Analysis of Classification Societies Rules for Yacht Superstructure Scantlings – Application to a Light Alloy Superstructure

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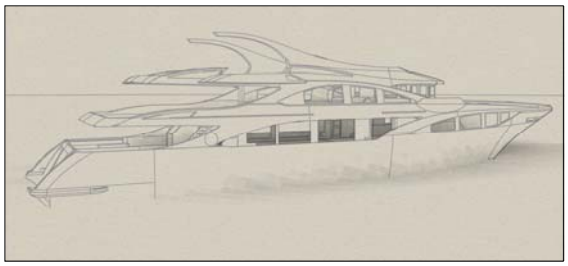
Topics

1. FEM Analysis of Superstructure – Stress, Deformation
2. Comparison of Superstructure Rules (RINA, LR, ABS)



45m Benetti Semi Custom Yacht

Yacht Characteristics

Length Overall	45.14 m
Breadth Overall	9.10 m
Waterline Length	37.21 m
Depth	4.45 m
Draught	2.40 m
Design Speed	14.50 kn
Displacement	445 t

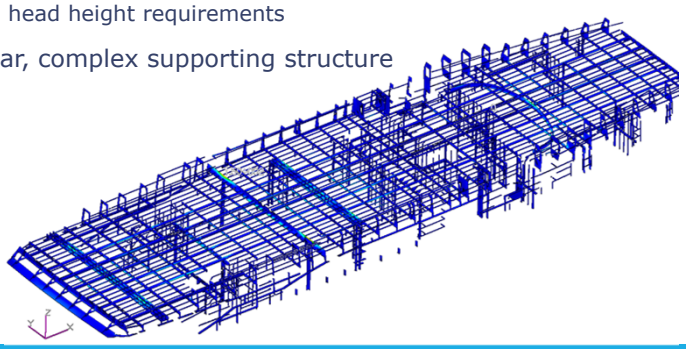
Aluminium Alloy	Minimum guaranteed yield stress for welded construction
5083 (plates)	125 N/mm²
6082 (reinforcements)	250 N/mm²

Why Superstructures?

Luxurious interior layout demands

- Large open spaces
- Big windows
- Concentrated static loads
- Minimum head height requirements

→ Irregular, complex supporting structure



Superstructure Rules

Classification Societies:
- RINA
- LR
- ABS

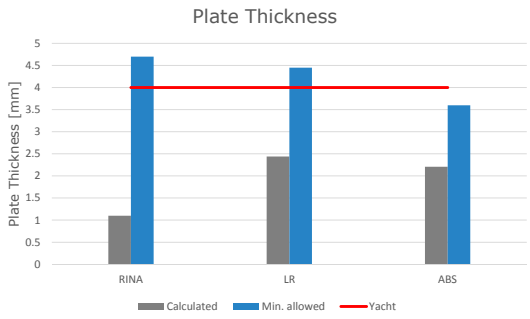
Limited and sparse

Required to calculate:
- minimum thickness for plates and stiffeners
- minimum section modulus for reinforcements

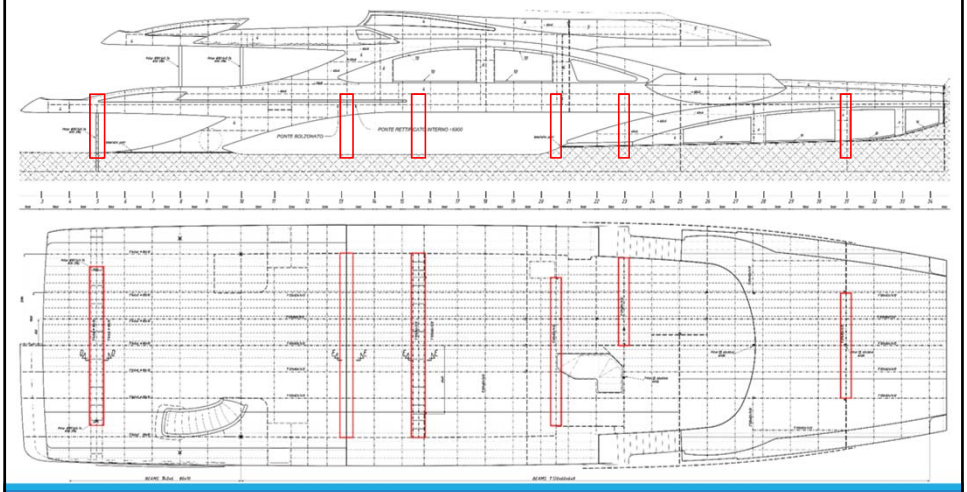
Superstructure Rules – Plate thickness

Two values:

