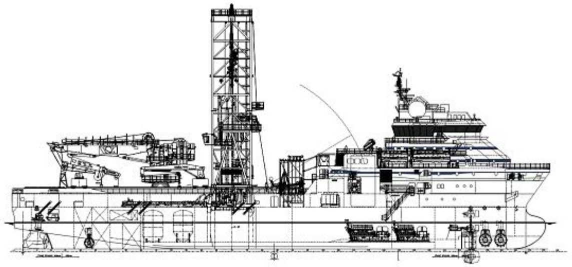

Structural Design of Helicopter Landing Platform on Offshore Ship

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18th February 2013, Gdynia

Contents

Objectives and scope of thesis

- To perform design and analysis of helicopter landing structure on offshore ship.
- To understand more about important features, calculation procedures in design process.

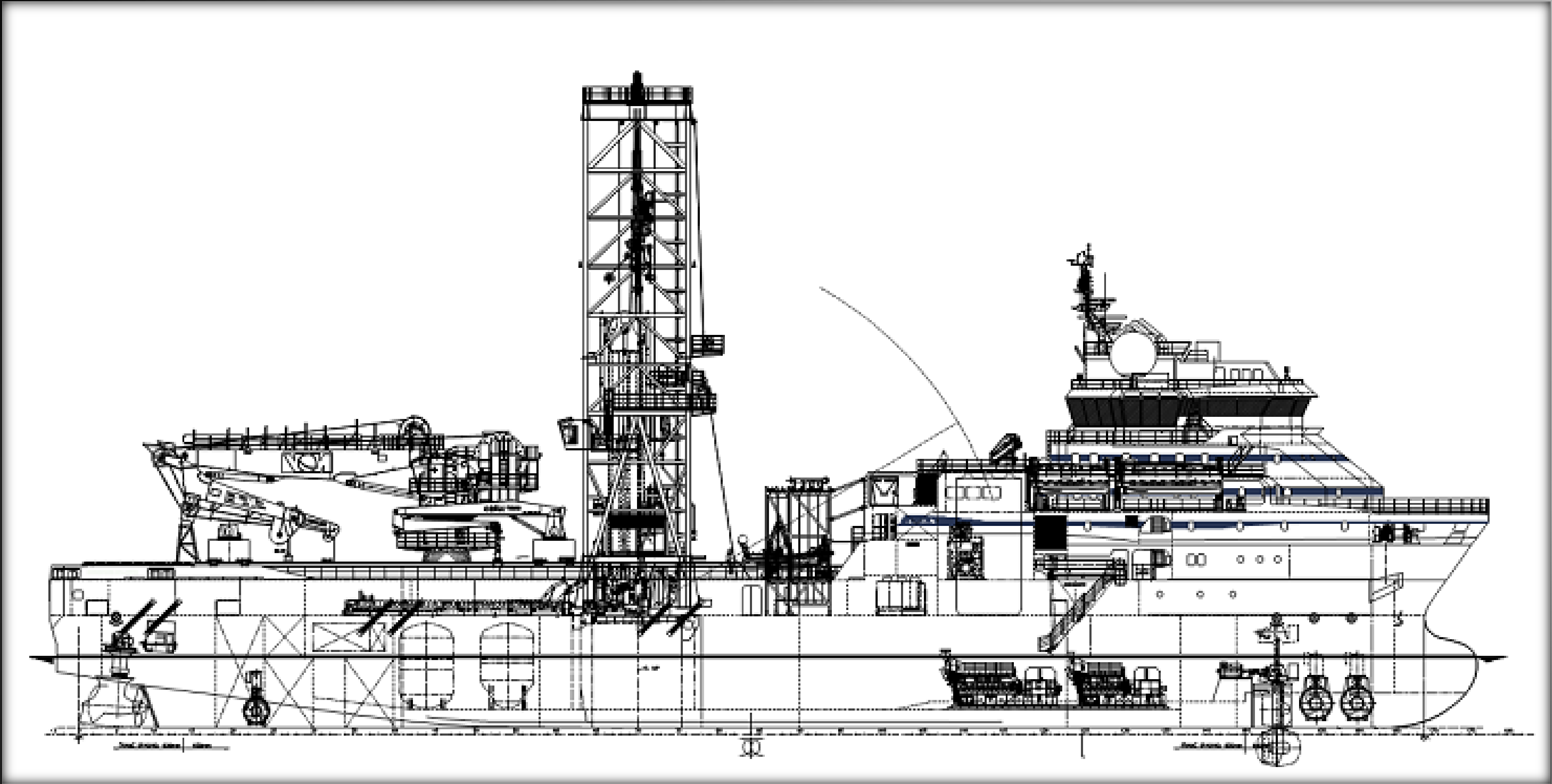
- Only basic design
- Uncertainty about modelling aluminium alloy.

General Description of the Problem

- Availability of space
- Safety requirements
- Strength requirements

Main Technical Parameters of the Ship

Description	Value
LOA	115.4 m
LPP	107.95 m
Rule length, L	105.6 m
Breadth, B	22 m
Depth to main deck	9 m
Draught	7.15 m
Depth to summer water line	7.095 m
Block coefficient	0.731
Displacement	12767.53 tonnes
Propulsion	2 x 3000 kW
Trail speed	14.5 knots

