SARKAR Sandwipan

8^{th} EMship cycle: October 2017 – February 2019

Master Thesis

Structural Analysis & Design to mitigate lateral deflections of an offshore mining vessel’s stern

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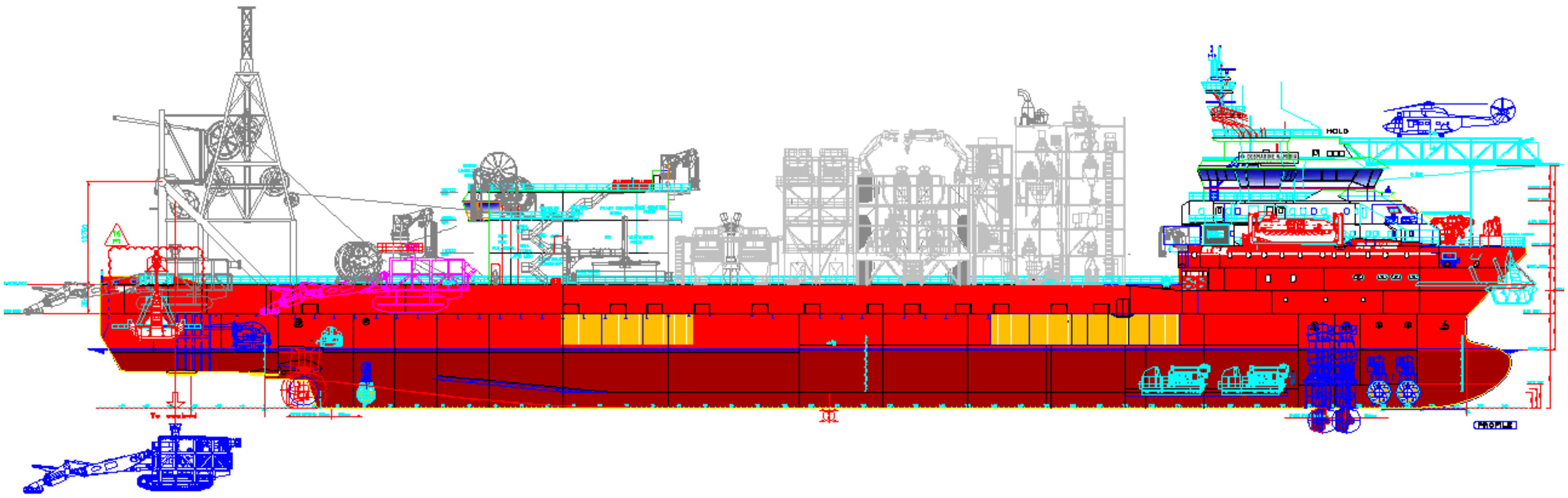
Internship tutor: Mr. Marcin Przyblski, Managing Director, Marin Teknikk Szczecin
Reviewer: Professor Hervé Le Sourne, Institut Catholique d’Arts et Métiers , France

Szczecin, January 2019

A 177 m. Offshore Sea Mining Vessel currently being worked on by Marin Teknikk AS



Main Dimensions

Length O.A. = 176.56 m.

LBP = 148.925 m.

Breadth = 27 m.

Depth = 11.7 m.

Scantling draught = 8.3 m.

C_b = 0.73 m.

Dwt = 26453 tonnes.