1. Calculated plate thickness
2. Minimum allowed plate thickness

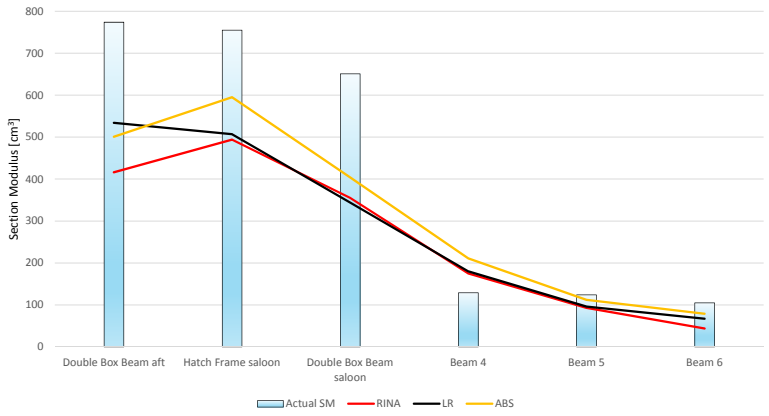


Scantling Plan



Rules - Minimum Section Modulus

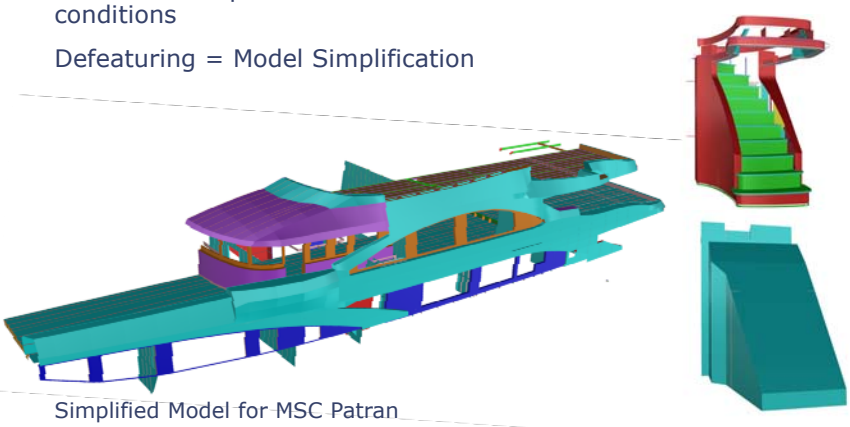
σ_a=250 N/mm^2



Finite Element Method – Objective & Preparation

Understand superstructure behaviour with different load conditions

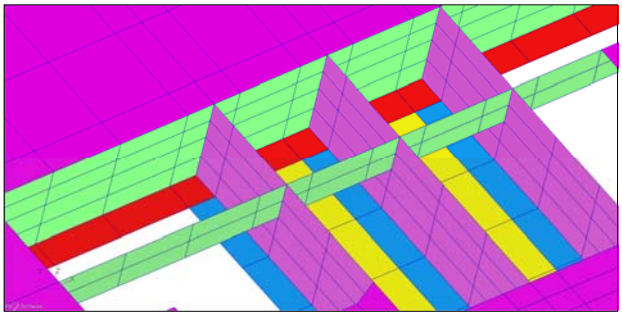
Defeaturing = Model Simplification



Simplified Model for MSC Patran

Finite Element Method – Meshing

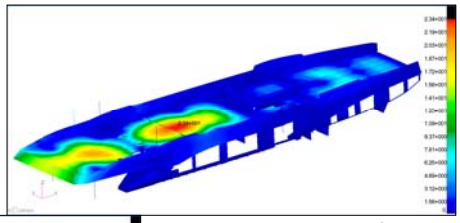
Member	Element size in mm
Beam Junction	30 x 30
Stiffeners	30 x 100
Plates	100 x 100



142’277 elements, 135’882 nodes

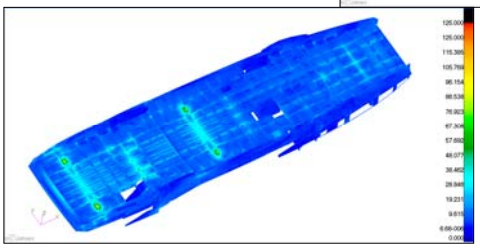
Analysis - Load Case 1 – RINA Deck Pressure