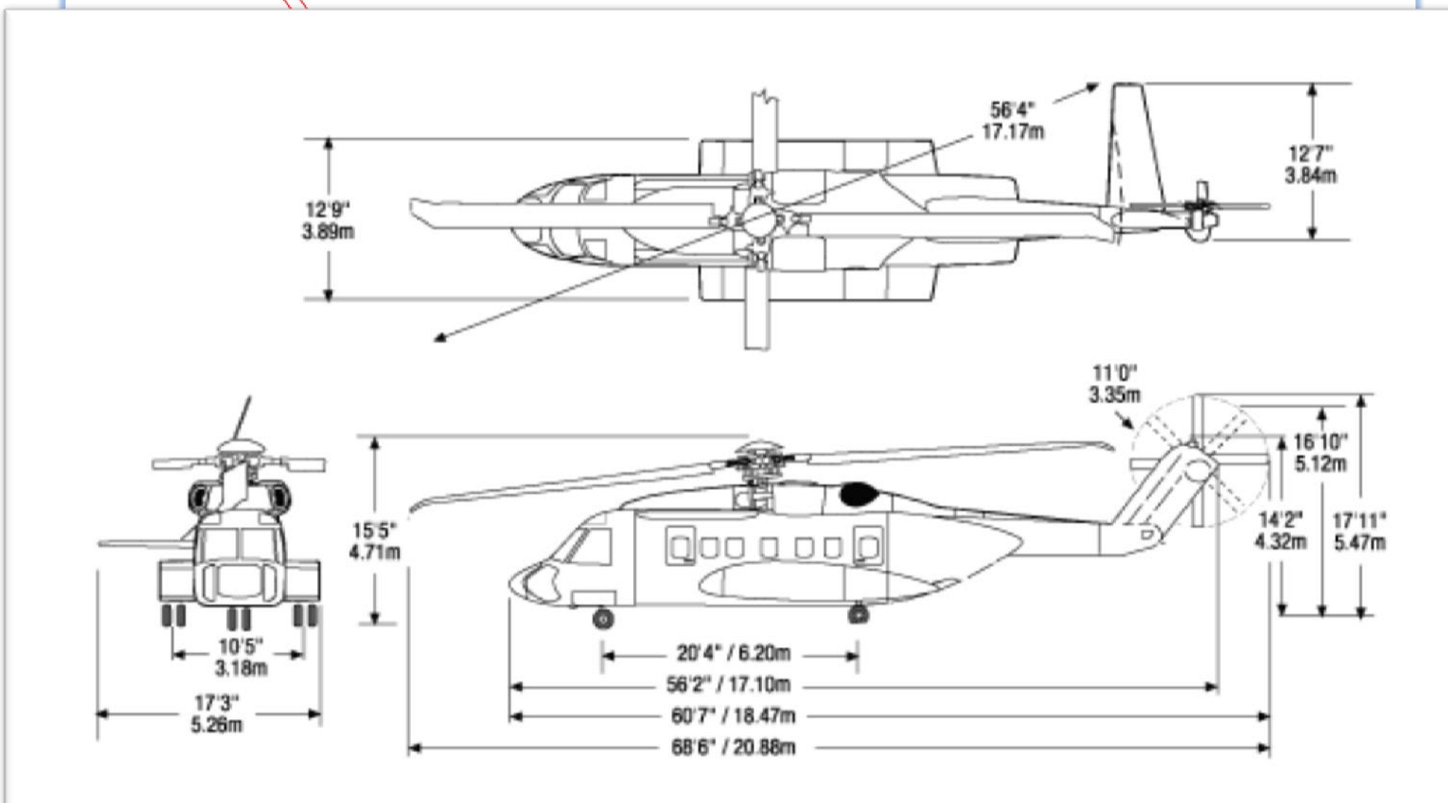


Profile

Helicopter

- Sirkosky S-92
- Maximum take off mass = 12020 kg
- D-value = 20.88 m
- Rotor diameter = 17.17 m

Helicopter



56'4"
17.17m
12'7"
3.84m
12'9"
3.89m
11'0"
3.35m
16'10"
5.12m
15'5"
4.71m
14'2"
4.32m
17'11"
5.47m
10'5"
3.18m
17'3"
5.26m
20'4" / 6.20m
56'2" / 17.10m
60'7" / 18.47m
68'6" / 20.88m

Review of Applicable Codes and Standards

- DNV Rules
- SOLAS & CAP437

DNV OS-E-401

- Also needs to comply with DNV rules for classification of ships Pt.6 Ch.1 Sec.2B
  - Landing condition
  - Stowed condition

DNV Rule

Landing condition

- Landing impact force
- Gravity and inertia force of structure with equipment
- Wind forces on structure

Stowed condition

- Gravity & inertia of helicopter
- Gravity & inertia of structure
- Wind forces
- Ice loads on structure
- Green sea on pillars

SOLAS

- Fire exit!
- Arrangement for safety and fire-fighting equipment.

No	Item	No/Capacity
1	dry powder extinguisher	2/total 45kg
2	carbon dioxide extinguishers	18 kg
3	foam fire fighting system	500 L/min for helicopter length between 15 to 24 m
4	Fire fighting nozzles and hoses	at least 2 with hoses long enough to reach every part of helideck
5	two set of fire fighter's outfits with following elements: • adjustable wrench, • fire resistant blanket • cutter, bolt 60 cm • hook, grab or salving • heavy duty hacksaw with 6 spare blades • ladder • lift line 5 mm diameter with 15 m in length • pliers • set of assorted screwdrivers • knife	

CAP437

- Helideck dimension, approach areas, marking, lighting, rescue, fire fighting, communication and navigation equipments.