Max speed in calm water = 13 knots

Primary structures and equipment onboard –

Umbilical Reeler,

Crawler,

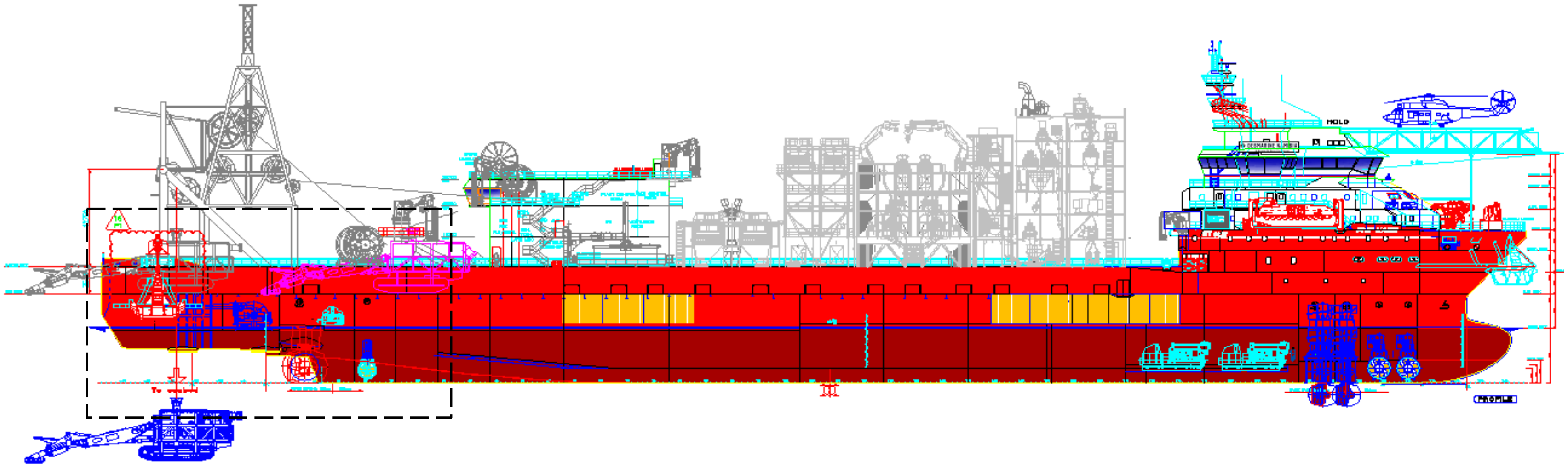
Moonpool,

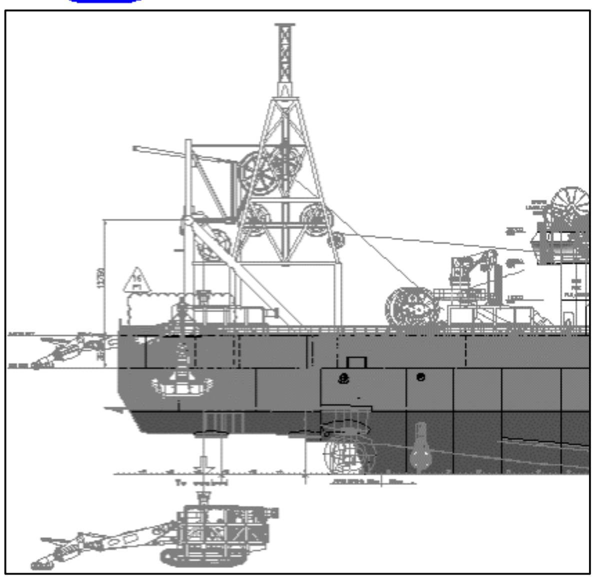
Treatment Plant,

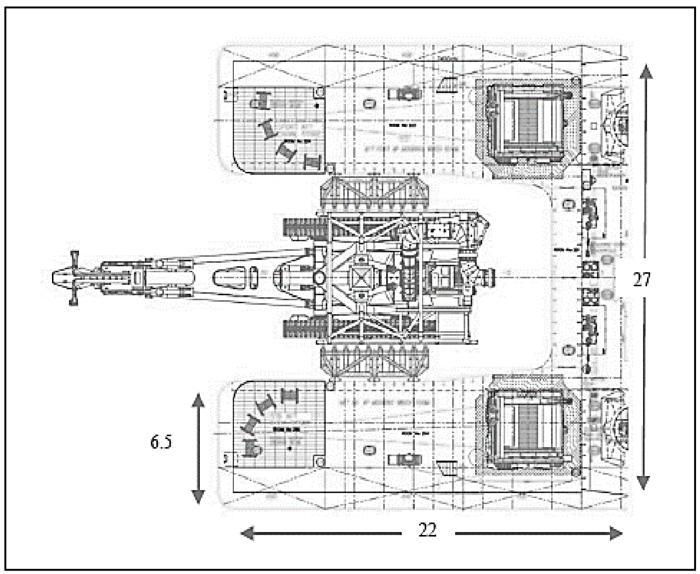
Sliding rails for the crawler,

Helideck, etc.

Region of Interest in the vessel for work



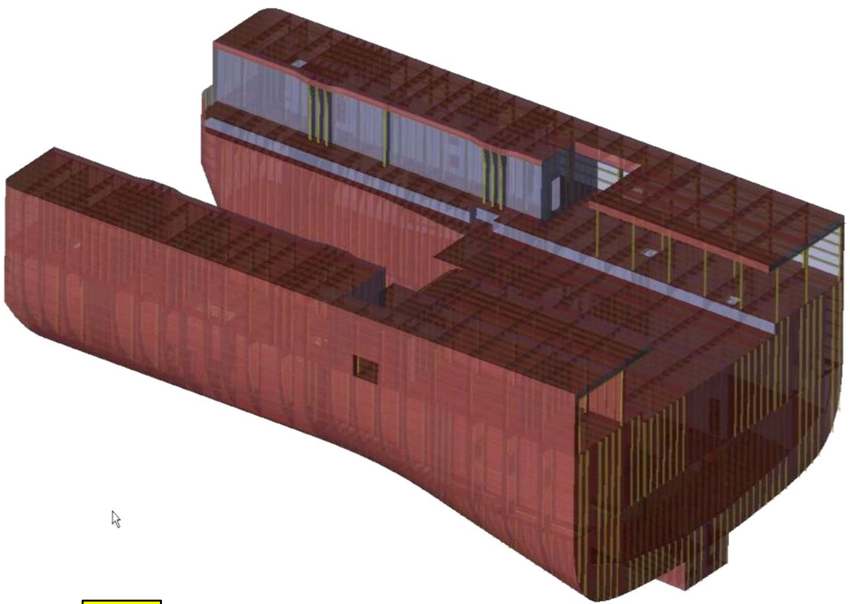


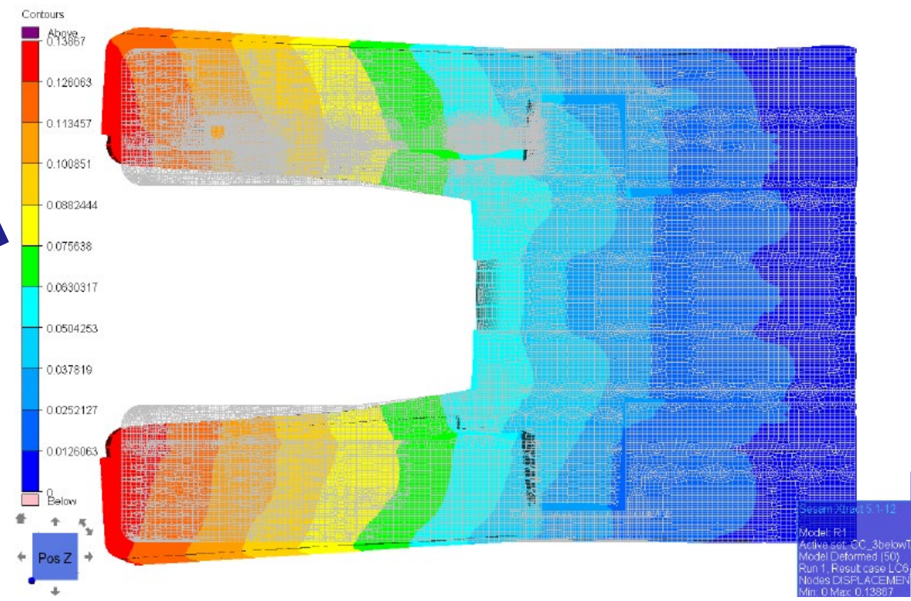


A. Side view of stern region

B. Top view of stern region

Understanding the special kind of deflection initially recognised in the software DNV GL Sesam – to validate the typical deformation nature of the stern structure OSV and analyze the cause of it using classification society rules

