RAHMAN Sohanur

8th EMship cycle: October 2017 – February 2019

Master Thesis

Investigation of Hull Strength of River-Sea Container Vessel

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Reviewer:Prof. Rigo Philippe, University of Liege, Belgium.

Hamburg, February 2019

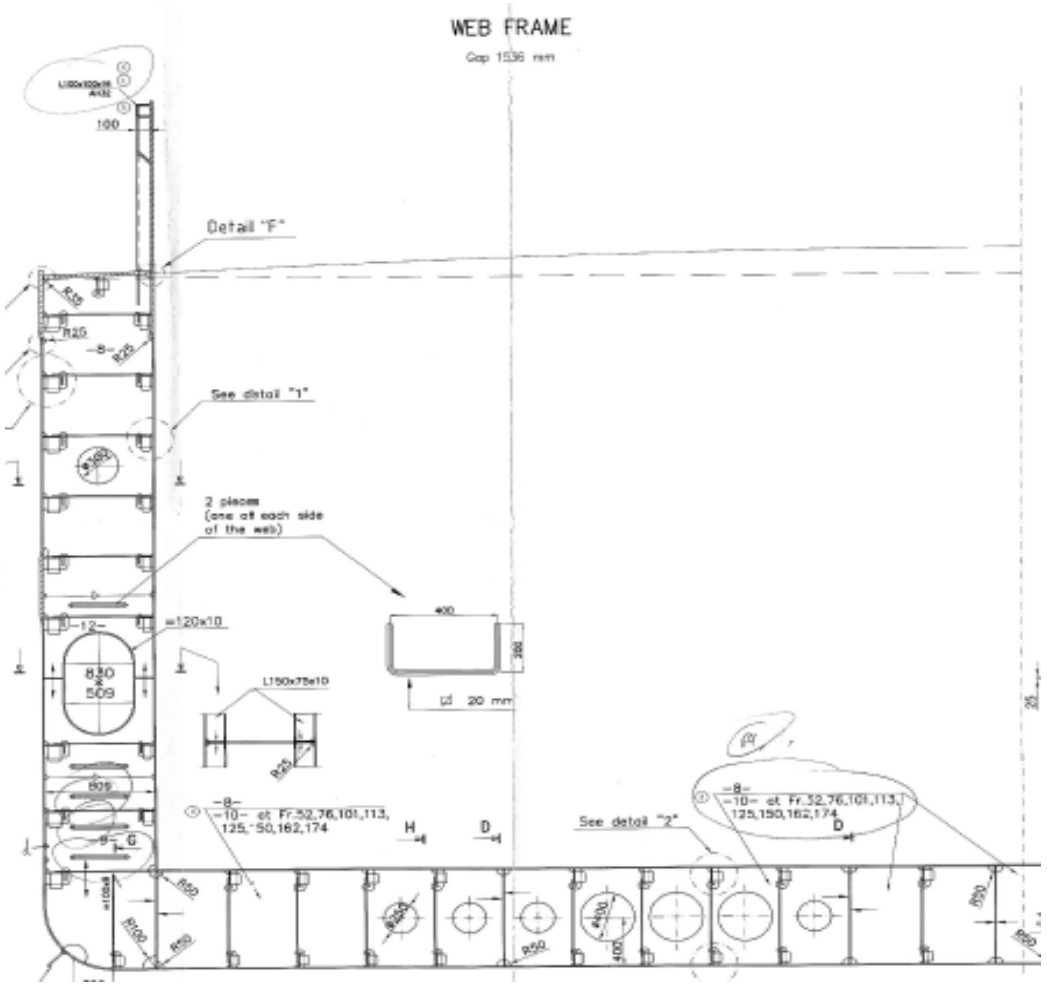
Table of Contents

Research objectives

To investigate the structural strength (in service condition) and the torsional strength and hull girder deflection of the river-sea container vessel.

Table of Contents

Main particulars of the investigated vessel



Midship section

Vessel Particulars:
Length overall: 134.05m
Length between perpendicular: 131.55m
Breadth: 14.5m
Depth: 5.7m
Draught: 3.6m
Range of Navigation: IN (1.7)
Loading sequence: 2R (2 runs)
Propulsion: Self propelled
Hull Material: Steel
Material Properties:
Yield Strength= 235 MPa (Mild steel-Grade **A**)
Yield Strength=355 MPa (High tensile steel-Grade **AH36**-for hatch coaming & **DH36**-for deck structures)

Table of Contents

Design loads

	Hogging (KN.m)	Sagging (KN.m)
Design S.W.B.M.-Navigation condition	81873	-62046
Design S.W.B.M.-Harbour condition	92431	-94028
Design vertical wave bending moment	104985	-104985
Design horizontal wave bending moment	49176	49176

Rule based design bending moment

	Full load condition (Sagging)	Ballast load condition (Hogging)
Still water bending moment (KN.m)	-14419	71563

Still water bending moment from direct calculation

	Long term response (Single amplitude) (KN.m)	
	Full load condition	Ballast load condition
Vertical wave bending moment	-85400	77300
Horizontal wave bending moment	0	0
Torsional wave bending moment	0	0

Wave bending moment for upright loadcase from direct calculation

	Long term response (Single amplitude) (KN.m)	
	Full load condition	Ballast load condition
Vertical wave bending moment	-34160	33930
Horizontal wave bending moment	49640	28345
Torsional wave bending moment	14505	7520

Wave bending moment for inclined loadcase from direct calculation

Design loads

		Upright loadcase	
Loading condition		**Rule based value**	**Direct calculation**
Full load condition	Total vertical bending moment (KN.m)	-137503	-75800
	Horizontal wave bending moment (KN.m)	0	0
	Torsional bending moment(KN.m)	0	0
Ballast load condition	Total vertical bending moment(KN.m)	157330	127122
	Horizontal wave bending moment(KN.m)	0	0
	Torsional bending moment(KN.m)	0	0

Comparison between rule based value and direct calculation (Upright loadcase)

		Incline loadcase	
Loading condition		**Rule based value**	**Direct calculation**
Full load condition	Total vertical bending moment (KN.m)	-92229	-38971
	Horizontal wave bending moment (KN.m)	49176	49640
	Torsional bending moment(KN.m)	4553(only still water torsional moment)	19058
Ballast load condition	Total vertical bending moment(KN.m)	112056	95950
	Horizontal wave bending moment(KN.m)	49176	28345
	Torsional bending moment(KN.m)	4553(only still water torsional moment)	12073

Comparison between rule based value and direct calculation (Inclined loadcase)

Table of Contents

Hull girder strength check

Section modulus	Distance from baseline (m)	Rule	Actual
Bottom (m^3)	0.0	0.52	1.72
Deck (m^3)	5.7	0.37	1.26
Hatch coaming top (m^3)	7.163	0.37	0.88

Section modulus comparison

Items	Distance from baseline (m)	Hogging, σ_H (N/mm^2)	Sagging, σ_S (N/mm^2)
Bottom	0.0	86.55	58.03
Deck	5.7	119.87	80.38
Hatch coaming top	7.163	169.60	113.72

Hull girder normal stress

Scantling check of plating

Plating	Net thickness	
	Actual thickness (mm)	Rule thickness (mm)
Bottom	9.5	7
Inner bottom	11.5	6.5
Container seating inset plate	14.5	13.5
Side shell	9.5	6
Inner side shell	9.5	8.5
Stringer deck	23.5	5.5
Shear strake	23.5	17.5
Side girder at 209 OCL	6.4	7.9
Side girder at 1288, 3848, 6450 OCL	8	7.5
Hatch coaming	19	13
Bilge	11.5	7

Scantling check of secondary stiffeners

Ordinary stiffeners	Net thickness	
	Actual thickness (mm)	Minimum thickness (mm)
Bottom	8	6.1
Inner bottom	7	5.9
Inner side shell	7	5.9
Side shell-upper	10	6.5
Side shell-lower	10	6.5
Stringer deck	8	5.6
Hatch coaming	16	6.0

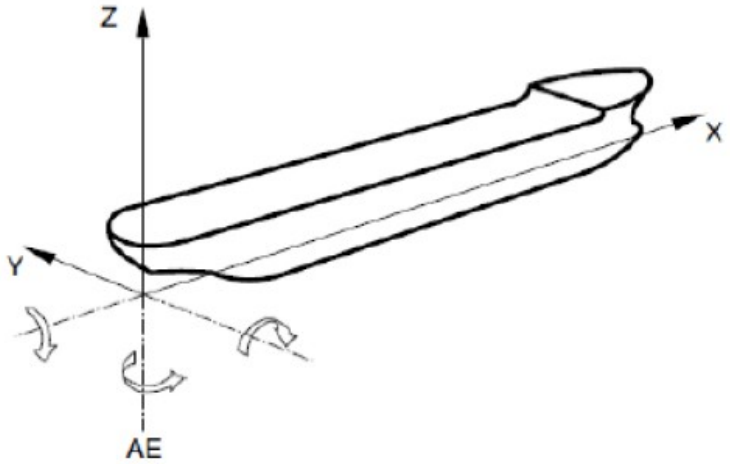
Net thickness of stiffener web

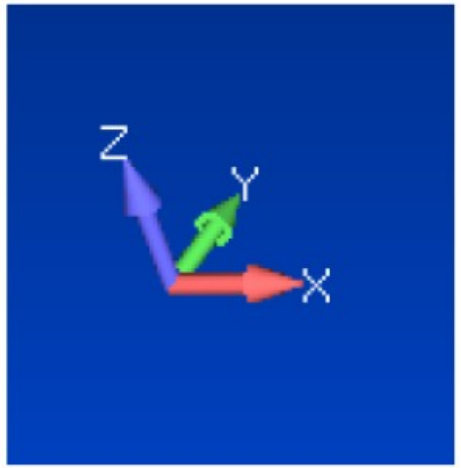
Ordinary stiffeners	Shear area (cm^2)		Section modulus (cm^3)	
	Actual	Rule	Actual	Rule
Bottom	8.96	1.84	74.88	34.73
Inner bottom	7.84	1.72	71.33	28.72
Inner side shell	5.29	1.72	57.38	26.83
Side shell-upper	11.34	0.95	149.69	16.9
Side shell-lower	11.34	1.9	136.21	29.66
Stringer plate	8.96	0.04	84.91	0.37
Hatch coaming	12.75	0.01	149.05	0.3

