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STRENGTH ASSESSMENT IN OBLIQUE DESIGN WAVES FOR A EUROPE B2 1740T RIVER BARGE TYPE

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ABSTRACT

The operation limits of a Europe B2 1740T barge have to be evaluated by several safety criteria. A practical approach is based on the global strength criteria evaluation by equivalent beam barge model and equivalent rules waves, with several heading angle cases. There are considered the Danube river navigation conditions and eventually a costal route, too. The barge is considered with three loading cases and the numerical analyses are done by P_QSW eigen program. The numerical results, hull beam sectional efforts, are evaluated by shipbuilding rules global strength criteria and the allowed operation conditions are obtained.

Keywords: Europe B2 1740T barge, global strength, equivalent oblique waves.

1. INTRODUCTION

A practical approach for the operation limits of a Europe B2 1740T barge [3] is based on the global strength analysis by equivalent beam model [4,5].

The main data of the barge are presented in Table 1 [1] and the barge shape in Fig.1.

Table 1. The barge main data [3]

L = 76.5 m	Case	Δ [t]	T_m [m]
B = 10.96 m	Barge_1	405.95	0.55
H = 3.2 m	Barge_2	1540.95	2.00
$h_{w\,max}$=2 m	Barge_3	2108.40	2.70
μ=0-75deg.	405 stations / 21992 points		

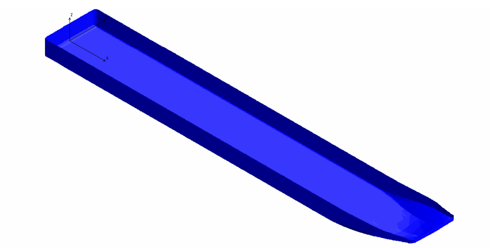

Fig.1.The Europe B2 barge shape [3]

There are considered three loading cases (Table 1) corresponding to: light displacement, common cargo load, full cargo load conditions [3].

The numerical analyses are developed by *P_QSW* eigen program [4], with oblique equivalent rules waves [2,5], using an iterative algorithm for the computation of the equilibrium between the wave and the barge [4]. The wave height range is h_w=0-2 m, step 0.25m, sagging and hogging cases, for Danube river and costal routes. The main heading angle range is μ=0-75 deg., extended over 360 deg., with step of 15 deg.

The computed beam sectional efforts are assessed by Bureau Veritas Rules [2] global strength criteria and the operation limits are obtained.

Table 2. Global strength criteria, BV [2]

Vertical bending M_v [kNm]	2.44E+04
Vertical shearing T_v [kN]	1.19E+03
Horizontal bending M_h [kNm]	5.74E+03
Horizontal shearing T_h [kN]	2.23E+02
Torsional moment M_t [kNm]	8.78E+03

2. THE STRENGTH ASSESSMENT FOR LIGHT DISPLACEMENT CASE

The numerical global strength results for case *Barge_1* are present as following:
-Tables 3.a,b the maximum values for sectional efforts, hogging and sagging, main selection for μ=0-75 deg. (15 deg.), h_w=0-2m, case 1;
-Figs.2.a-e the assessment of the global strength criteria by maximum sectional efforts, case 1;
-Fig.3 the polar diagram of operation limits in terms of equivalent wave height h_w, by global strength and equivalent beam models, case 1;
-Figs.4.a-e the maximum sectional efforts diagrams, sagging and hogging conditions, case 1.

Table 3.a Barge_1 case, max. efforts, hogging

μ	0	15	30	45	60	75
M_v	**2.41E+4**	2.40E+4	2.36E+4	2.27E+4	1.99E+4	1.79E+4
T_v	**1.05E+3**	1.04E+3	1.03E+3	9.87E+2	8.78E+2	8.11E+2
M_h	0.00E+0	9.02E+1	1.92E+2	3.24E+2	5.15E+2	5.96E+2
T_h	0.00E+0	8.21E+0	1.74E+1	2.91E+1	4.50E+1	5.08E+1
M_t	0.00E+0	5.68E+2	1.21E+3	2.06E+3	3.36E+3	3.95E+3