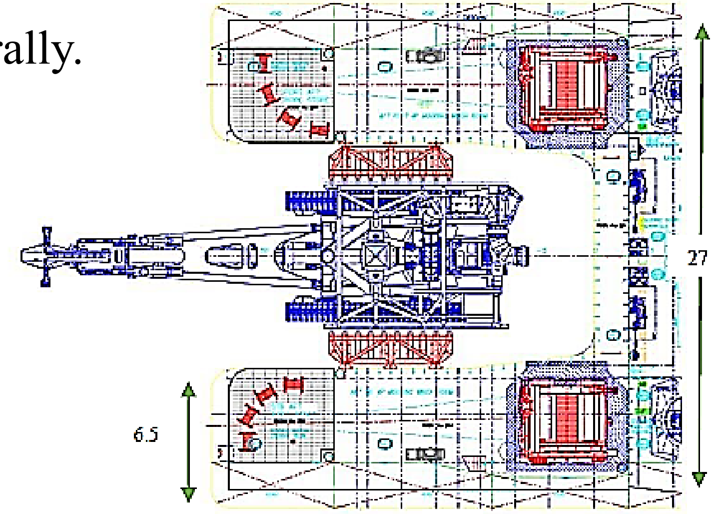




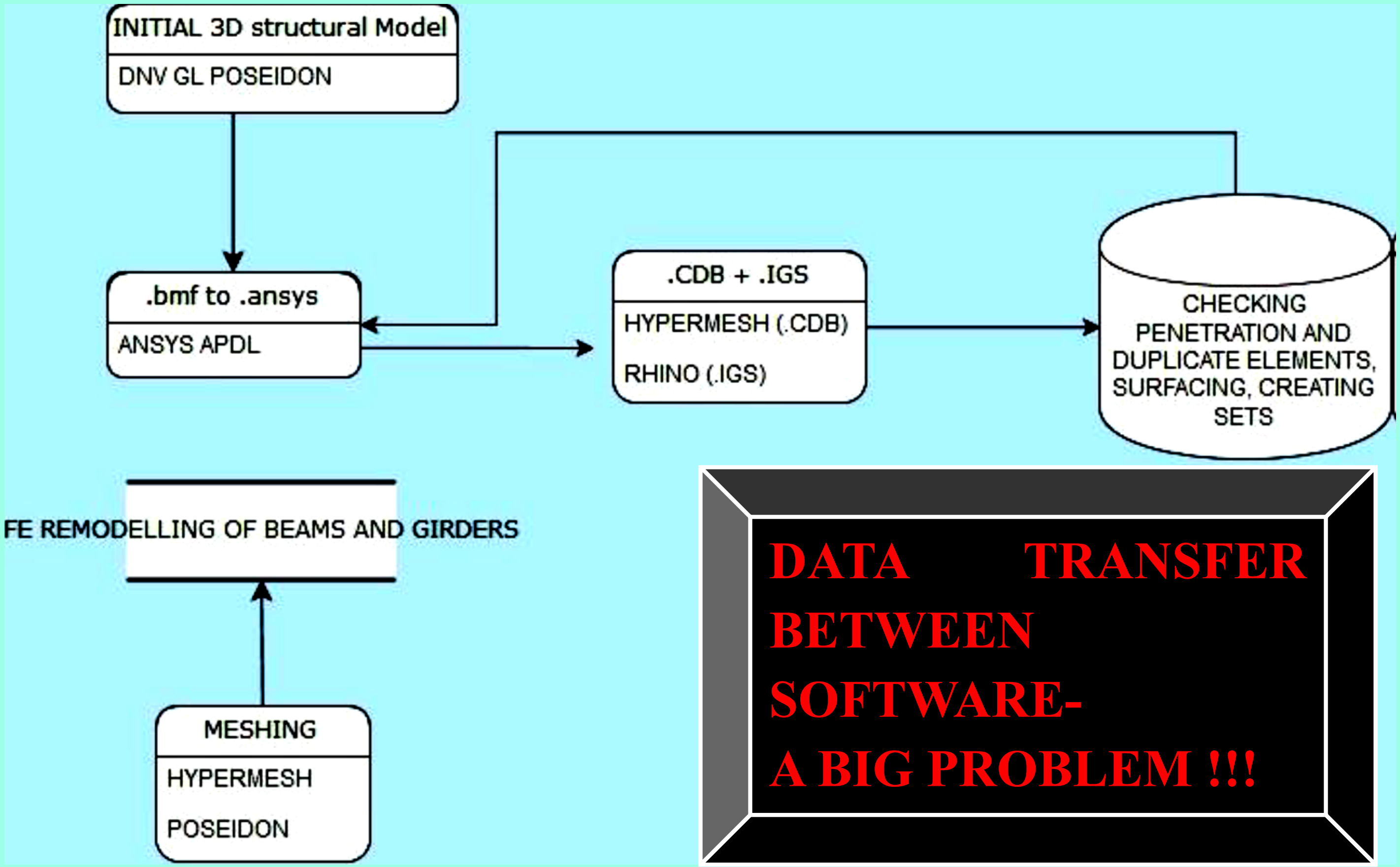
View 1

View 2

- The shape of the stern cannot be changed nor can the fixed loading conditions, which involves the design loads on decks and loads induced by components used for mining operations.
- Looking at the problem, one might suggest providing an external lateral bracing to the structure to counter the lateral deflection, but that contradicts the free movement of the proposed ramp for the crawler.
- The limit of deflection for the given type of vessels, hasn't been defined in any of the codes clearly, so the target deflection was as per the owner's requirements, i.e. maximum deflections of less than 10 mm laterally.