Shear area/ Section modulus (actual v/s required); Net values

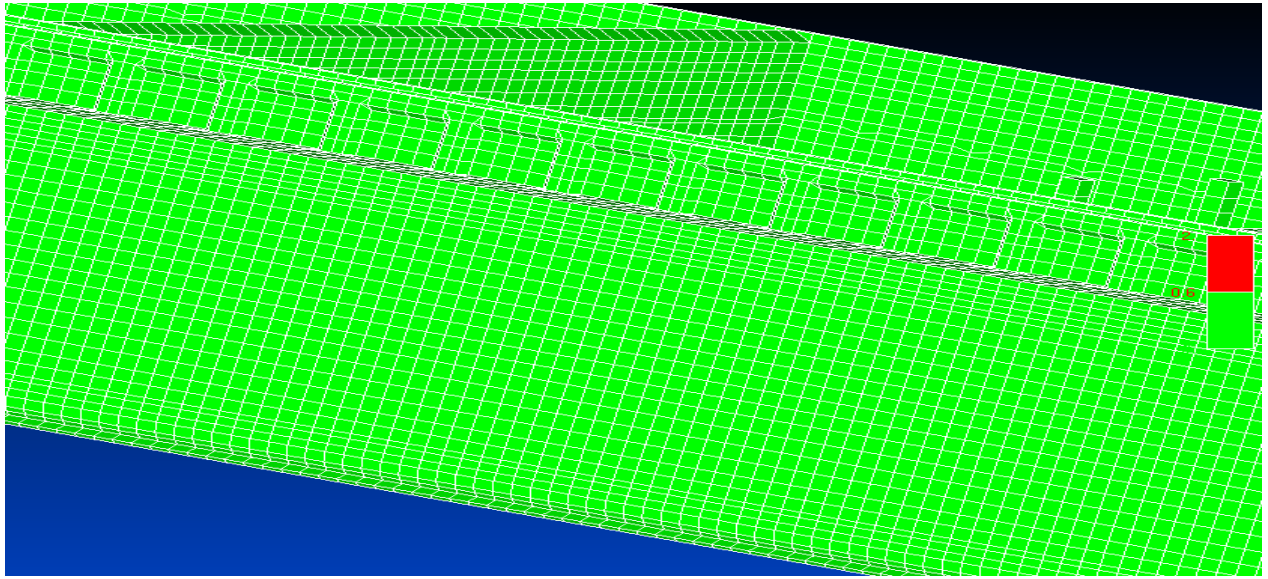
Strength check of primary supporting members

Coordinate system





Mesh shapes



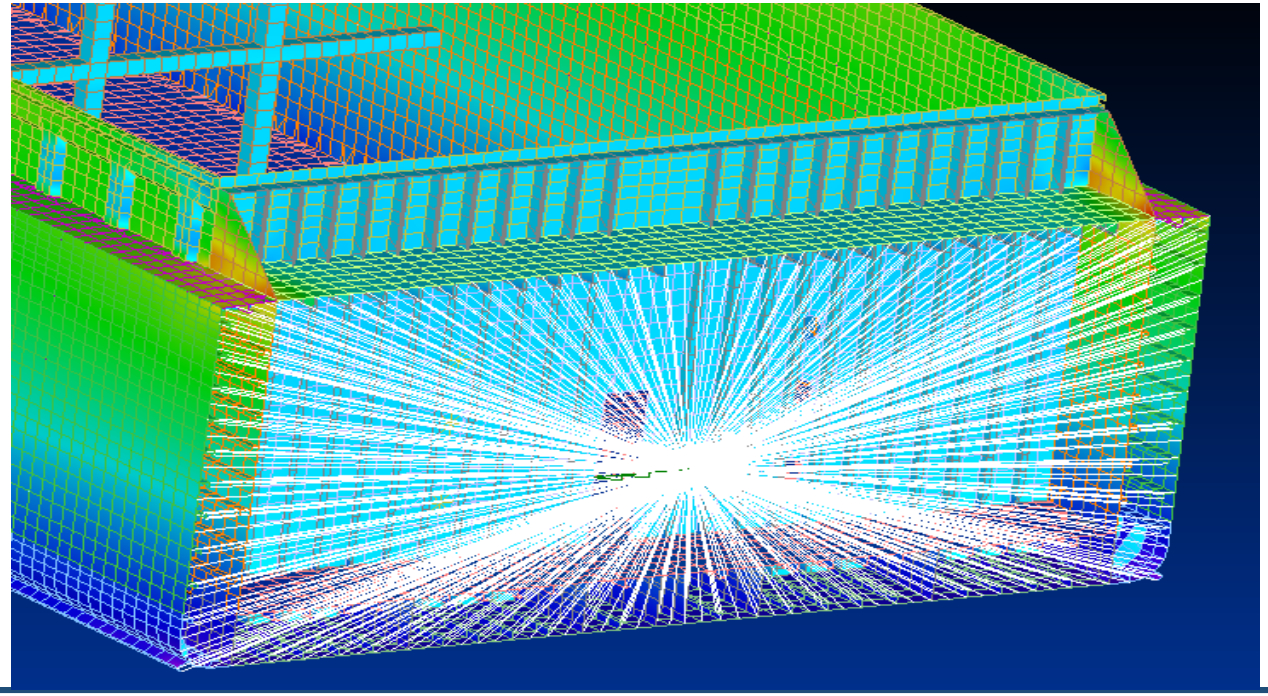
Strength check of primary supporting members

Case 1: Cantilever applied with bending moment only

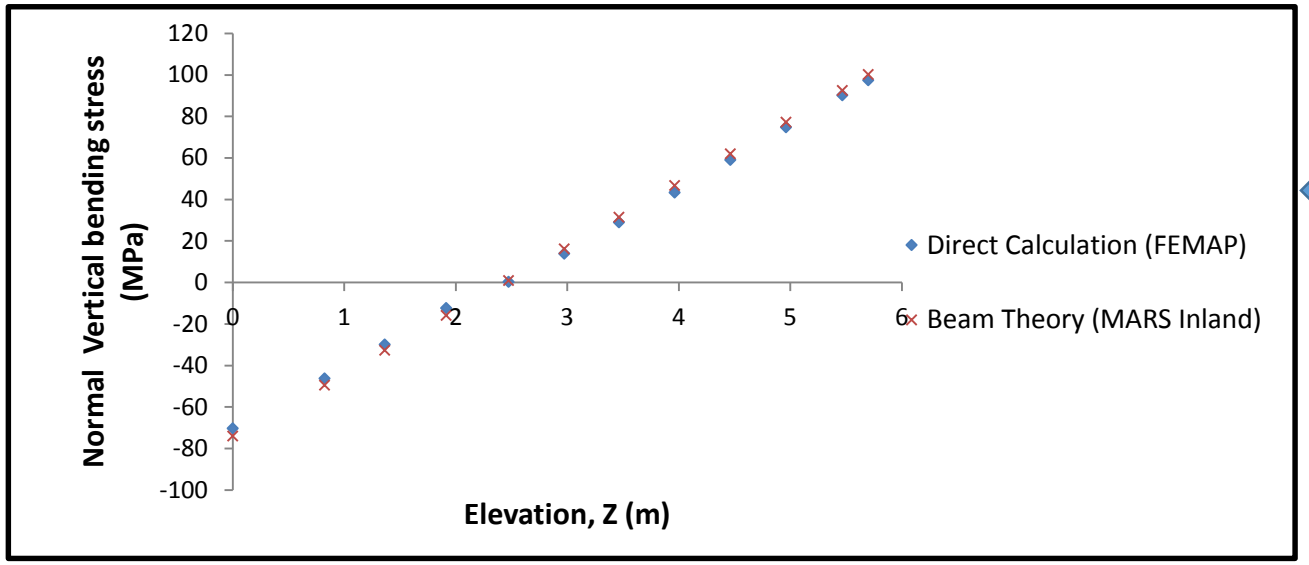
Boundary condition (Cantilever)