Table 3.b Barge_1 case, max. efforts, sagging

μ	0	15	30	45	60	75
M_v	1.21E+4	1.20E+4	1.16E+4	1.05E+4	7.43E+3	9.81E+3
T_v	7.23E+2	7.18E+2	7.00E+2	6.54E+2	5.33E+2	5.55E+2
M_h	0.00E+0	7.28E+1	1.55E+2	2.63E+2	4.26E+2	**6.18E+2**
T_h	0.00E+0	6.14E+0	1.31E+1	2.19E+1	3.45E+1	**5.15E+1**
M_t	0.00E+0	6.00E+2	1.28E+3	2.17E+3	3.49E+3	**4.88E+3**

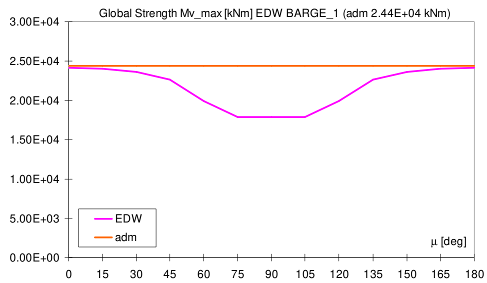

Fig.2.a. Barge_1,max. M_v[kNm], μ=0-180 deg.

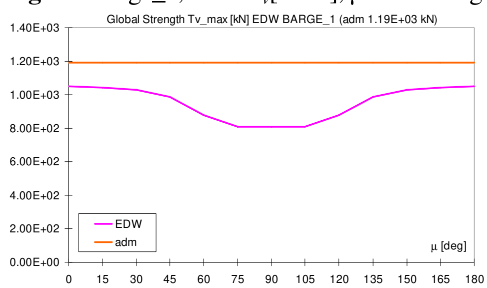

Fig.2.b. Barge_1, max. T_v[kN], μ=0-180 deg.

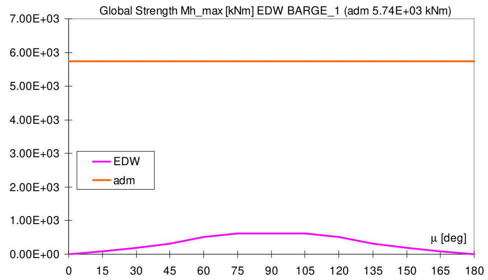

Fig.2.c. Barge_1,max. M_h[kNm], μ=0-180 deg.

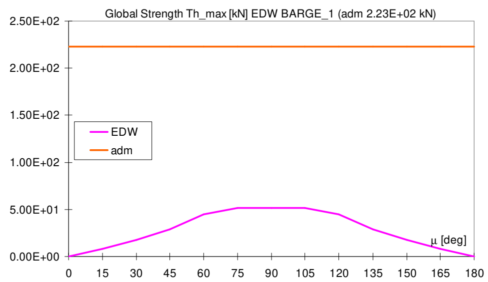

Fig.2.d. Barge_1, max. T_h[kN], μ=0-180 deg.

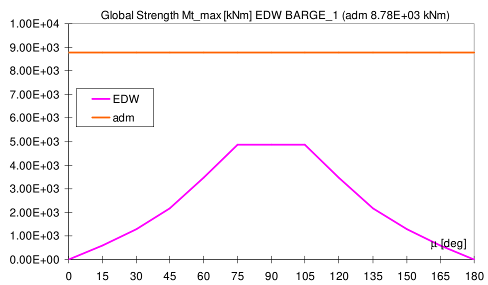

Fig.2.e. Barge_1,max. M_t[kNm], μ=0-180 deg.