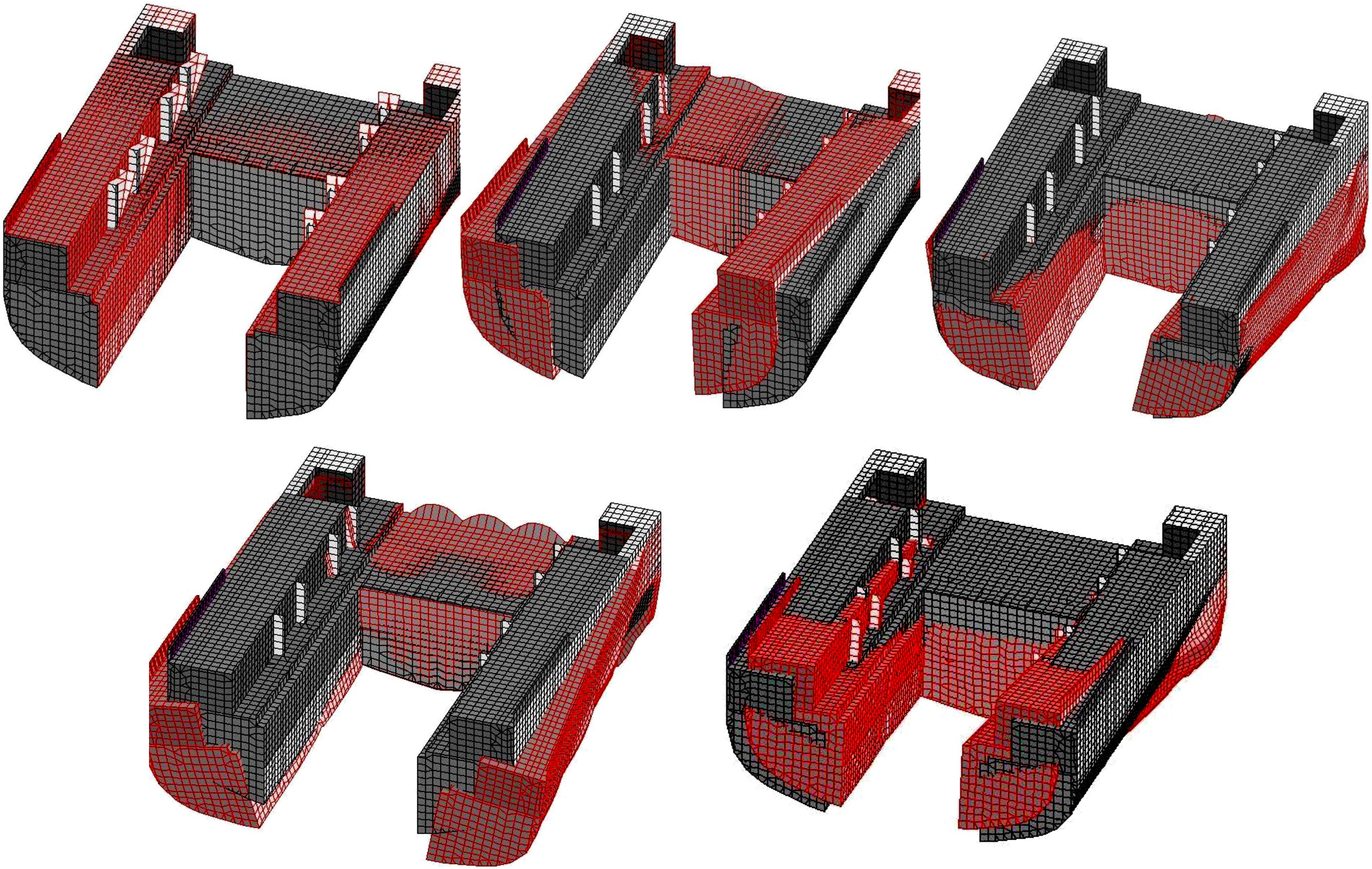
4. Software Used

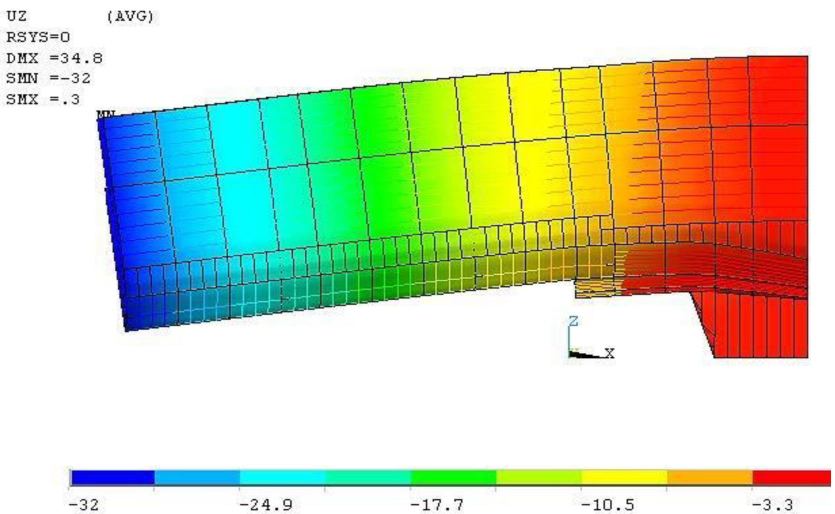


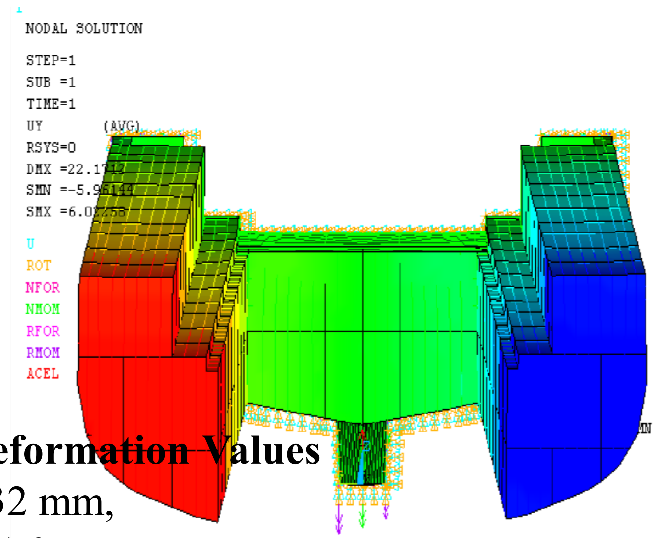
5. Results for Initial Structure

Loading Conditions	*Displacement results Z axis*	*Displacement results Y axis*	*Remarks*
1. Still water and deck loads	*(Min) 0 .67mm.* *(Max) 32 mm.*	*(Min) 11.2 mm.* *(Max) 11.33 mm.*	*Initial condition*
2. Wave loading considered along with (1)	*(Min) 0.63 mm.* *(Max)-16.06 mm.*	*(Min) -4.54 mm.* *(Max) 4.53 mm.*	*Wave considered 0.03647 MPa added, as per DNV GL guidelines.* ***Higher deflections for still-water case (i.e. in Load case 1) observed.***