Pressure = 6.21 kN/m²



Deformation

Max. Deformation 23.4 mm



Peak Stress 180 N/mm²

Stress distribution

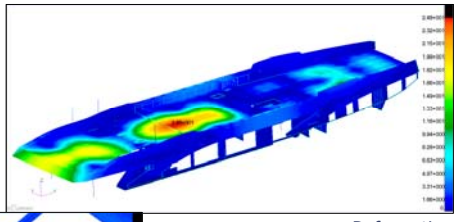
Analysis - Load Case 4 – Vertical Acceleration

a_{CG} = 0.7g

Sun deck weight

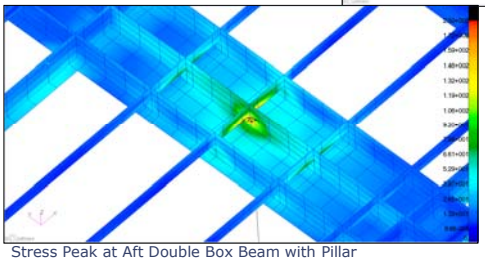
Outfitting weight

2 distributed loads of 6m²



Deformation

Max. Deformation 24.8 mm



Peak Stress 170 N/mm²

Stress Peak at Aft Double Box Beam with Pillar

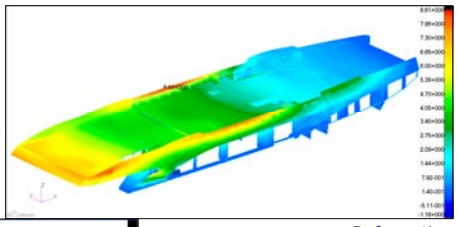
Analysis - Load Case 5 – Racking

a_T = 0.94g – 1.11g

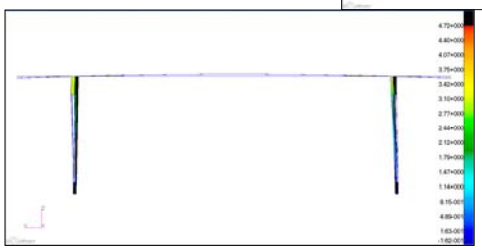
Sun deck weight

Outfitting weight

2 distributed loads of 6m²



Deformation



Vertical deformation of side plating

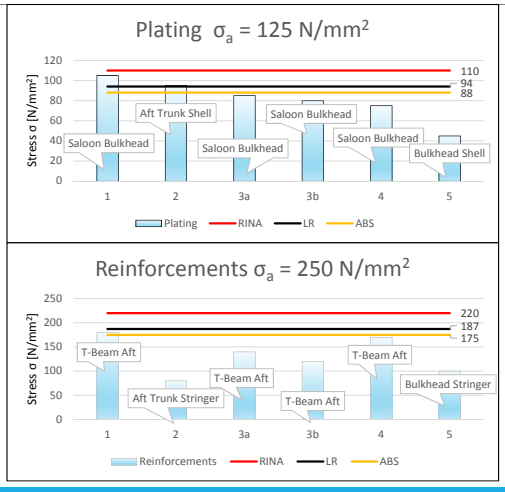
Bulwark deformation:

8.6 mm

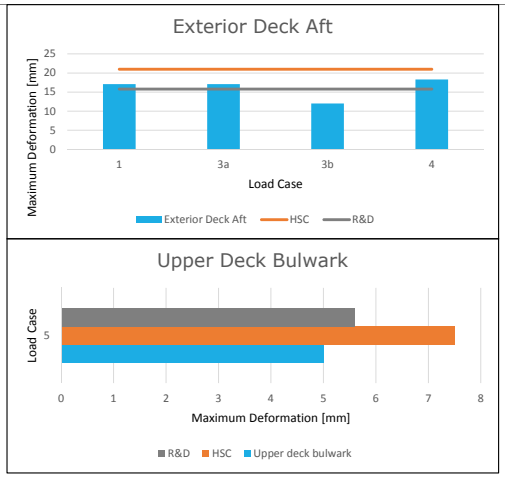
Side plating deformation:

4.7 mm

von Mises Stress Values vs. Rule Limits



Maximum Deformation vs. Limits



HSC Limit:

1% of shortest width of corresponding global plate

Summary

Rule Comparison:

- RINA lightest structure
- ABS heaviest structure
- Section Modulus Requirements met
- Some Stresses above Rule limits

No Rule Limits for Racking

FEM:

- No structural failures
- Areas with elevated stress and deformation