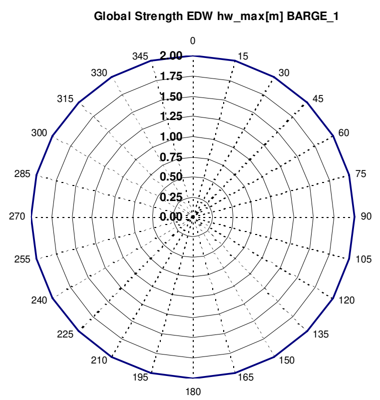

Fig.3 The polar diagram of operation limits in terms of equivalent wave height, by global strength criteria, case 1, h_{wlimit} = 2 m, IN(2.0)

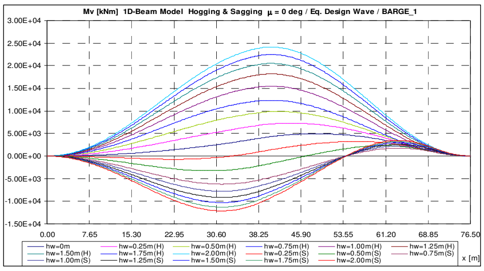

Fig.4.a. Barge_1, M_v[kNm], μ=0 deg., H&S

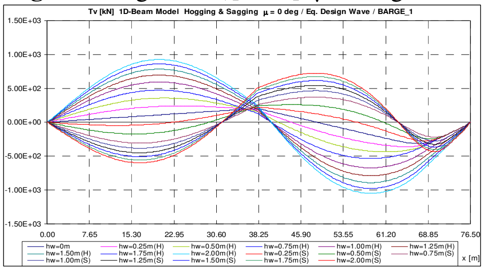

Fig.4.b. Barge_1, T_v[kN], μ=0 deg., H&S

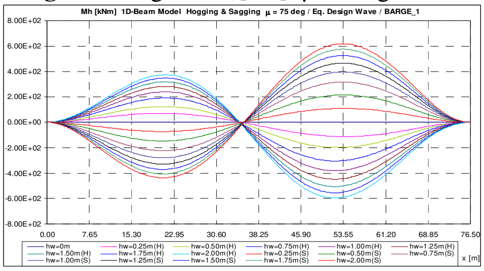

Fig.4.c. Barge_1, M_h[kNm], μ=75 deg., H&S

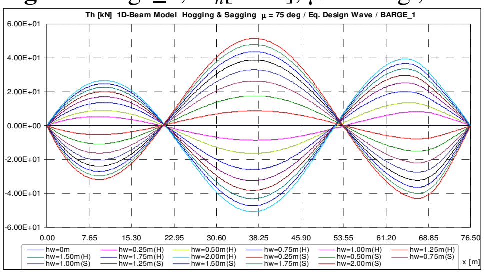

Fig.4.d. Barge_1, T_h[kN], μ=75 deg., H&S

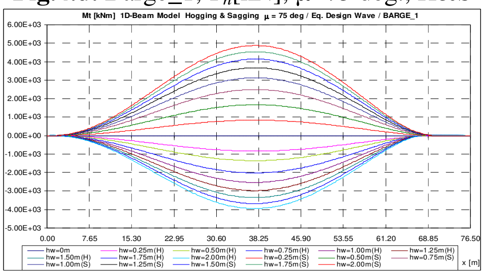

Fig.4.e. Barge_1, M_t[kNm], μ=75 deg., H&S

3. THE STRENGTH ASSESSMENT FOR COMMON CARGO LOAD CASE

The numerical global strength results for case *Barge_2* are present as following:

-Tables 4.a,b the maximum values for sectional efforts, hogging and sagging, main selection for μ=0-75 deg. (15 deg.), h_w=0-2m, case 2;

-Figs.5.a-e the assessment of the global strength criteria by maximum sectional efforts, case 2;

-Fig.6 the polar diagram of operation limits in terms of equivalent wave height h_w, by global strength and equivalent beam models, case 2;

-Figs.7.a-e the maximum sectional efforts diagrams, sagging and hogging conditions, case 2.