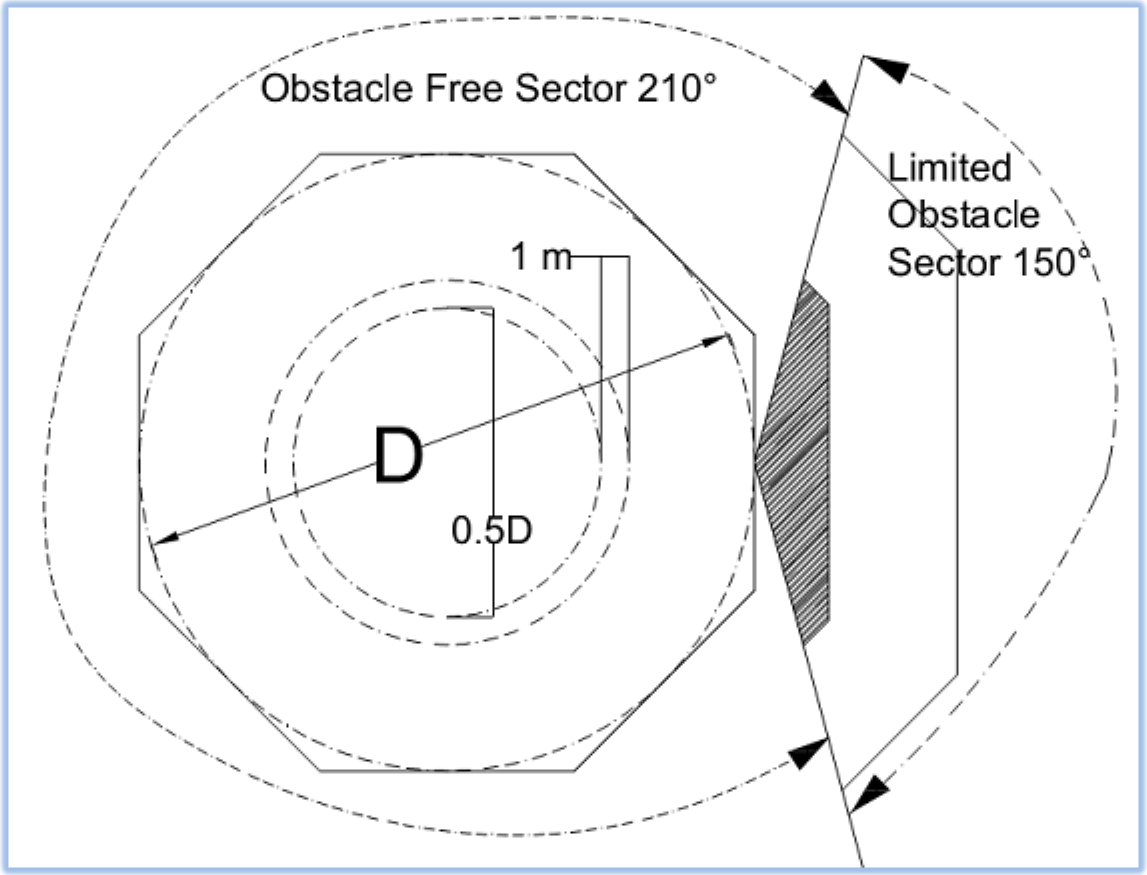
CAP 437

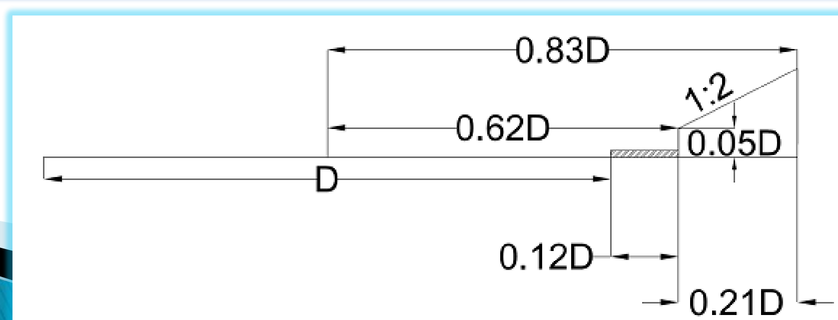
- Sizing (Weight and dimensions)

Type	D-value (metres)	Perimeter 'D' marking	Rotor diameter (metres)	Max weight (kg)	't' value	Landing net size
Bolkow Bo 105D	12	12	9.9	2400	2.4t	Not recommended
EC 135 T2+	12.2	12	10.2	2910	2.9t	Not recommended
Bolkow 117	13	13	11	3200	3.2t	Not recommended
Agusta A109	13.05	13	11	2600	2.6t	Small
Dauphin AS365 N2	13.68	14	11.93	4250	4.3t	Small
Dauphin AS365 N3	13.73	14	11.94	4300	4.3t	Small
EC 155B1	14.3	14	12.6	4850	4.9t	Medium
Sikorsky S76	16	16	13.4	5307	5.3t	Medium
Agusta/Westland AW 139	16.63	17	13.8	6800	6.8t	Medium
Bell 412	17.13	17	14.02	5397	5.4t	Not recommended
Bell212	17.46	17	14.63	5080	5.1t	Not recommended
Super Puma AS332L	18.7	19	15.6	8599	8.6t	Medium
Bell 214ST	18.95	19	15.85	7938	7.9t	Medium
Super Puma AS332L2	19.5	20	16.2	9300	9.3t	Medium
EC 225	19.5	20	16.2	11000	11.0t	Medium
Sikorsky S92A	**20.88**	**21**	**17.17**	**12020**	**12.0t**	**Large**
Sikorsky S61N	22.2	22	18.9	9298	9.3t	Large
EH101	22.8	23	18.6	14600	14.6t	Large

CAP 437

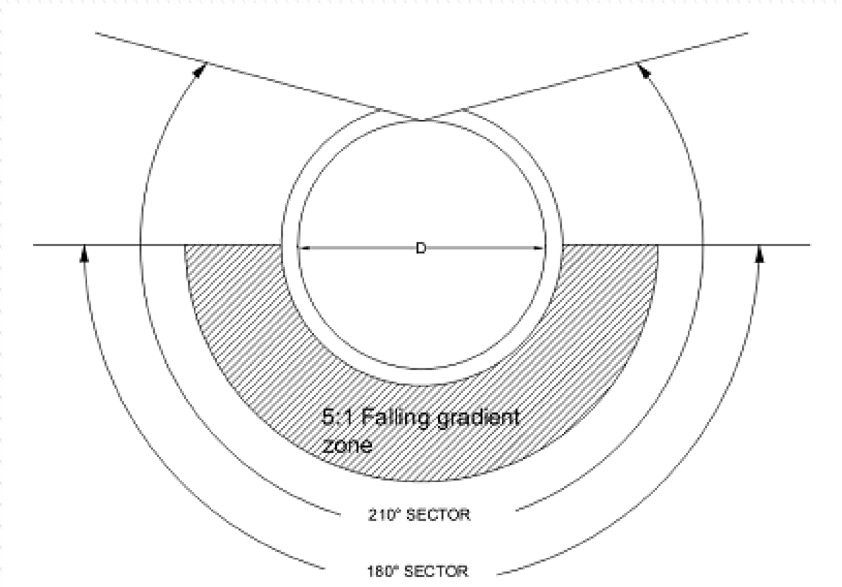
- Approach areas

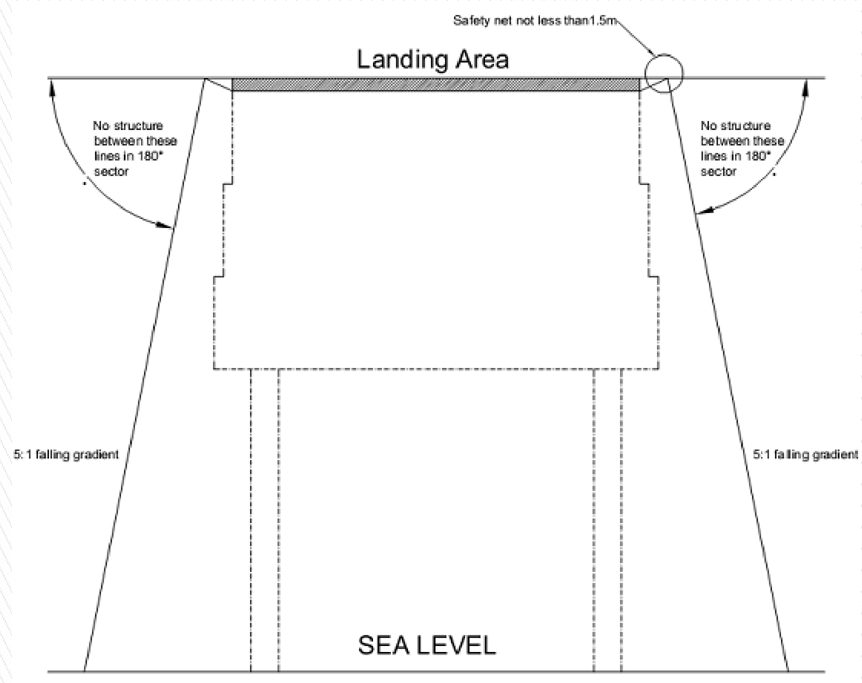




CAP 437

Deck clearance below landing level





Analysis of Loads

Various loads are calculated based on Rule formulas:

