	H0.30	0.398	0.098	0.398
8	S0.40	0.048	0.448	0.048
9	H0.40	0.448	0.048	0.448
10	S0.50	-0.003	0.498	-0.003
11	H0.50	0.498	-0.003	0.498
12	S0.60	-0.061	0.539	-0.061
13	H0.60	0.539	-0.061	0.539

9. CONCLUSIONS

This study assessed the river-barge 1400 tdw structural capacity by applying the admissible stress criteria for equivalent design wave loads, by the DNV rules [2].

The analysis involved a comparative study of stress levels for two operational conditions: light and full cargo cases (Tables 3 and 4). From the strength standpoint, both loading cases are within acceptable stress limits.

From the freeboard analysis (Table 4), for the full case, results that the 1400 tdw river barge's deck is at risk of flooding from design waves, due to inadequate coaming height. To mitigate this risk, it is necessary to at least add an additional 0.1 m coaming height to the deck panel.

Acknowledgements

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