Table 4.a Barge_2 case, max. efforts, hogging

μ	0	15	30	45	60	75
M_v	**3.79E+4**	3.77E+4	3.71E+4	3.55E+4	2.76E+4	1.98E+4
T_v	**1.62E+3**	1.61E+3	1.59E+3	1.52E+3	1.25E+3	1.03E+3
M_h	0.00E+0	4.21E+2	8.95E+2	1.50E+3	2.70E+3	**2.86E+3**
T_h	0.00E+0	3.92E+1	8.33E+1	1.39E+2	2.43E+2	**2.51E+2**
M_t	0.00E+0	8.69E+2	1.86E+3	3.15E+3	6.02E+3	**7.39E+03**

Table 4.b Barge_2 case, max. efforts, sagging

μ	0	15	30	45	60	75
M_v	2.08E+4	2.06E+4	1.98E+4	1.79E+4	1.27E+4	1.44E+4
T_v	1.04E+3	1.03E+3	1.01E+3	9.33E+2	7.94E+2	8.42E+2
M_h	0.00E+0	2.96E+2	6.36E+2	1.09E+3	1.81E+3	2.82E+3
T_h	0.00E+0	2.36E+1	5.05E+1	8.57E+1	1.39E+2	2.40E+2
M_t	0.00E+0	8.85E+2	1.89E+3	3.20E+3	5.19E+3	7.28E+03

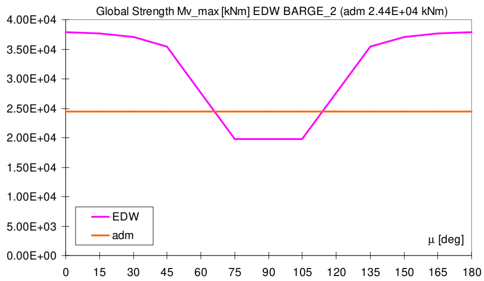

Fig.5.a. Barge_2,max. M_v[kNm], μ=0-180 deg.

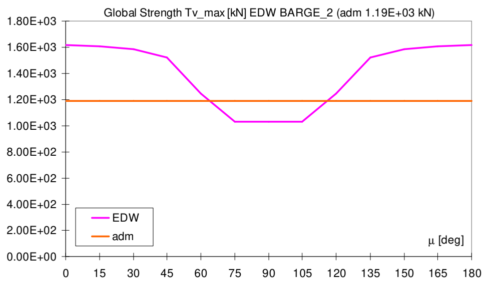

Fig.5.b. Barge_2, max. T_v[kN], μ=0-180 deg.

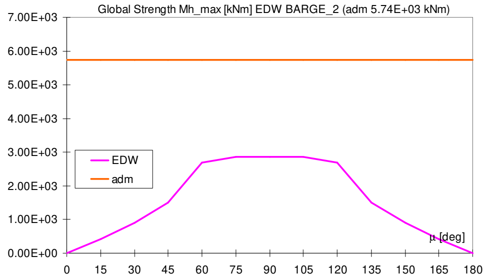

Fig.5.c. Barge_2,max. M_h[kNm], μ=0-180 deg.

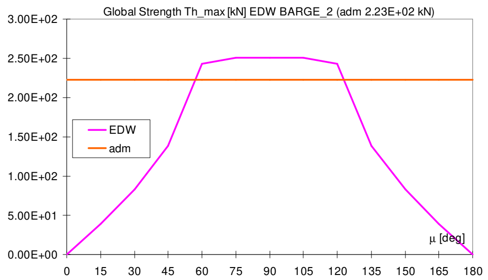

Fig.5.d. Barge_2, max. T_h[kN], μ=0-180 deg.

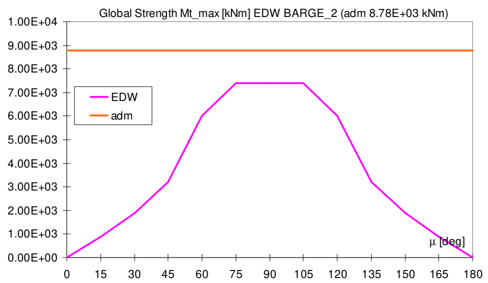

Fig.5.e. Barge_2,max. M_t[kNm], μ=0-180 deg.