- Landing forces
- Inertia forces
- Wind forces
- Ice loads
- Green sea load
- Landing Positions
- Load combinations

Landing forces

- Treated as vertical static force
- 2 x MTOM for normal landing
- 3 x MTOM for accidental landing

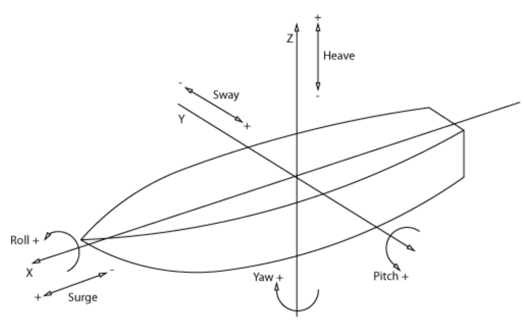
$$P_v = 2\,g M_H (kN)$$

Inertia forces

- Surge, sway , heave accelerations are calculated
- Possible ship motion forces are calculated as:

1. Vertical forces alone
2. Combined vertical and transverse forces
3. Combined vertical and longitudinal forces

Item	Acceleration factor
Vertical alone	1.49
Vertical+ Transverse	1 , 0.39
Vertical + Long:	1.49, 0.44



Wind forces

- Wind forces are calculated by class' recommended velocities:

  $V_{1imin,10} = 30\ ms^{-1}$ (landing)

  $V_{1imin,10} = 55\ ms^{-1}$ (stowage)

- Take into account of solidification & shielding effects as well as normal wind pressure force over pad.

Green sea load

- Assumes sea pressure acting horizontally on the two main pillars located on boat deck.
- Can be determined by class' formula:

$$p = 4.1 C_D a \, (1.79 \, C_W - h_0)(kNm^{-2})$$

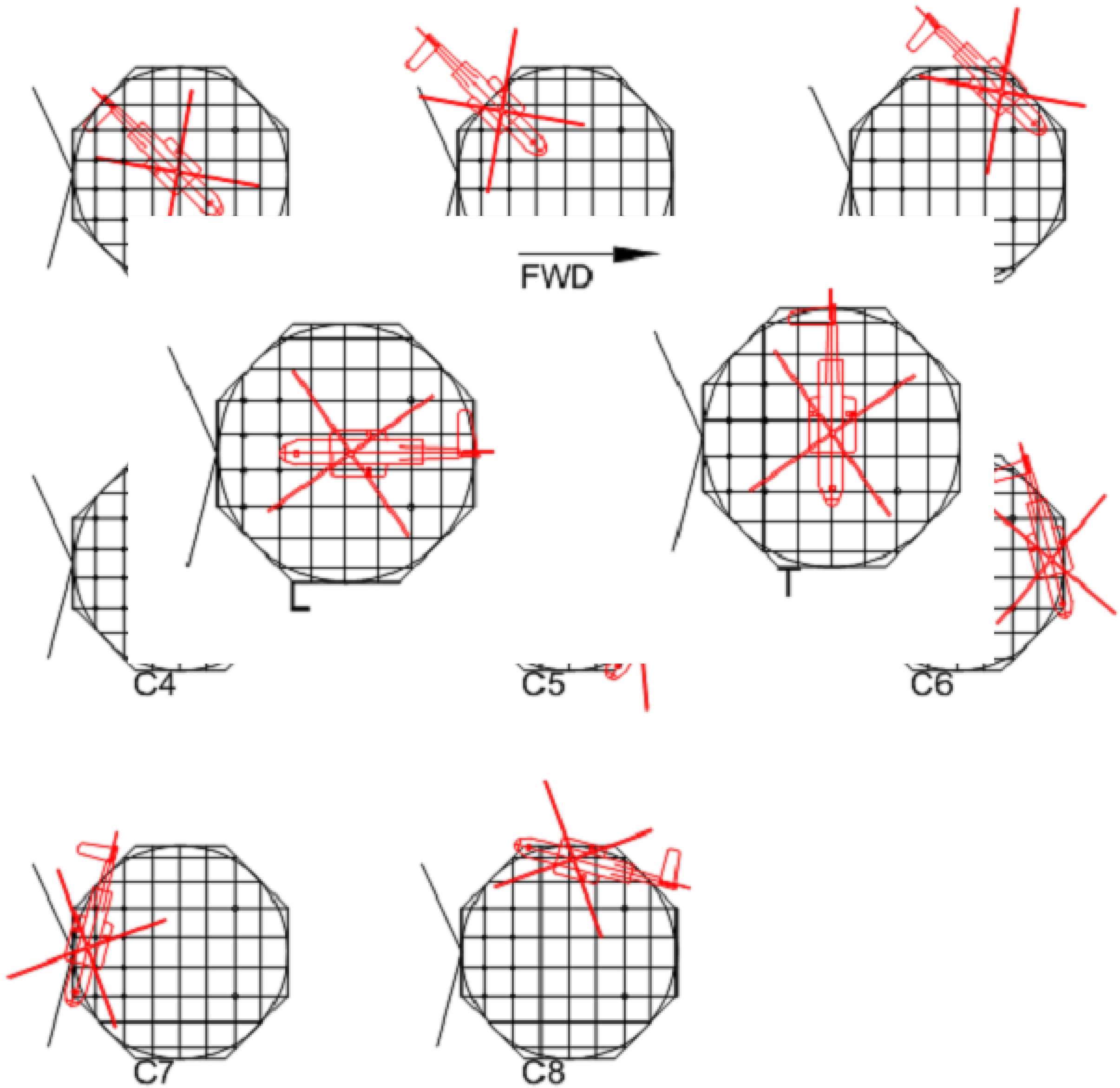
- Green sea on each pillar is 104.07 kN acting in the X-direction.