Boundary conditions	Translations in directions			Rotation around axes		
	X	Y	Z	X	Y	Z
Node at aft end	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Node at fore end	Free	Free	Free	Free	Free	Free

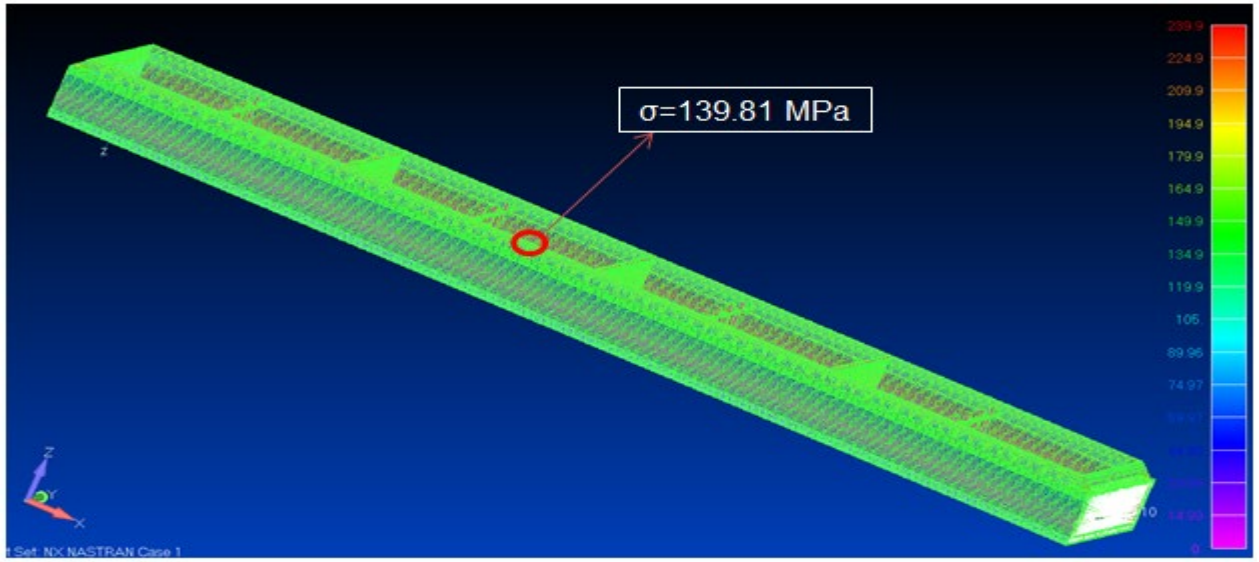
Rigid element



Strength check of primary supporting members



Comparison of normal stress between MARS inland model and FE model at X=61m (Hogging-Upright condition)



Strength check of primary supporting members

Case 2: Simply supported beam applied with local loads

Boundary condition (Simply supported)

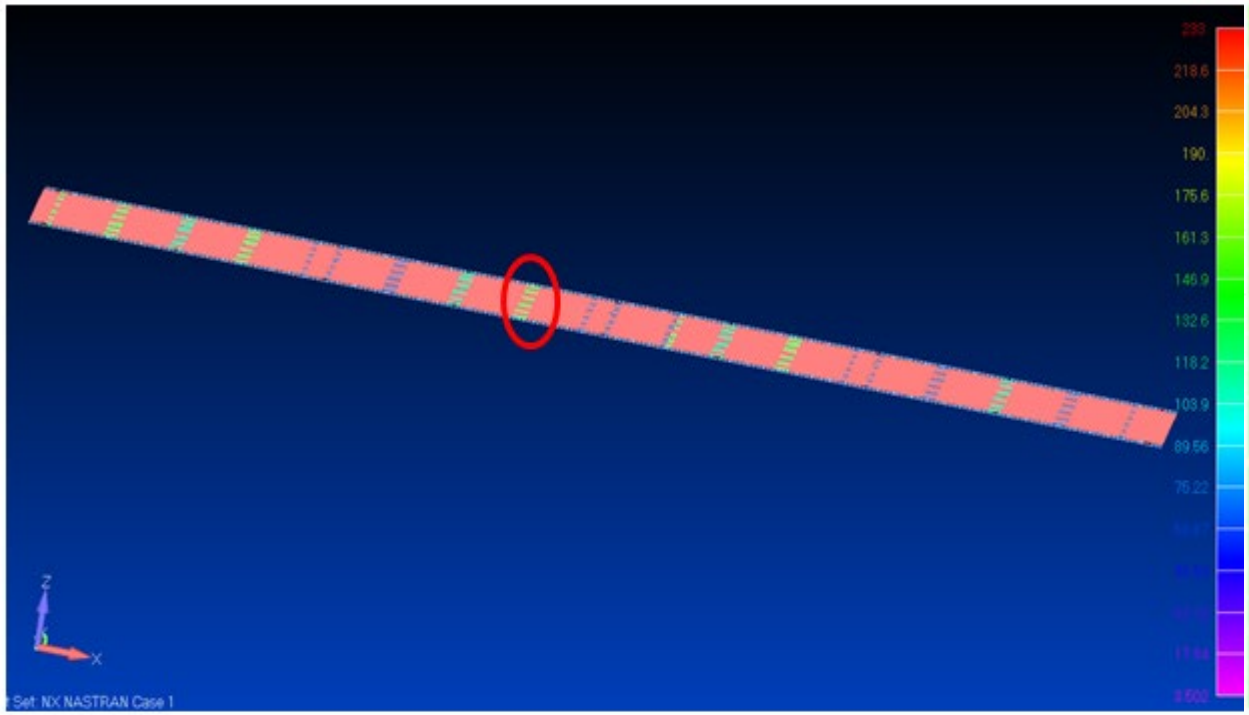
Boundary conditions	Translations in directions			Rotation around axes		
	X	Y	Z	X	Y	Z
Node at aft end	Fixed	Fixed	Fixed	Fixed	Free	Fixed
Node at fore end	Fixed	Fixed	Fixed	Fixed	Free	Fixed

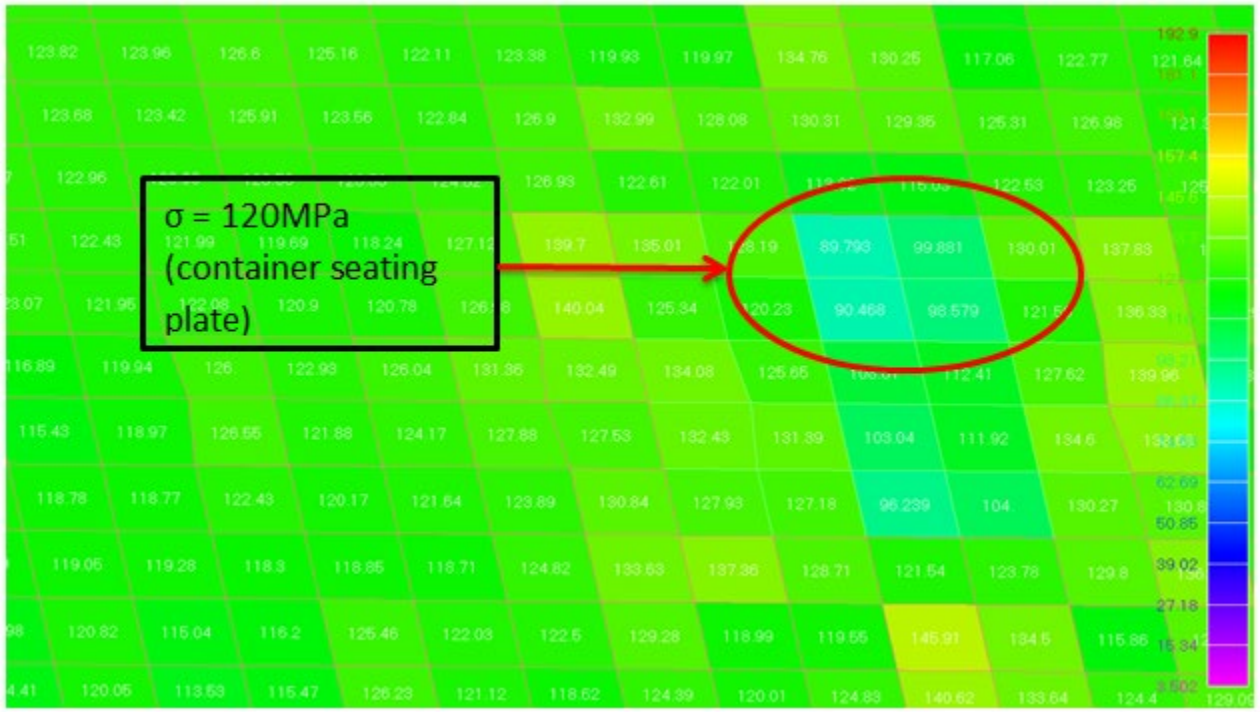
Local loads

Location	Fully-loaded (Sagging)
Inner bottom	Container loads (Static + Inertial)
Stringer plate	Exposed deck loads
Bottom	River-sea pressure (Static + wave)
Bilge	River-sea pressure (Static + wave)
Side shell	River-sea pressure (Static + wave)