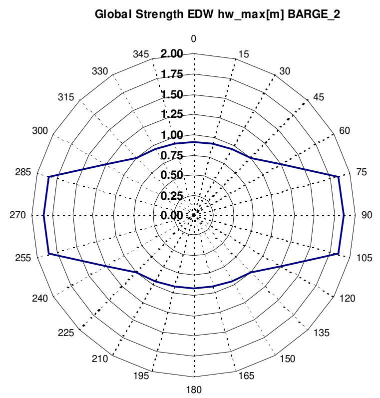

Fig.6 The polar diagram of operation limits in terms of equivalent wave height, by global strength criteria, case 2, h_{wlimit}=0.911m, IN(0.9)

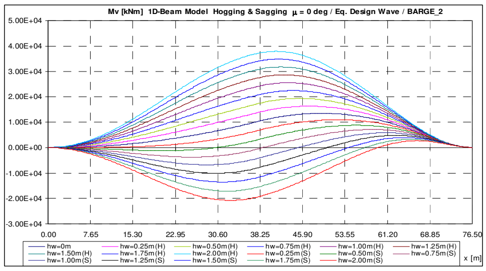

Fig.7.a. Barge_2, M_v[kNm], μ=0 deg., H&S

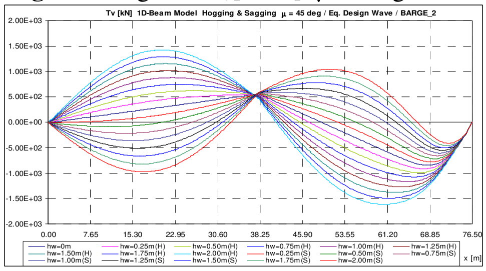

Fig.7.b. Barge_2, T_v[kN], μ=0 deg., H&S

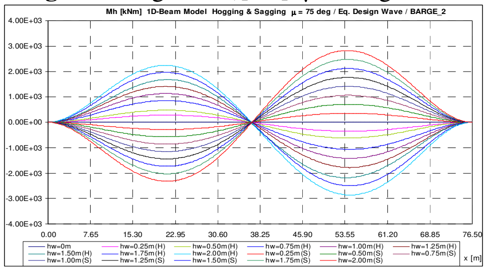

Fig.7.c. Barge_2, M_h[kNm], μ=75 deg., H&S

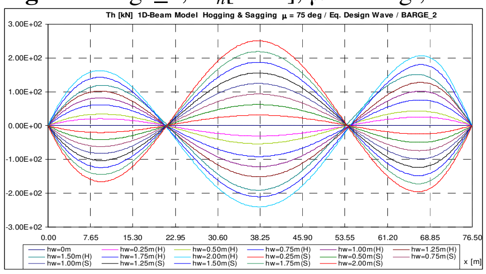

Fig.7.d. Barge_2, T_h[kN], μ=75 deg., H&S

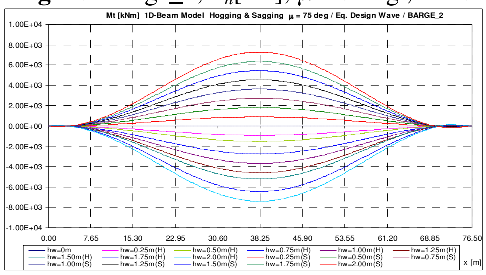

Fig.7.e. Barge_2, M_t[kNm], μ=75 deg., H&S

4. THE STRENGTH ASSESSMENT FOR FULL CARGO LOAD CASE

The numerical global strength results for case *Barge_3* are present as following:
-Tables 5.a,b the maximum values for sectional efforts, hogging and sagging, main selection for μ=0-75 deg. (15 deg.), h_w=0-2m, case 3;
-Figs.8.a-e the assessment of the global strength criteria by maximum sectional efforts, case 3;
-Fig.9 the polar diagram of operation limits in terms of equivalent wave height h_w, by global strength and equivalent beam models, case 3;
-Figs.10.a-e the maximum sectional efforts diagrams, sagging and hogging conditions, case 3.