Ice load

- Ice thickness of 5 cm is to be considered under stowed condition over exposed surfaces.
- Virtual densities are created in GeniE.
- Total mass of ice for the whole structure is approximately 116.67 tonnes.

$$\rho_{virtual} = \frac{A_{ice} \times \rho_{ice}}{A_{section}}$$

Landing positions



Load combinations

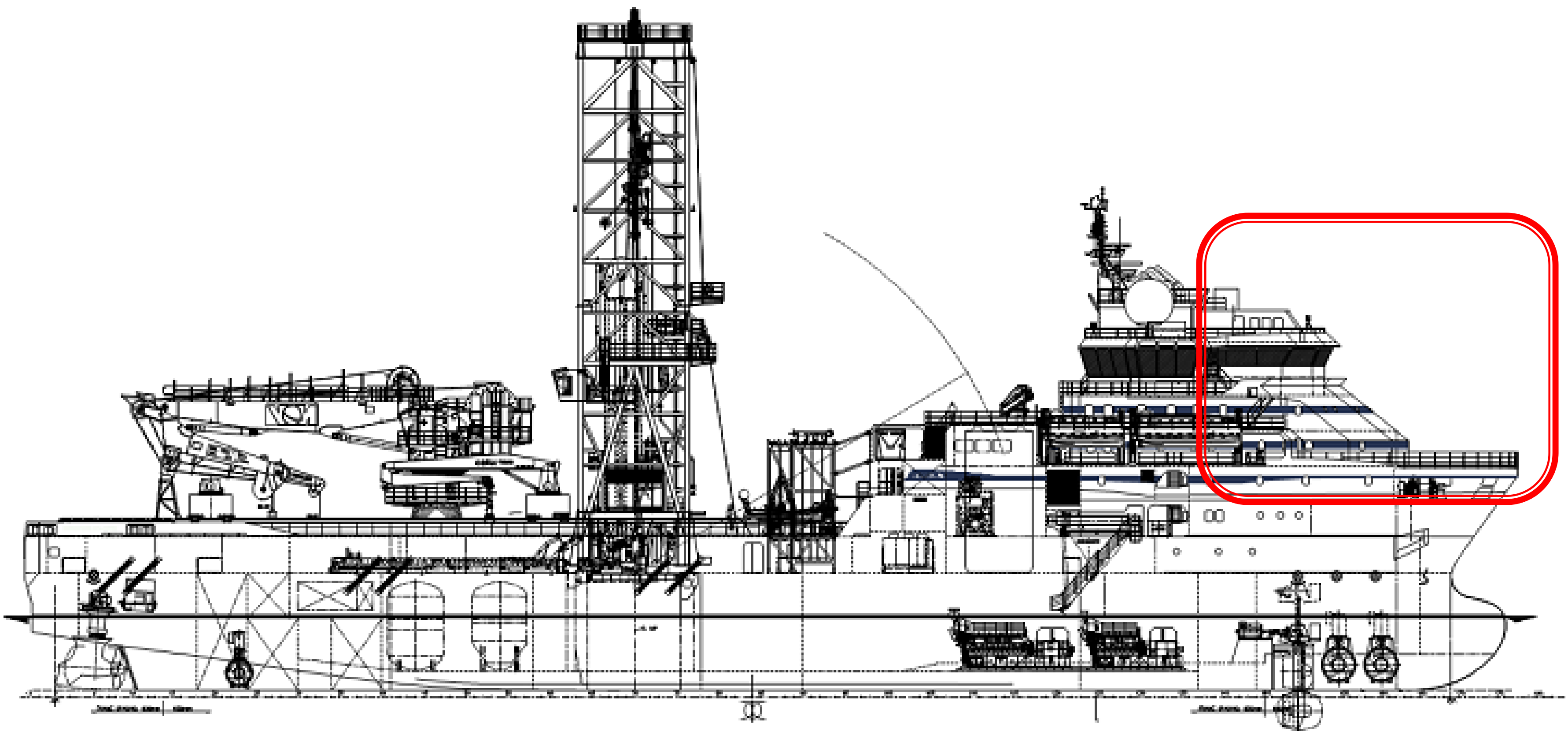
Emergency Stowed Condition (starts with 3)										
AFT WIND										
Stowed position	L					T				
Load Case No	**301**	**302**	**303**	**304**	**305**	**306**	**307**	**308**	**309**	**310**
Structure Self Wt X-dirn		0.46	-0.46				0.46	-0.46		
Structure Self Wt Y-dirn				0.39	-0.39				0.39	-0.39
Structure Self Wt Z-dirn	1.49	1.49	1.49	1	1	1.49	1.49	1.49	1	1
Helicopter Wt X-dirn L			-0.46							
Helicopter Wt Y-dirn L				0.39	-0.39					
Helicopter Wt Z-dirn L	1.49	1.49	1.49	1	1					
Helicopter Wt X-dirn T							0.46	-0.46		
Helicopter Wt Y-dirn T									0.39	-0.39
Helicopter Wt Z-dirn T						1.49	1.49	1.49	1	1
Ice load X-drin		0.46	-0.46				0.46	-0.46		
Ice load Y-drin				0.39	-0.39				0.39	-0.39
Ice load Z-drin	1.49	1.49	1.49	1	1	1.49	1.49	1.49	1	1
Green sea load	1	1	1	1	1	1	1	1	1	1
Wind FWD										
Wind AFT	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36	3.36
Wind SB										

Structural design and scantling check

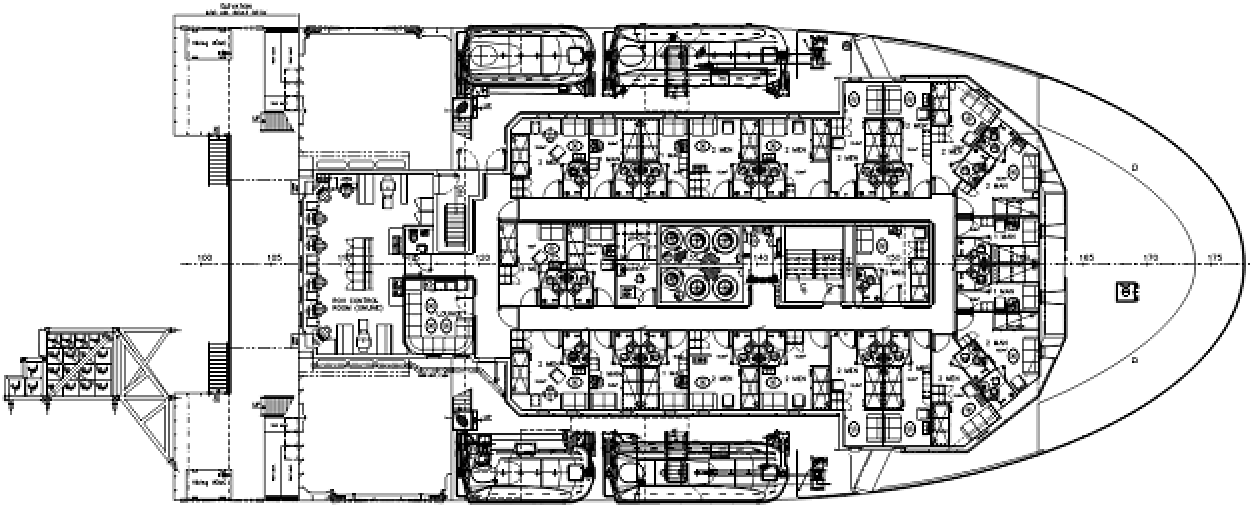
- Design concept
- Scantling requirements for plates, stiffeners and girders
- Materials
- Permissible stresses
- Structural model
- Aluminium and steel connection
- Buckling check