3. Exposed Main deck load removed from (2)	*Min) -0.7 mm.* *(Max) 2.56 mm.*	*(Min) -1.43 mm.* *(Max) 1.39 mm.*	*Test case.* ***Reason for Problem Identified.*** ***The eccentric loading identified as a cause for torsion.***

6. Analysis in DNV-GL Poseidon (for different load cases)



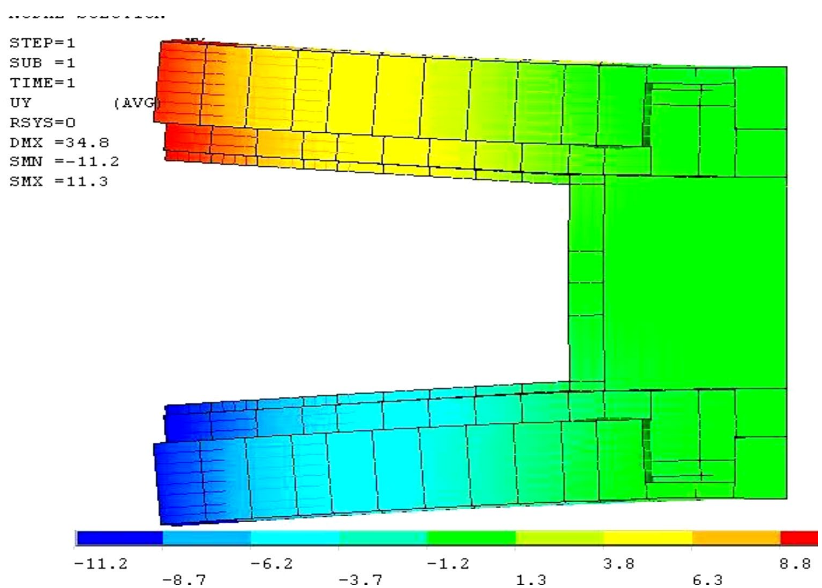


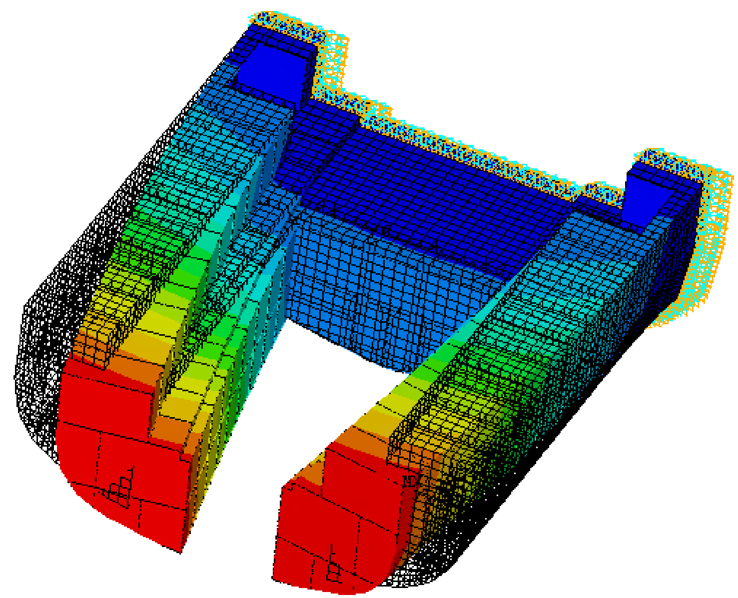


Initial Deformation Values

Z_{max} = -32 mm,

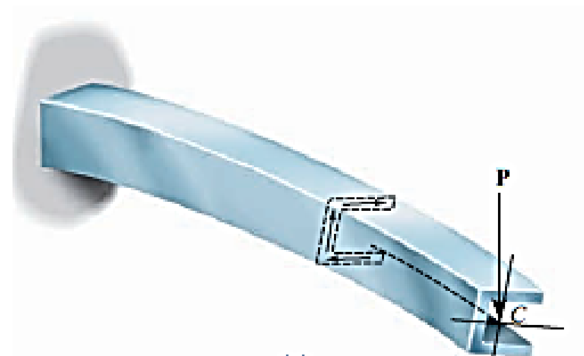
Y_{max} = 11.3 mm.





Most Possible Local Changes in Scantling made

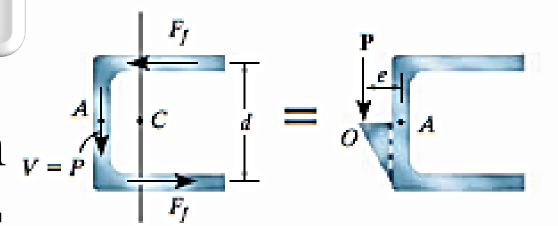
- **Problem Persists !!**



(a)

Understanding the nature of deformation, which is similar to other structures like, bridges, buildings