Table 5.a Barge_3 case, max. efforts, hogging

μ	0	15	30	45	60	75
M_v	**4.46E+4**	4.44E+4	4.39E+4	4.26E+4	4.18E+4	2.34E+4
T_v	**2.09E+3**	2.08E+3	2.07E+3	2.04E+3	2.01E+3	1.53E+3
M_h	0.00E+0	3.88E+2	8.27E+2	1.39E+3	1.63E+3	2.89E+3
T_h	0.00E+0	3.52E+1	7.50E+1	1.26E+2	1.47E+2	2.54E+2
M_t	0.00E+0	7.15E+2	1.53E+3	2.59E+3	3.04E+3	5.89E+3

Table 5.b Barge_3 case, max. efforts, sagging

μ	0	15	30	45	60	75
M_v	1.30E+4	1.34E+4	1.36E+4	1.32E+4	1.37E+4	2.58E+4
T_v	1.09E+3	1.19E+3	1.20E+3	1.12E+3	1.19E+3	1.54E+3
M_h	0.00E+0	2.57E+2	5.49E+2	1.22E+3	1.99E+3	**2.90E+3**
T_h	0.00E+0	2.12E+1	4.54E+1	9.97E+1	1.65E+2	**2.59E+2**
M_t	0.00E+0	5.33E+2	1.14E+3	2.57E+3	4.16E+3	**5.91E+3**

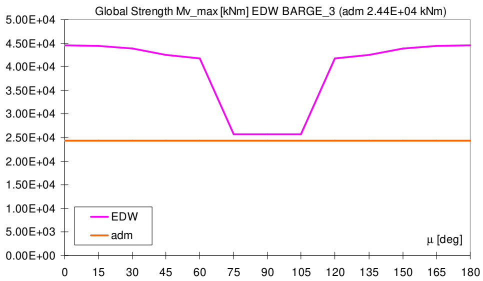

Fig.8.a. Barge_3,max. M_v[kNm], μ=0-180 deg.

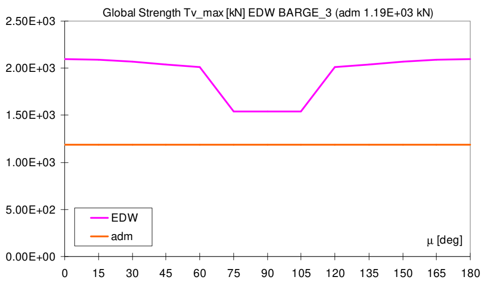

Fig.8.b. Barge_3, max. T_v[kN], μ=0-180 deg.

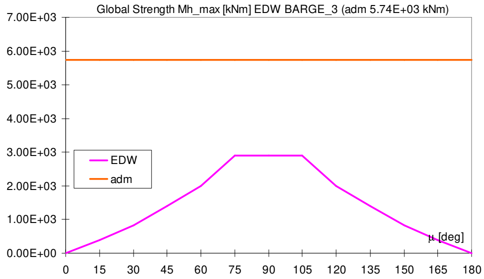

Fig.8.c. Barge_3, max. M_h[kNm], μ=0-180 deg.

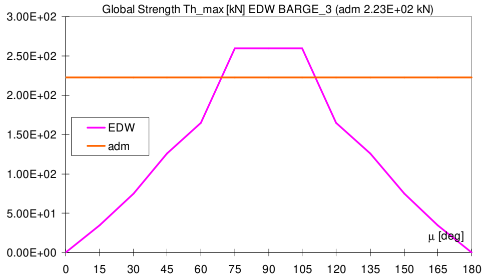

Fig.8.d. Barge_3, max. T_h[kN], μ=0-180 deg.

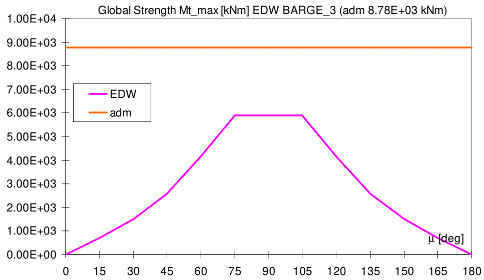

Fig.8.e. Barge_8,max. M_t[kNm], μ=0-180 deg.