Strength check of primary supporting members

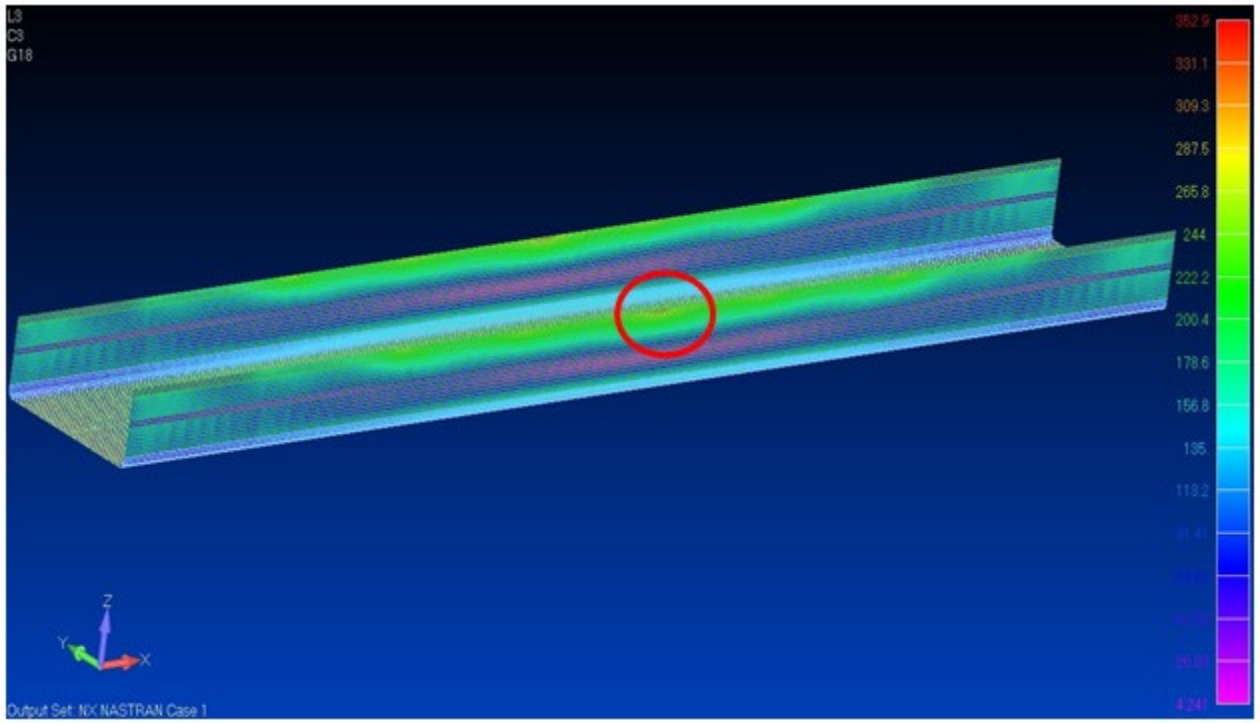
Von mises stress on inner bottom

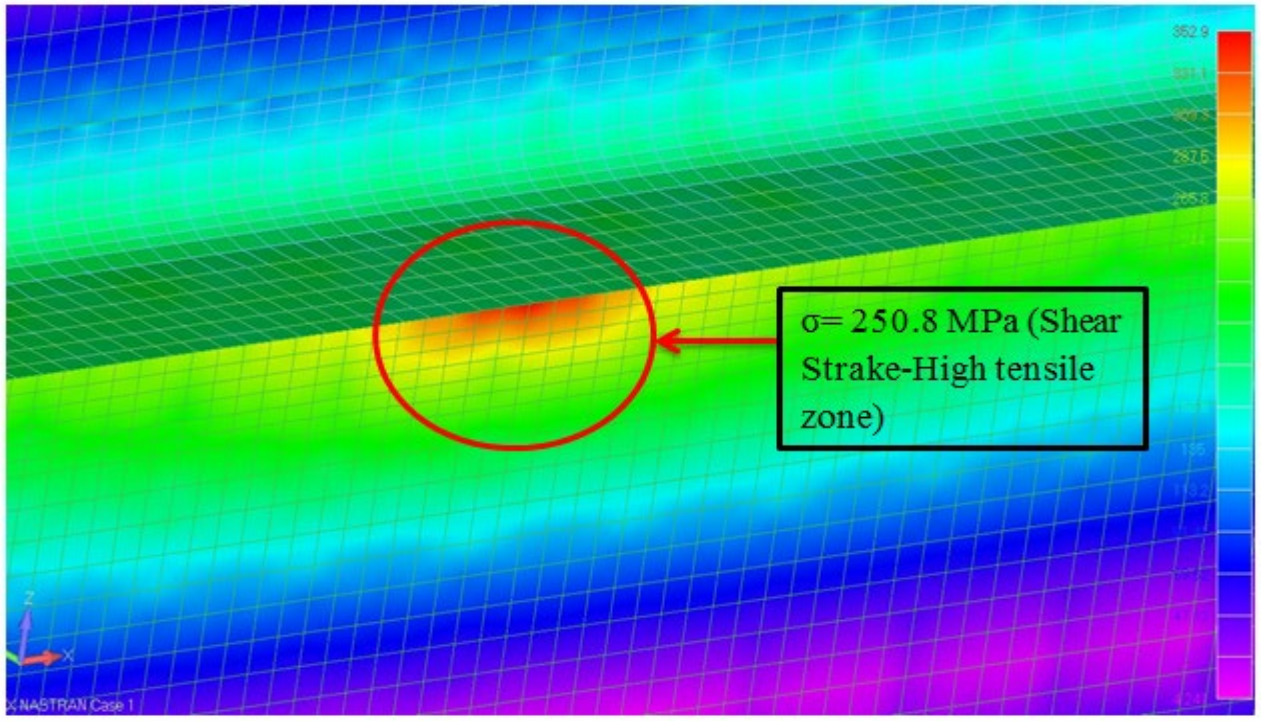




Strength check of primary supporting members