Concept of Shear Center & warping introduced



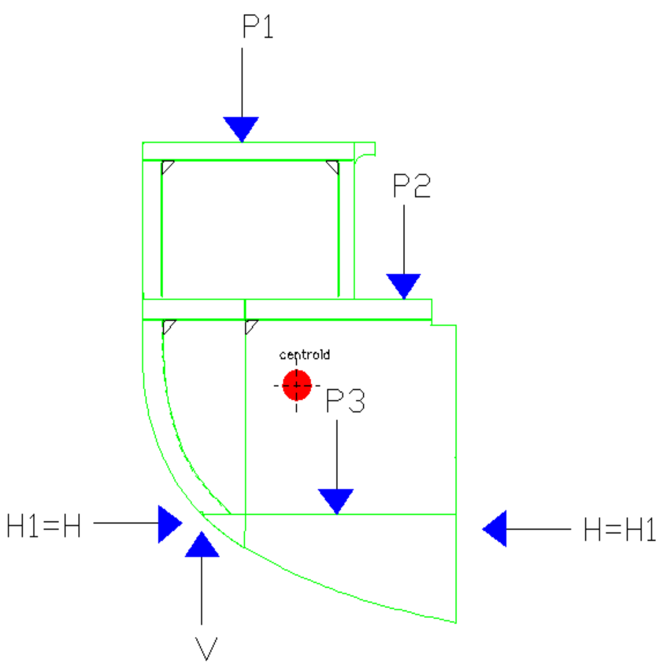
Shear Center

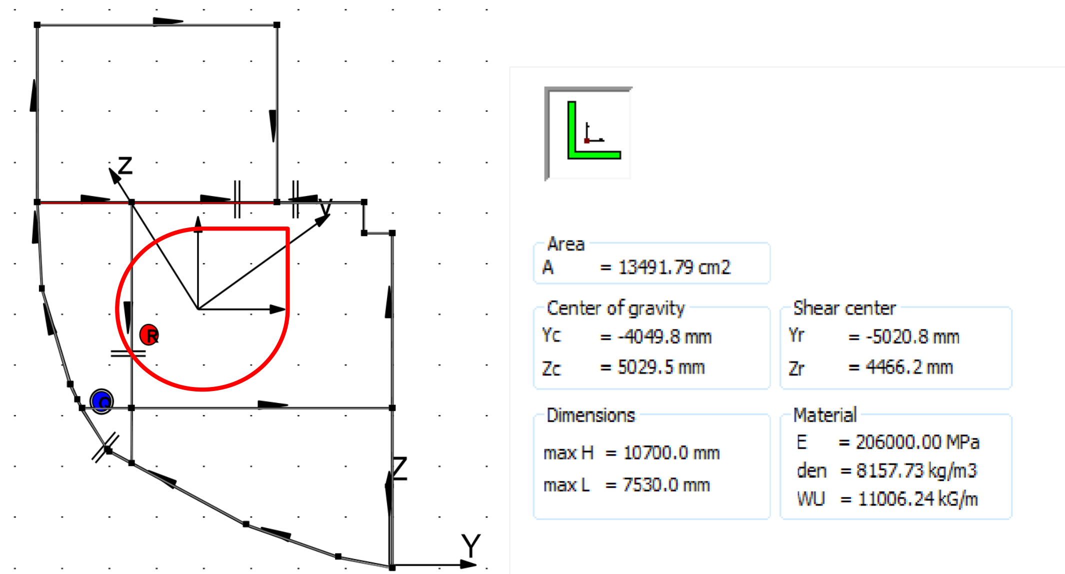
Point of application of force in a geometry, such that there is no twisting in it, while bending.