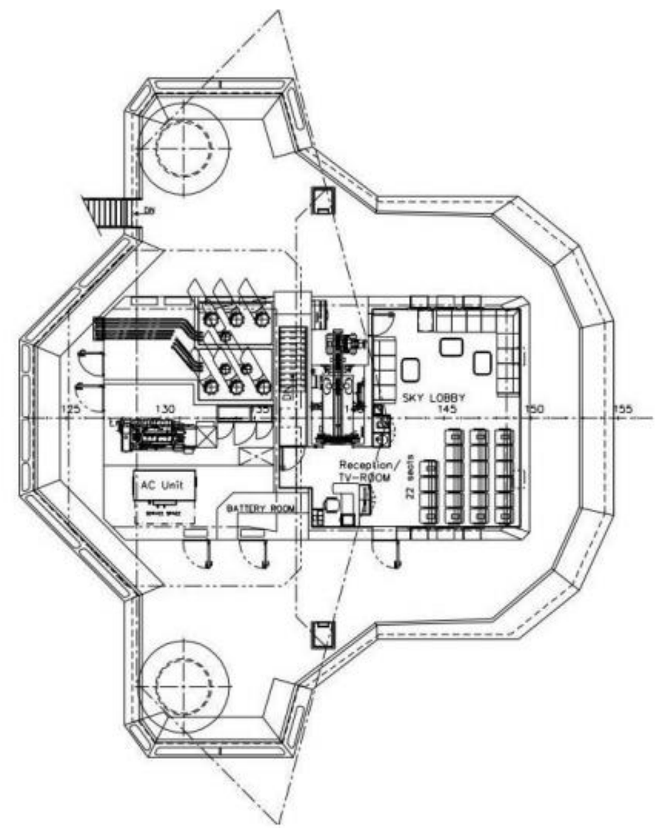
Design concept

- Space availability



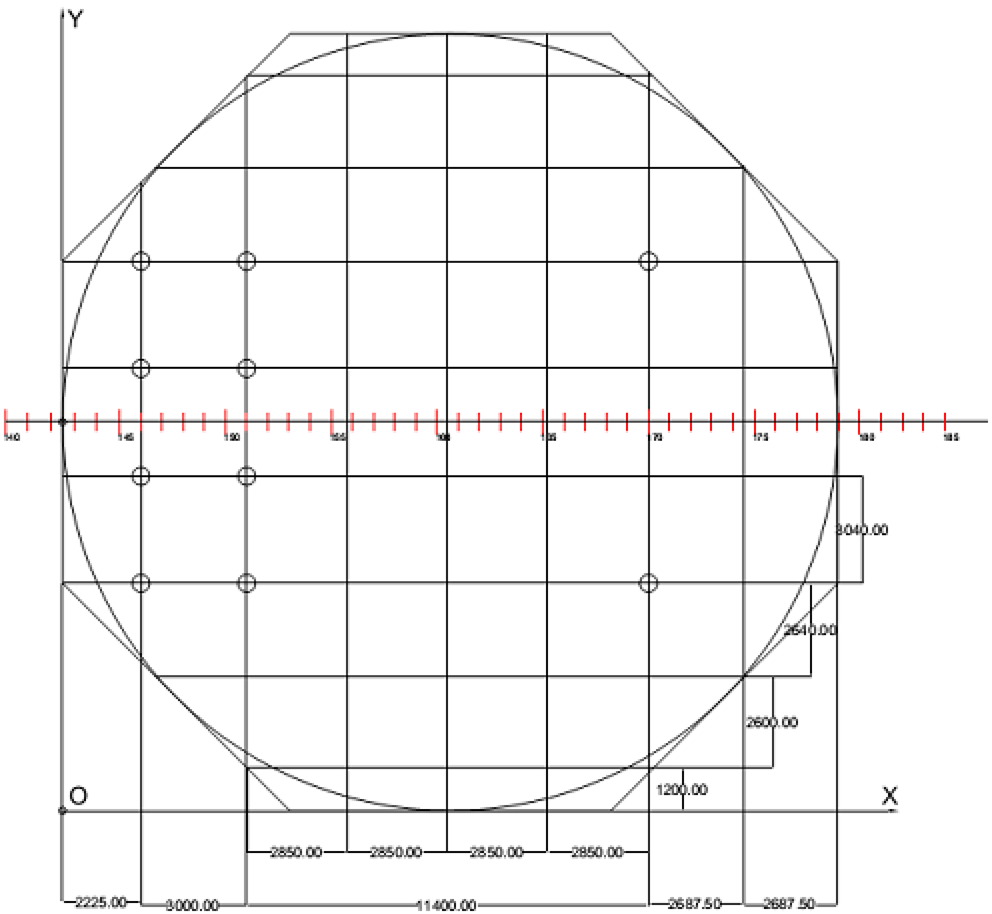
Design concept

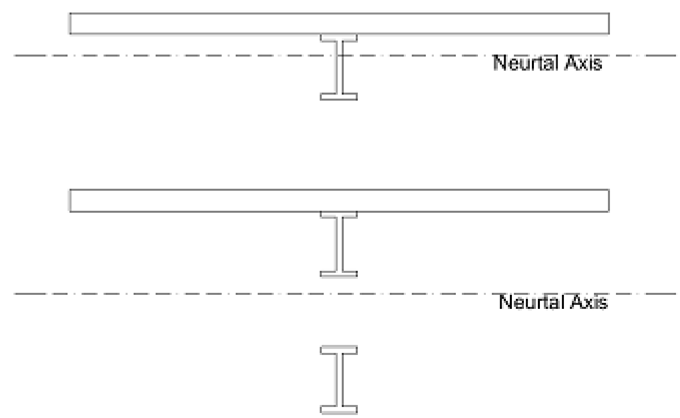




Design concept

- Support points chosen over ship's frames
- Distribute the beam spacing evenly





Plate, stiffeners and girders

Plate thickness $t = \frac{k\,(1+s)\sqrt{P_w}}{\sqrt{f_1}} + 1\ (mm)$

Section modulus of stiffener $Z = \frac{1.34.\,10^6 k_z labp}{m\sigma_f}(mm^3)$

Girders and supporting structures $\sigma_p = \eta_p \sigma_f$

Materials

Item	Grade	Yield Strength $R_{p0.2}$ / R_{eH} (MPa)	Tensile Strength R_m (MPa)