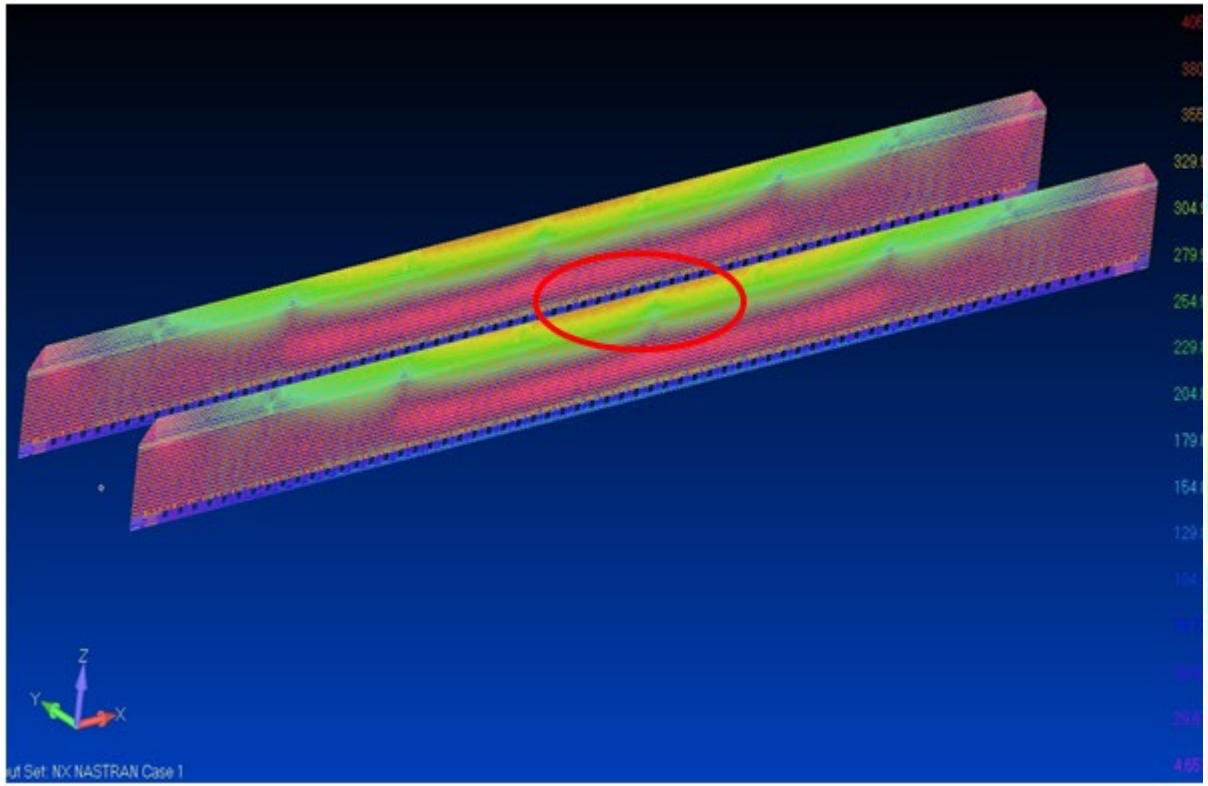
Von mises stress on side shell

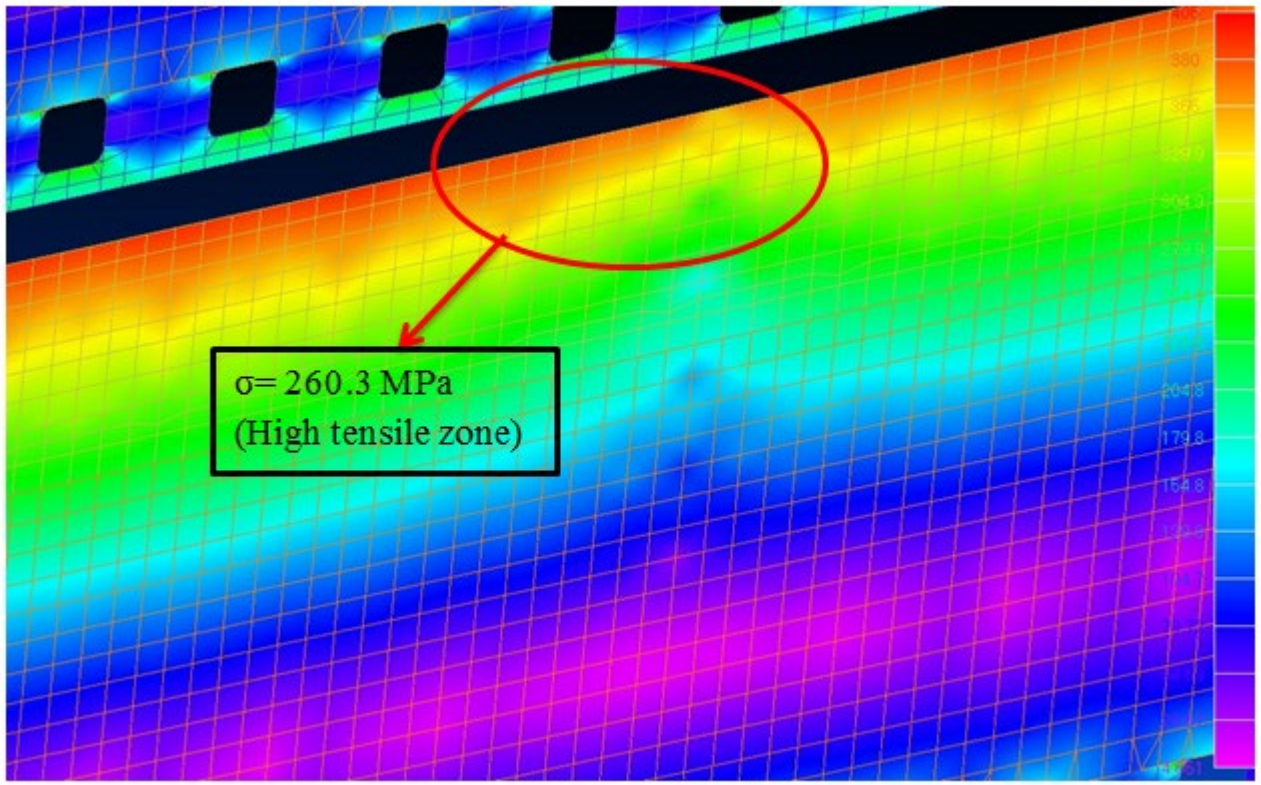




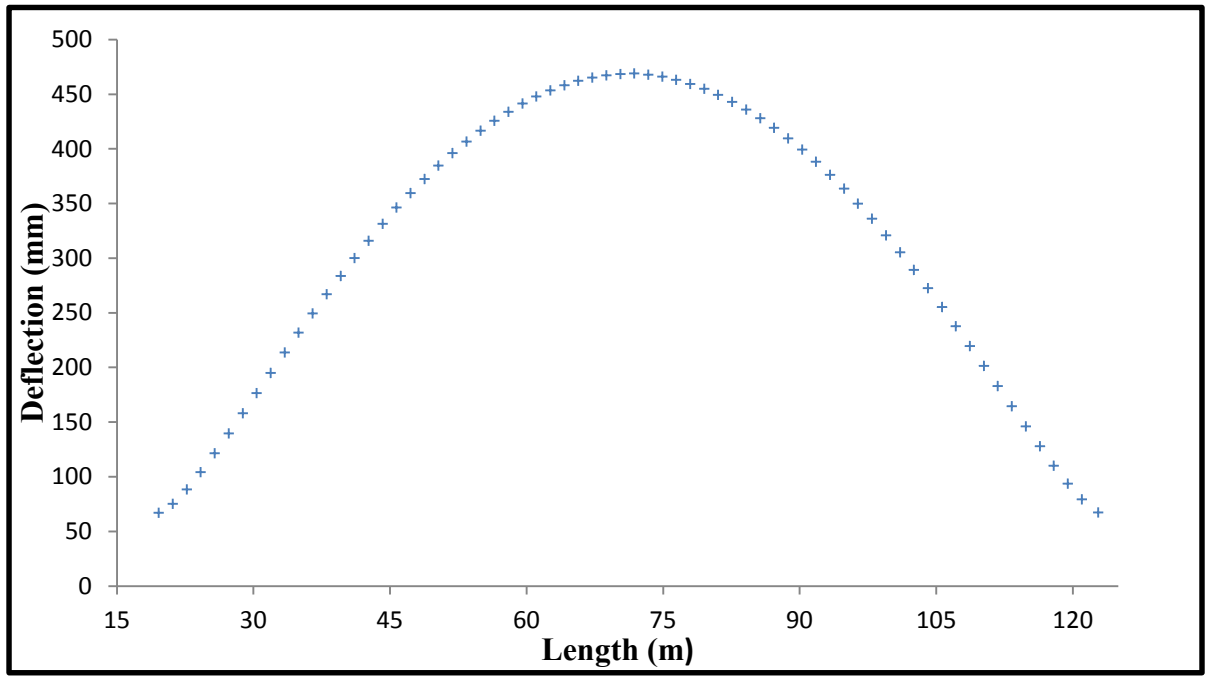
Strength check of primary supporting members