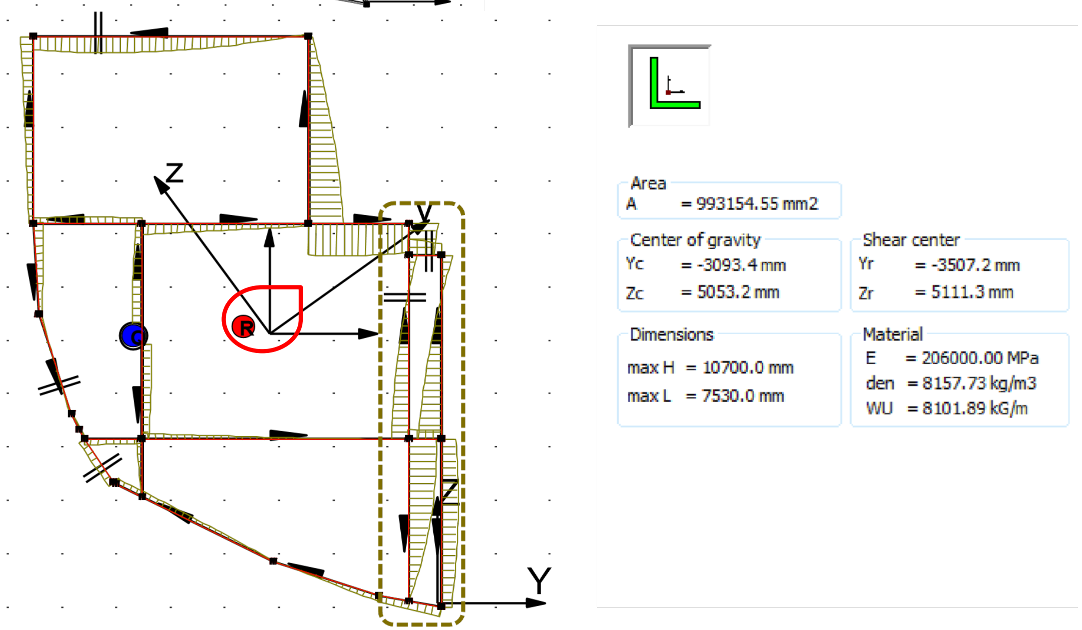
$$\tau = \frac{V\,Q}{I\,t}$$

$$V_y \times e = \int q\,.dS = \int (\tau \times t).dS$$

9. Influence of Shear Centre



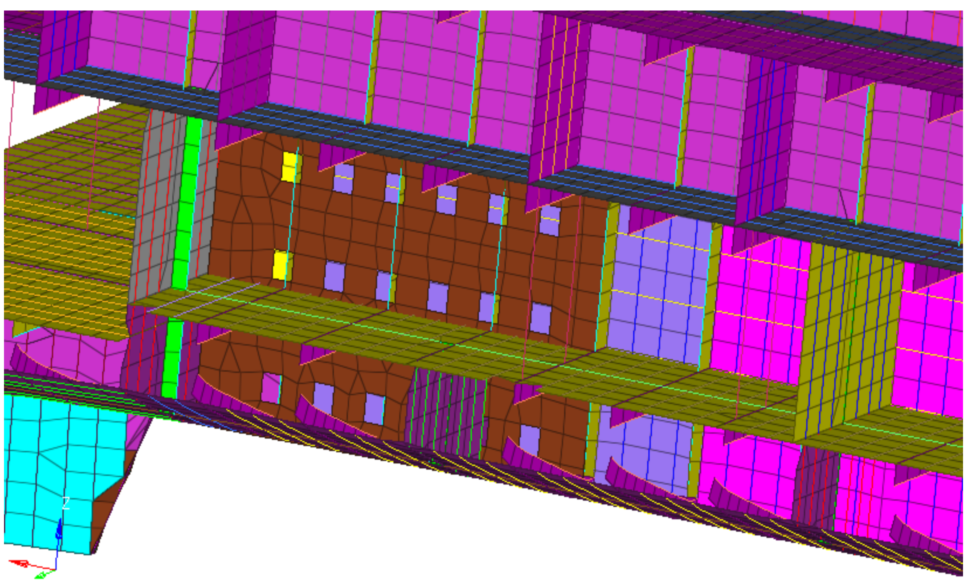


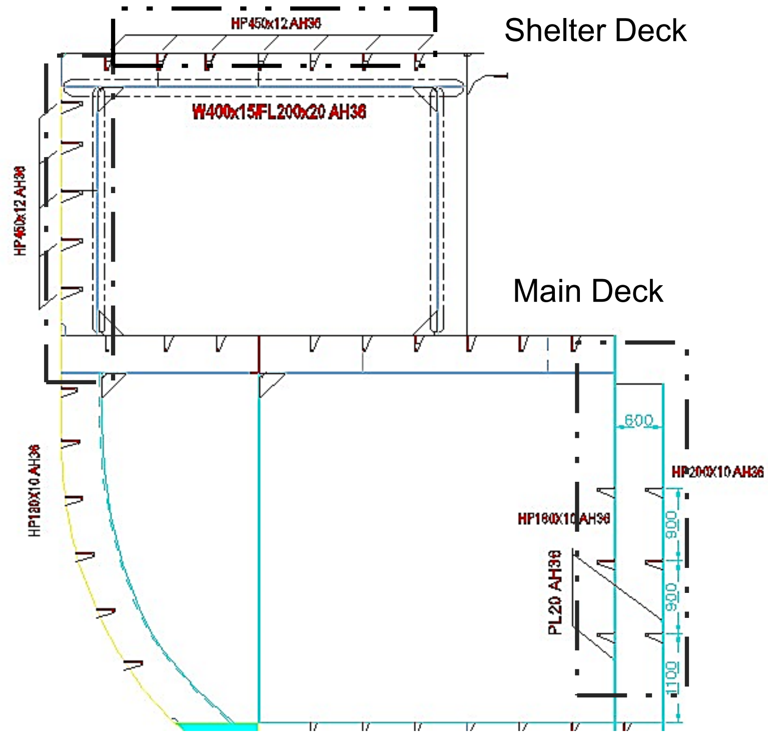


Line of action of force & shear center should coincidence

A trial and error method was used to select the best option for the modified hull girder design.

The element added was based on it's influence on shear flow, which directly affects the location of shear center, the location of centroid is also affected though due to change in structural weights.