Deck Plate	NV 5083-H116	215	305
Stiffeners & Girders	NV 6082-T6, $t \leq 5$	250	290
	$5 < t \leq 50$	260	310
Lower structure	NV D36, (Steel)	355	440

Item	Grade	Yield Strength $R_{p0.2}$ (MPa)	Tensile Strength R_m (MPa)
Deck Plates	NV 5083-0	125	275
Stiffeners & Girders	NV 6082-T4	110	205

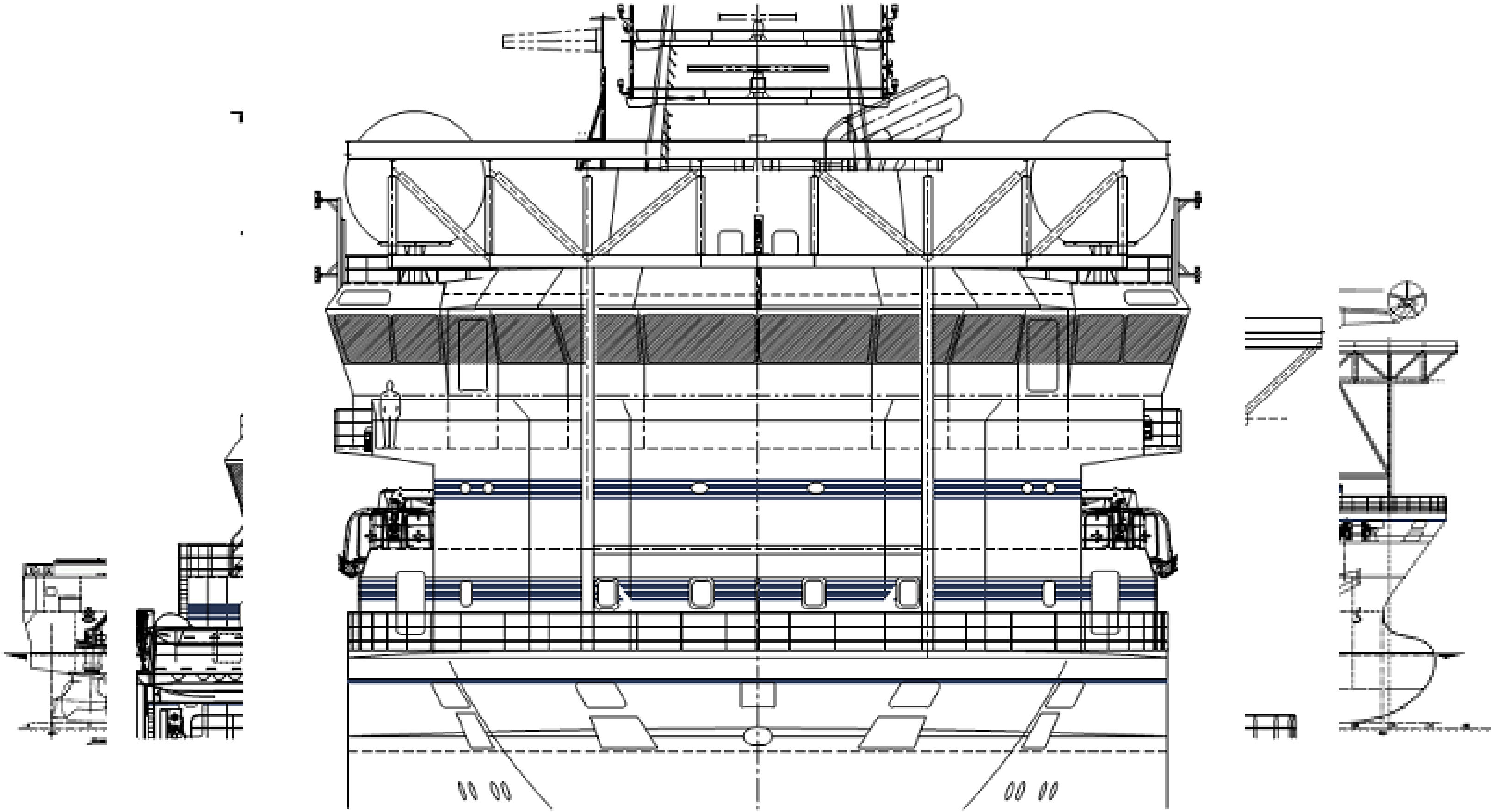
Permissible stresses

	Material	η_0	η_p	σ_p (MPa)
Landing	NV 5083-0	0.67	0.67	83.33
	NV 6082-T4	0.67	0.67	73.33
	NV D36	0.67	0.67	236.67
Stowed	NV 5083-0	0.8	0.8	100
	NV 6082-T4	0.8	0.8	88
	NV D36	0.8	0.8	284
Accidental Landing/Stowed	NV 5083-0	1.0	1.0	125
	NV 6082-T4	1.0	1.0	110
	NV D36	1.0	1.0	355