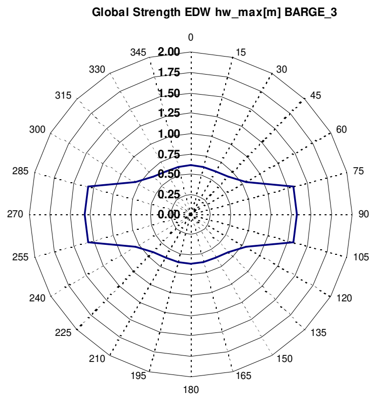

Fig.9 The polar diagram of operation limits in terms of equivalent wave height, by global strength criteria, case 3, h_{wlimit}=0.604, IN(0.6)

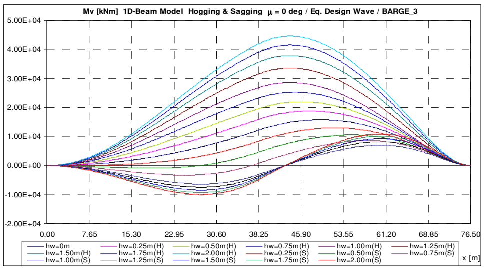

Fig.10.a. Barge_3, M_v[kNm], μ=0 deg., H&S

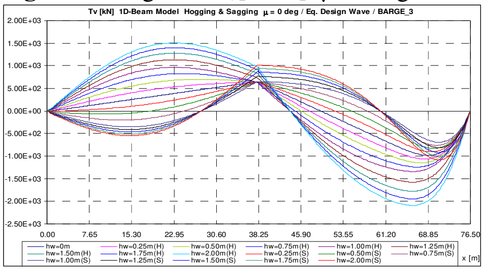

Fig.10.b. Barge_3, T_v[kN], μ=0 deg., H&S

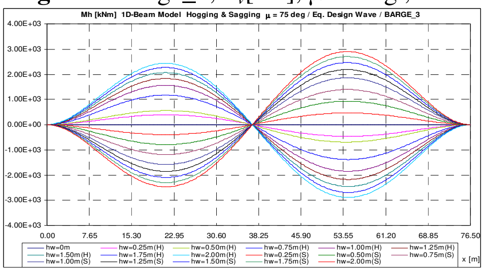

Fig.10.c. Barge_3,M_h[kNm],μ=75 deg., H&S

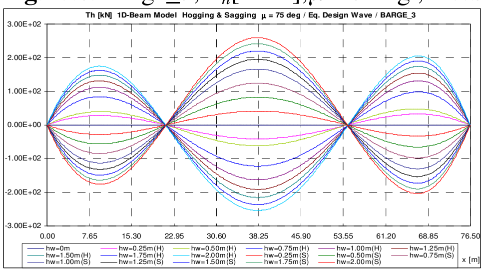

Fig.10.d. Barge_3, T_h[kN], μ=75 deg., H&S

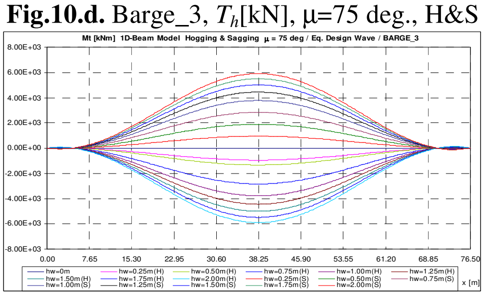

Fig.10.e. Barge_3,M_t[kNm],μ=75 deg., H&S

5. CONCLUSIONS

This study delivered the operation limits for the Europe B2 1740T barge [3], by global strength criteria from Bureau Veritas Rules [2], using the eigen iterative algorithm [4].

For the selected three main loading cases, results the following wave height operation limits: IN(2.0) no restriction for light displacement case, being possible even a costal route, IN(0.9) common cargo load case and the most restrictive IN(0.6) for full cargo load case.

Further studies will extend the analyses on 3D-FEM structural models, in order to include also local strength criteria. The wave and barge relative position will be computed by P_QSW program [4].

Acknowledgements

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