Von mises stress on hatch coaming





Numerical determination of hull girder deflection



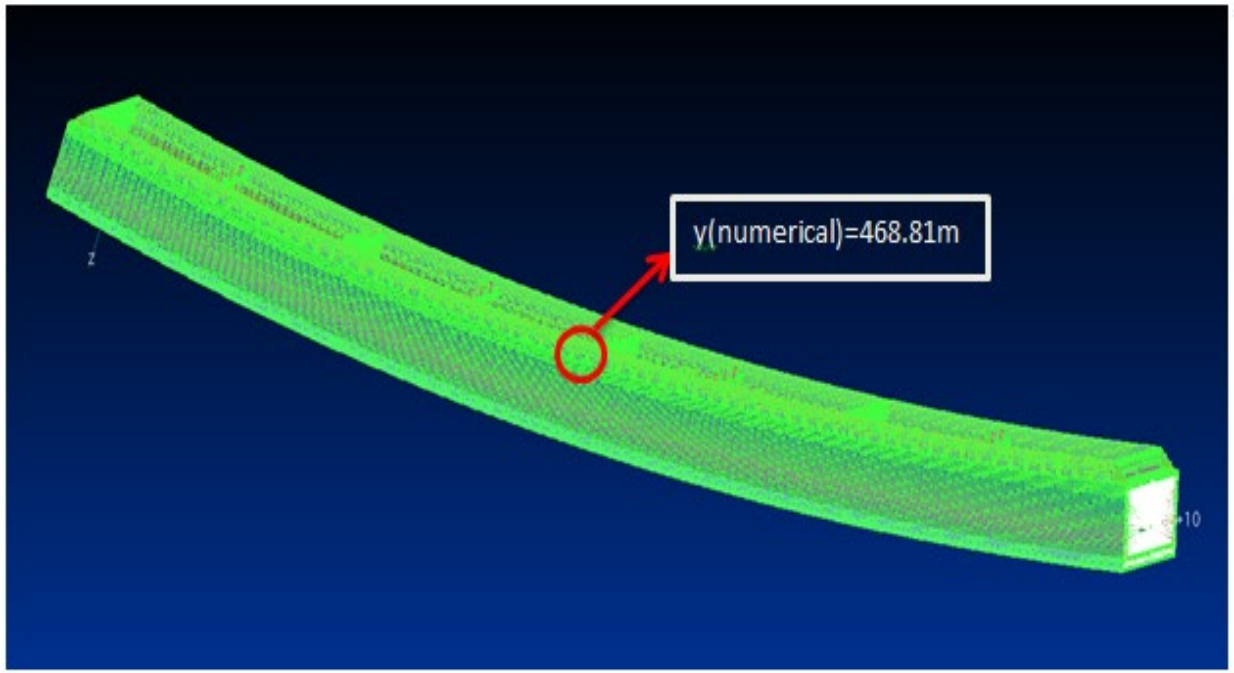
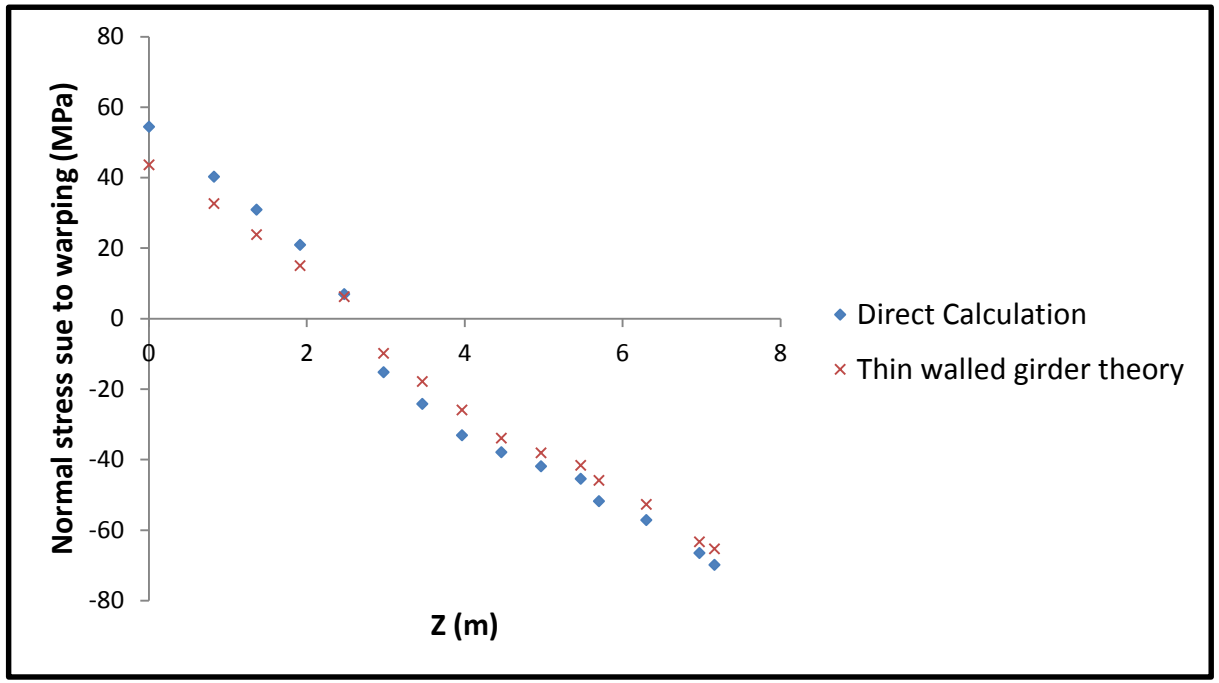
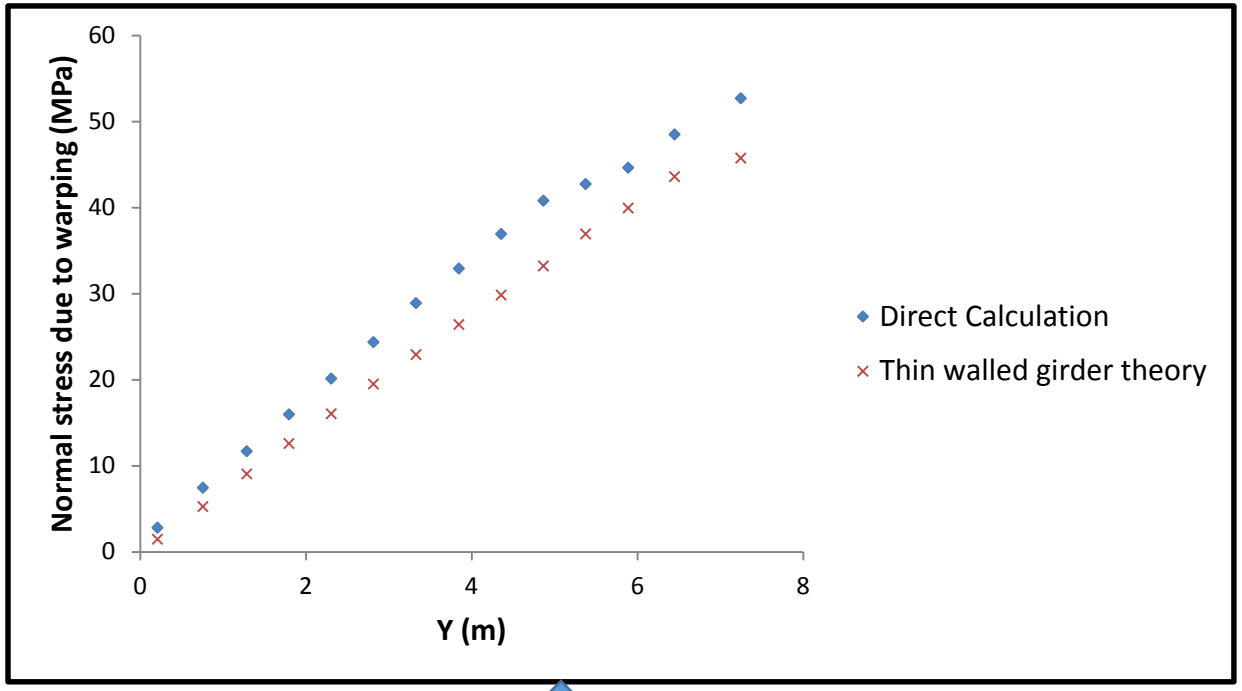


Table of Contents

Strength check

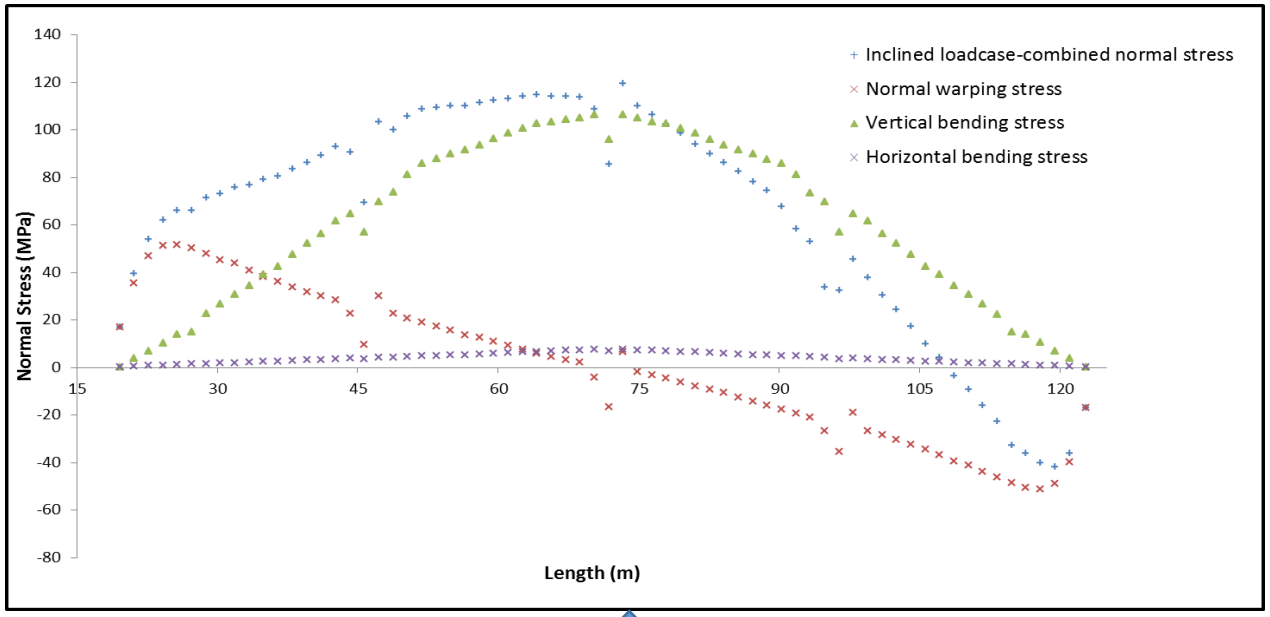


Comparison of normal stress due to torsion between MARS 2000 model and FE model (along inner side plate)- Sagging condition