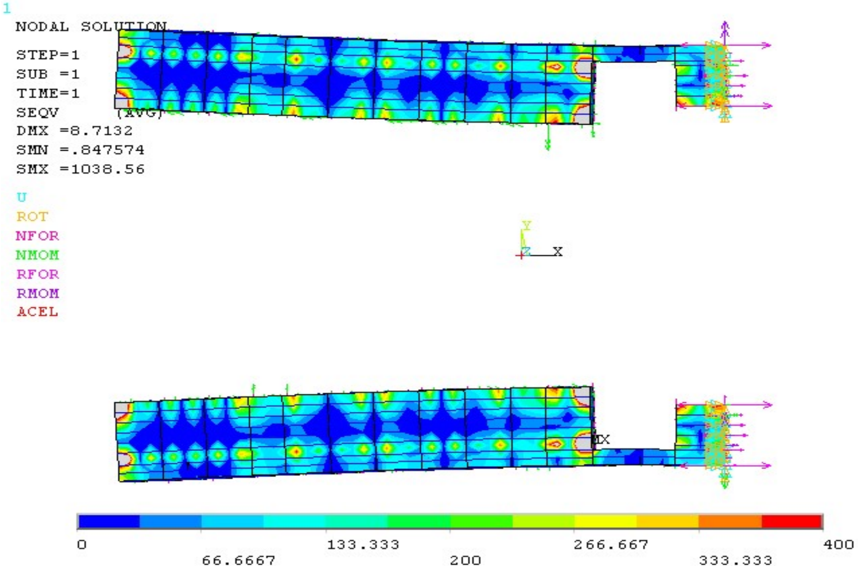


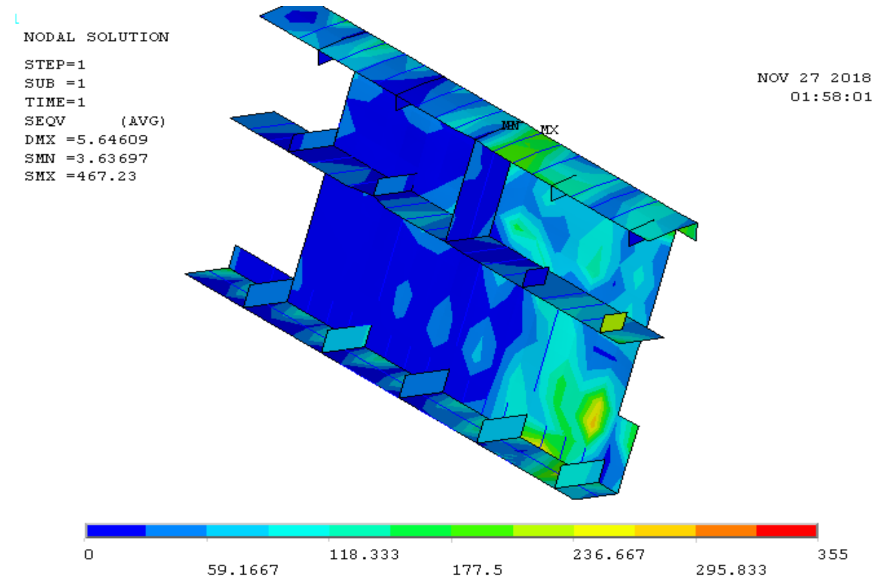


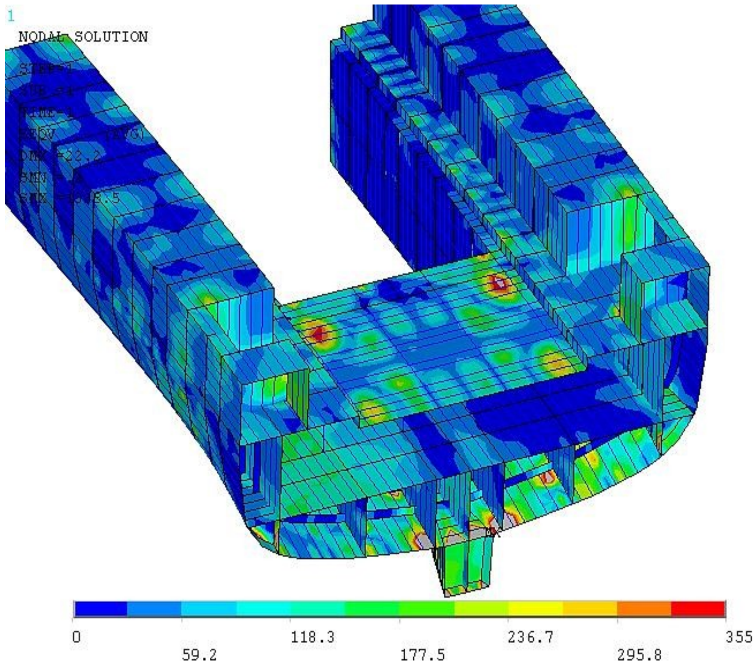
11. Deformation output due to change in structural configurations

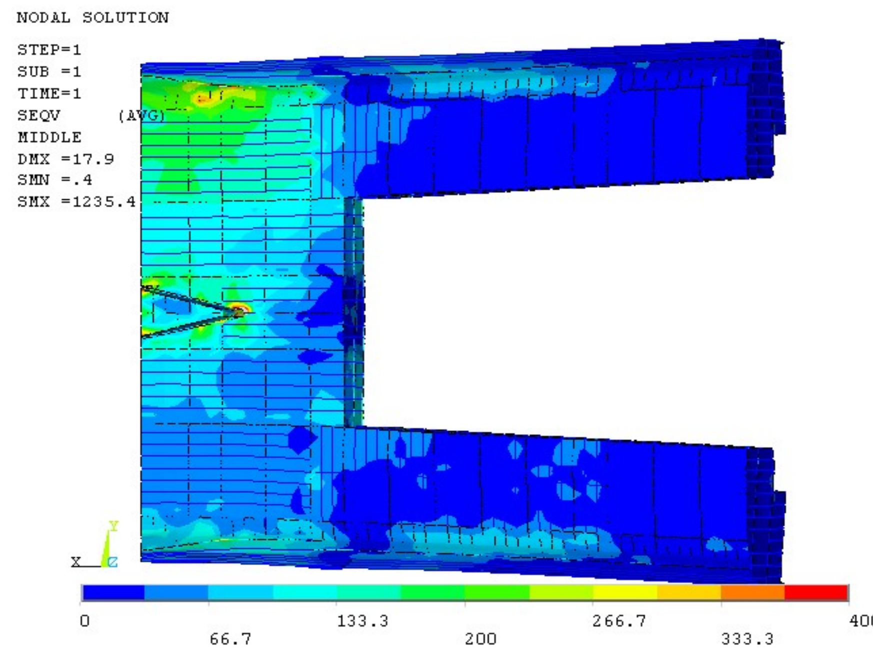
Modification	**Displacement results Z axis**	**Displacement results Y axis**	**Remarks**
1. Adding longitudinal deck girders to shelter deck and sheer deck, to give more resistance to bending. (Frame 14 to -32)	*-32 mm.(Max)* *0.3 mm. (Min)*	*-11.2 mm.(Min)* *12.3 mm. (max)*	*No required changes, both horizontal, vertical.*
2. Adding transversal bulkheads at 20 m. from aft and 24.8 m. From aft. To increase the transverse strength of stern.		*similar*	*No required changes* *Increase in vertical bending due to weight.*
3. Adding longitudinal side girders at the side shells of the vessel aft (Frame 0 to -32)		*similar*	*No required changes*
4. Adding thicker plates to inner hull side shell.		*similar*	*Increase in vertical deflection.*
5. Adding deck plates on shelter deck to cover the recess (see fig.16 Above) and then load applied		*similar*	*No required changes.*
7. Same elements as in (6) , the load applied also considers wave load	*(Min) 0.7 mm.* *(Max) -3 mm.*	*(Min) -9.8 mm.* *(Max) 9.67 mm.*	*Vertical bending has reduced drastically, but the lateral deformation has increased a bit, but still within limits.*
6. Adding 20mm. longitudinal swash bulkheads, with cut-outs to facilitate welding (Frame 3 to -16) **Max Loading condition (no wave loads)**	*(Min) 0.3 mm.* *(Max)-20.73 mm.*	*(Min) -5.5 mm.* *(Max) 5.59 mm.*	***The Lateral deflection has been minimized by 51%. Problem solved*** *The bending deflection has gone down by 35% but still needs further stiffening of elements*

12. Von-Misses Stress Check for safety









Thank you!

Any Questions??