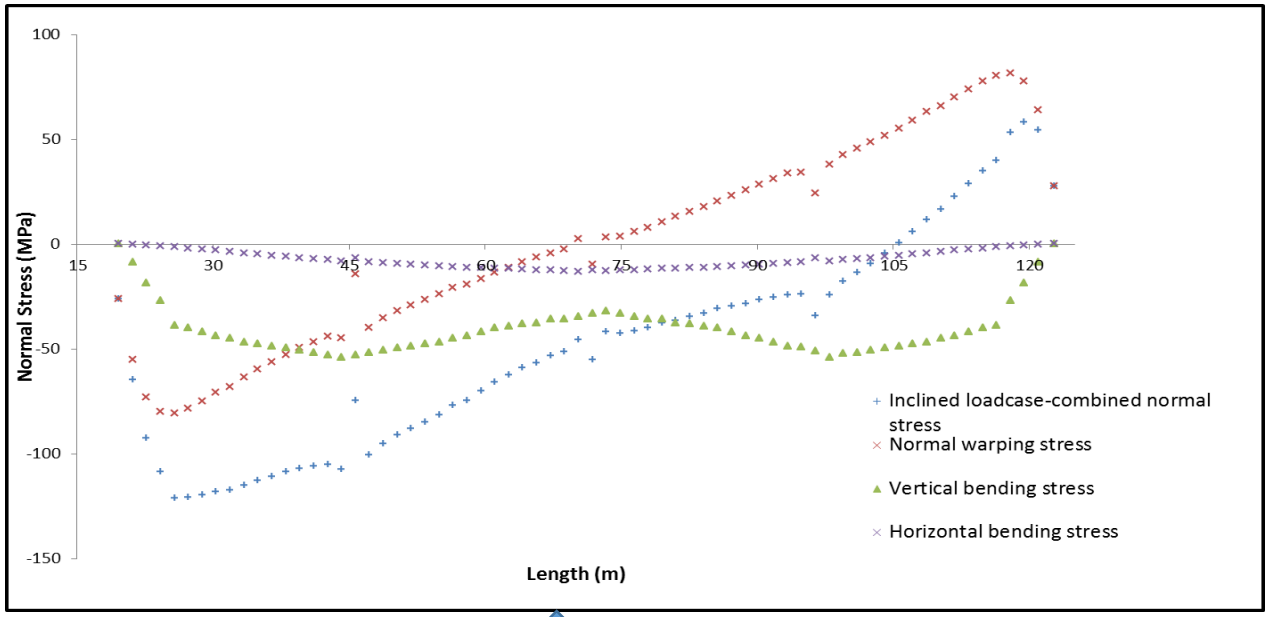


Comparison of normal stress due to torsion between MARS 2000 model and FE model (along bottom plate)-Sagging condition

Influence of different loading conditions



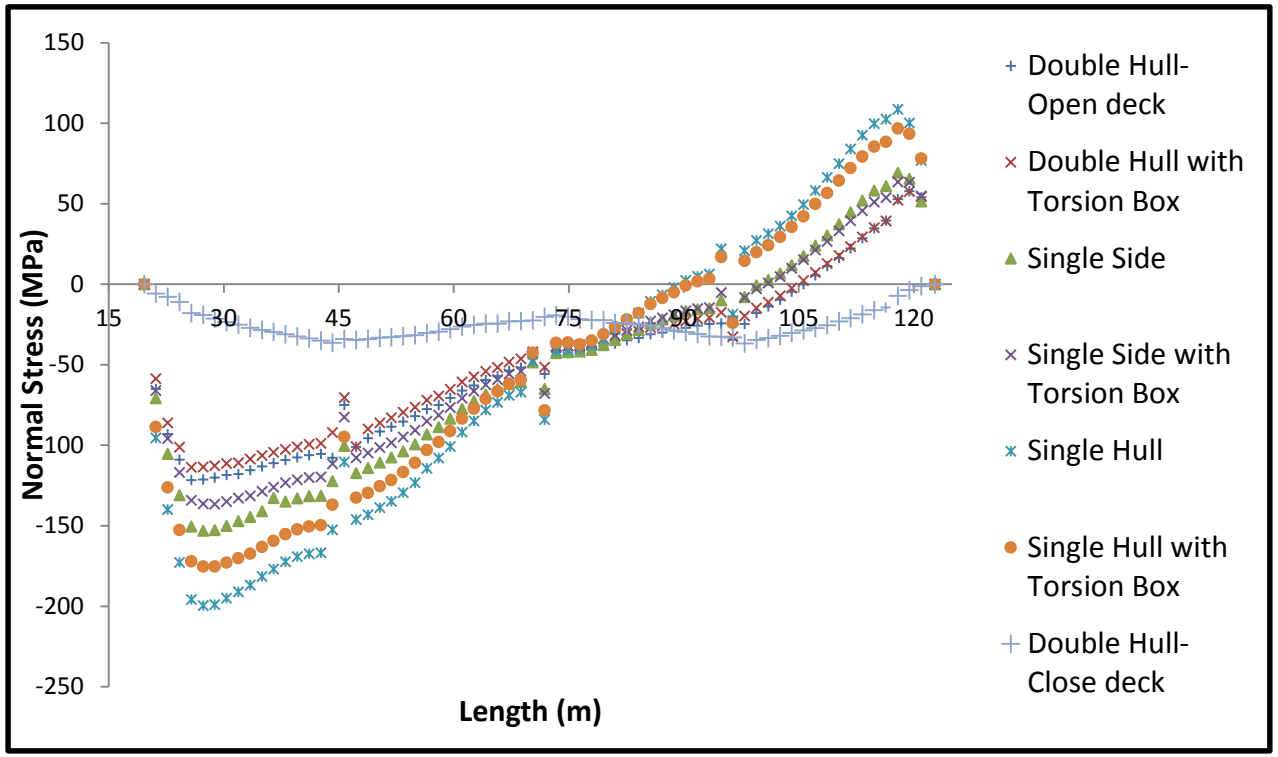
Combined bending and torsional structural response of lightweight condition

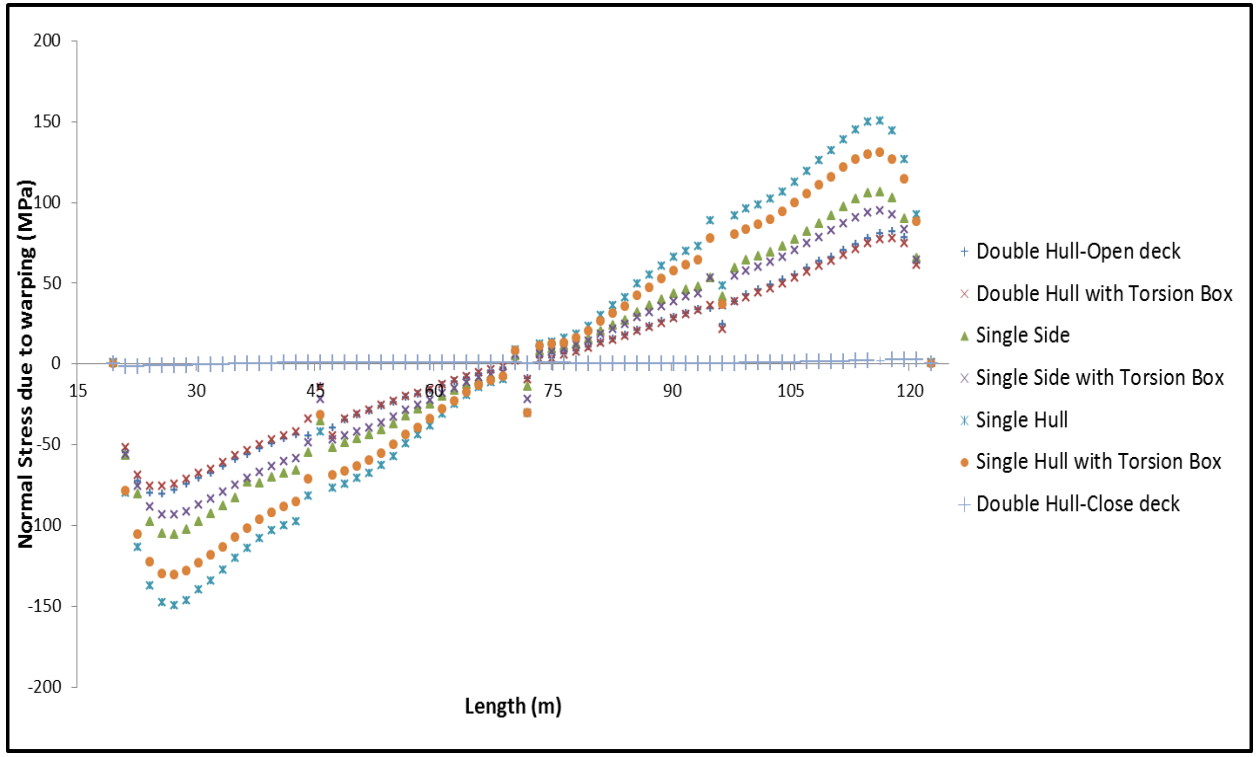


Combined bending and torsional structural response of full load condition

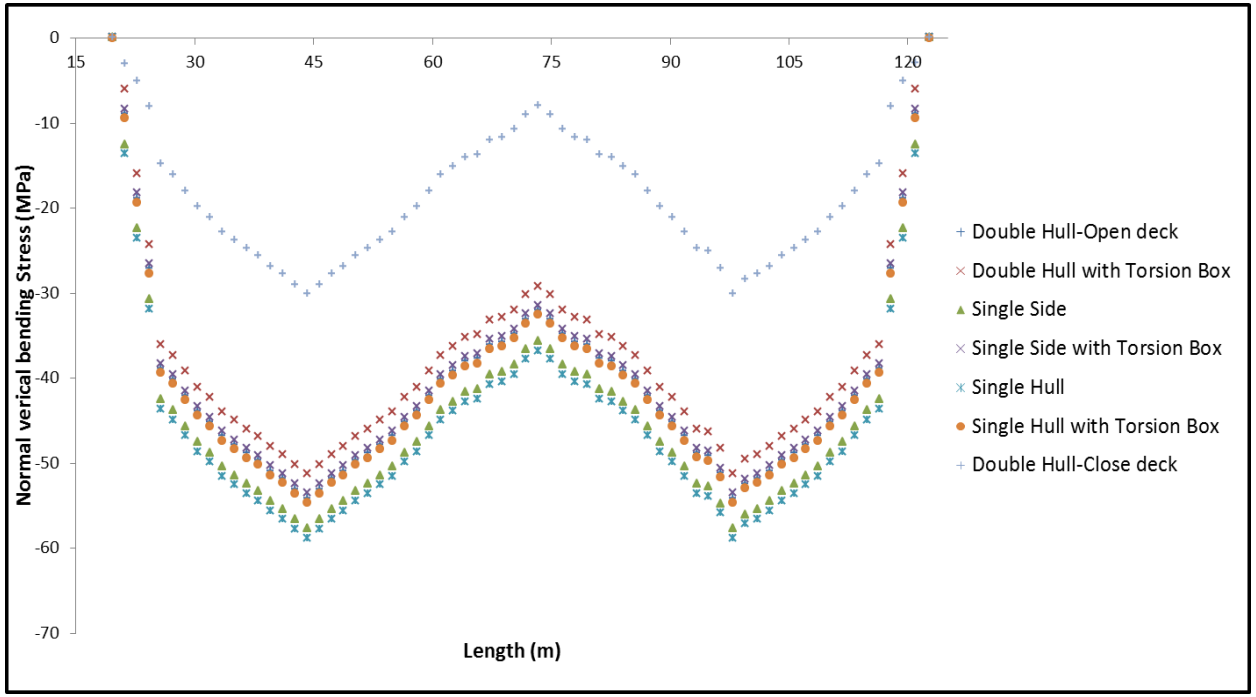
Table of Contents

Influence of different hull configurations on combined bending and torsion effects





Influence of different hull configurations on combined bending and torsion effects



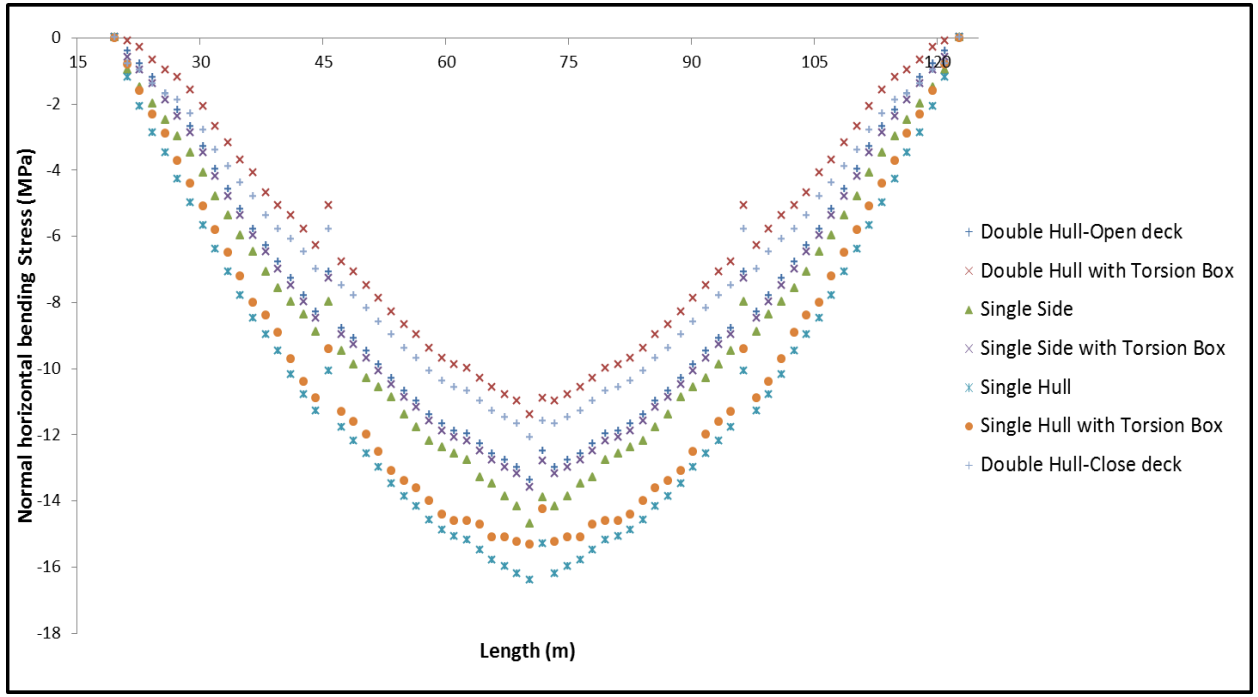


Table of Contents

Conclusions

-The hull scantling complies with Bureau Veritas Rules for the classification of inland navigation vessels – NR 217

-The level of stresses in way of critical areas of the cargo hold, determined using finite element analysis, complies with the Rules strength criteria

-The maximum hull girder deflection is 468 mm, remaining within the range of values compatible with the vessel serviceability

-The impact of the warping stresses induced by the torque and the normal stresses due to horizontal bending moment on the hull scantling remains negligible

Investigation of the impact of the structural configuration on the level of warping stresses shows that among different hull configurations considered, highest warping stresses values are found for single hull vessel.

As a recommendation, combined effect of vertical bending, horizontal bending and torsion should be taken into account when analysing hull strength of vessels with hull structural configuration other than double hull, i.e with double bottom and double side, fitted with open deck.

Thank You

Appendix

Scantling check of plating for different hull configurations

	Net thickness(mm)							
Plating	**Actual thikness(mm)**	**Rule thickness (mm)**						
		Double hull-Open deck	**Double hull with torsion box**	**Single hull**	**Single hull with torsion box**	**Single side**	**Single side with torsion box**	**Double hull-closed deck**
Bottom	9.5	7	7	8.5	8.5	7.5	7.5	7
Inner bottom	11.5	6.5	5.5	7.5	7.5	7	7	6.5
Side shell	9.5	6	6	7	7	7	7	6
Inner side shell	9.5	8.5	8	-	-	-	-	8.5
Stringer plate	23.5	5.5	5.5	7	7	7	7	7
Shear strake	23.5	17.5	17	18.5	18	18.5	18	17.5
Side girder at 209 OCL	10	7.9	7.9	10	10	9.5	9.5	8
Side girder at 1288,3848,6450OCL	10	7.5	7.5	10	10	9.5	9.5	8
Bilge	11.5	7	7	8	8	8	8	7
Hatch coaming	19	13	10.5	12	11.5	12	11.5	-

Scantling check of secondary stiffeners for different hull configurations

Ordinary stiffeners	Net thickness of stiffener web(mm)							
	Actual thikness(mm)	Rule thickness (mm)						
		Double hull-Open deck	Double hull with torsion box	Single hull	Single hull with torsion box	Single side	Single side with torsion box	Double hull-closed deck
Bottom	8	6.1	6.1	7.2	7.2	6.7	6.2	6.1
Inner bottom	7	5.9	5.9	-	-	6.5	6	5.9
Inner side shell	7	5.9	5.9	-	-	-	-	5.9
Side shell upper	10	6.5	6.5	7.5	7.1	7.4	7.2	6.5
Side shell lower	10	6.5	6.5	7.5	7.5	7.2	7.2	6.5
Stringer plate	8	5.6	5.6	6.4	6.1	6.4	6.2	5
Hatch coaming	16	6	6	7.5	7.1	7.5	7.3	-

Ordinary stiffeners	Net shear area (cm^2)							
	Actual shear area(cm^2)	Rule shear area (cm^2)						
		Double hull-Open deck	Double hull with torsion box	Single hull	Single hull with torsion box	Single side	Single side with torsion box	Double hull-closed deck
Bottom	8.96	1.84	1.51	2.15	2.15	1.8	1.8	1.84
Inner bottom	7.84	1.72	1.45	-	-	1.75	1.75	1.72
Inner side shell	5.29	1.72	1.46	-	-	-	-	1.72
Side shell upper	11.34	0.95	0.9	1.75	1.7	1.7	1.65	1.1
Side shell lower	11.34	1.9	1.62	2.27	2.25	2	2	1.9
Stringer plate	8.96	0.04	0.04	0.9	0.8	0.85	0.8	0.01
Hatch coaming	12.75	0.01	0.01	0.9	0.8	0.85	0.8	-

Ordinary stiffeners	Net section modulus (cm^3)							
	Actual section modulus(cm^3)	Rule section modulus (cm^3)						
		Double hull-Open deck	Double hull with torsion box	Single hull	Single hull with torsion box	Single side	Single side with torsion box	Double hull-closed deck
Bottom	74.08	34.73	34.58	53.95	51.78	44.7	44.1	33.54
Inner bottom	71.33	28.72	28.98	-	-	37.9	37	29.26
Inner side shell	57.38	26.83	24.05	-	-	-	-	26.83
Side shell upper	149.69	16.9	13.83	36.14	31.5	36	31.1	16.89
Side shell lower	136.21	29.66	26.36	43.5	42	40	37	29.66
Stringer plate	84.91	0.37	0.35	1.1	1	1.1	1	0.5
Hatch coaming	149.05	0.3	0.3	1.1	1	1.1	1	-