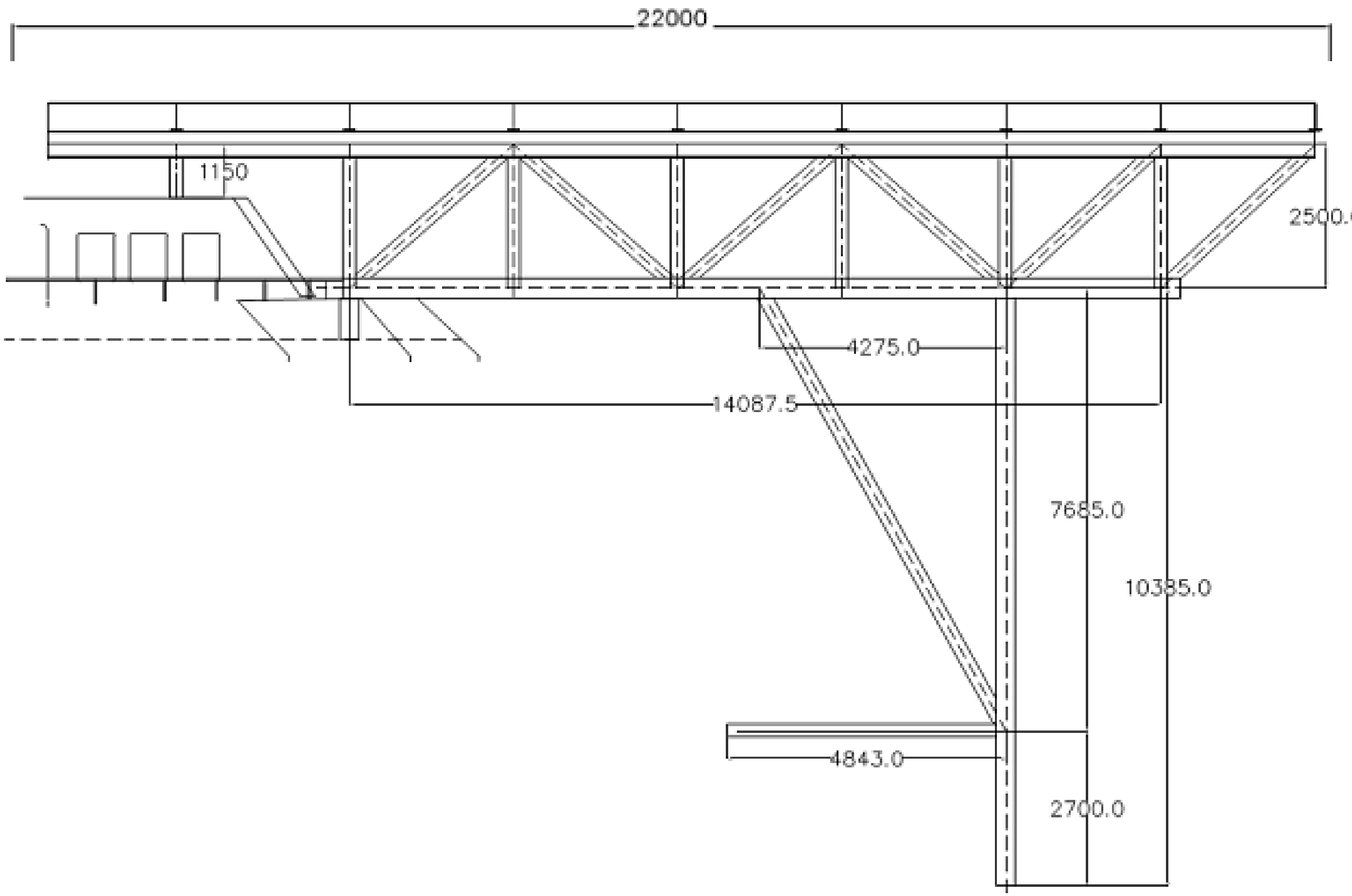
Structural model

Item	Mass [tonnes]	
Plate	13.1866	
Longitudinal Stiffeners	7.84226	
Upper transverse girders	6.03171	
Edge beams	0.977813	
Upper longitudinal girders	8.13636	
Short pillars	3.34023	
Main bracings	6.20608	
Lower longitudinal girders	3.76637	
Lower transverse girders	4.19544	
Pillars	6.58358	
Total	60.26644	
Centre of mass		
x [mm]	y [mm]	z [mm]
11529.6	11001	-1617.38

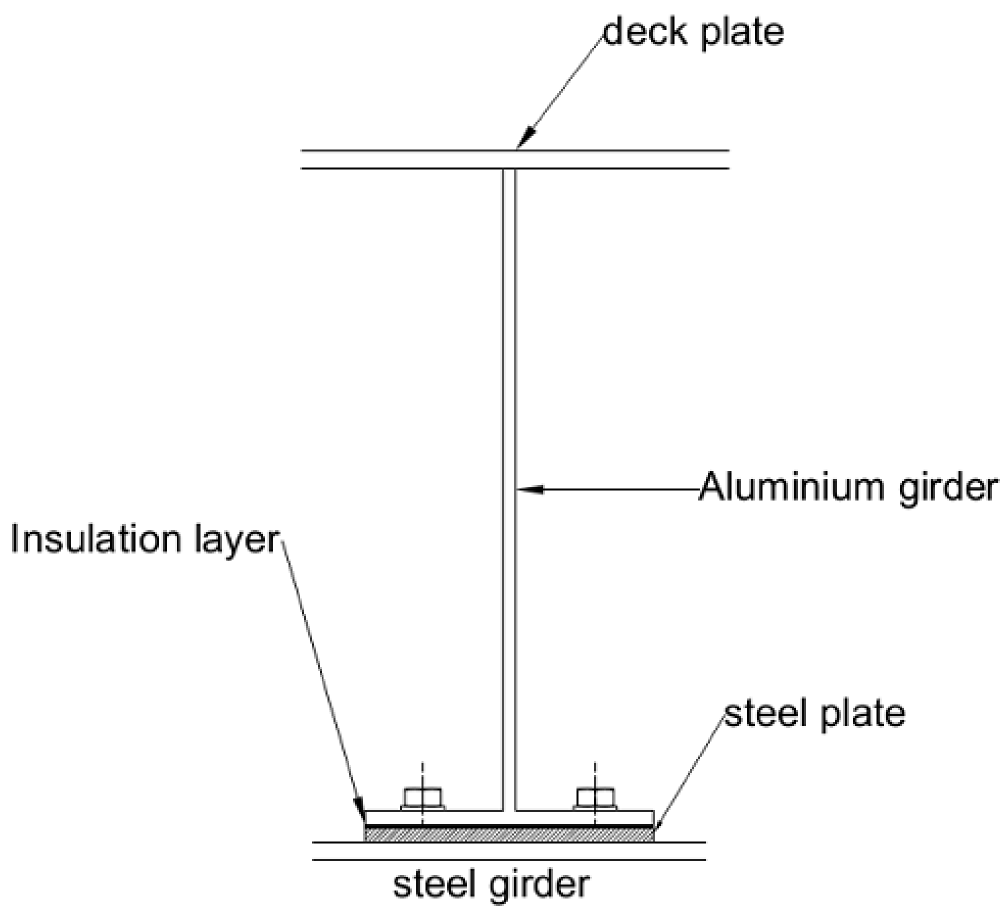
Drawings



Drawings



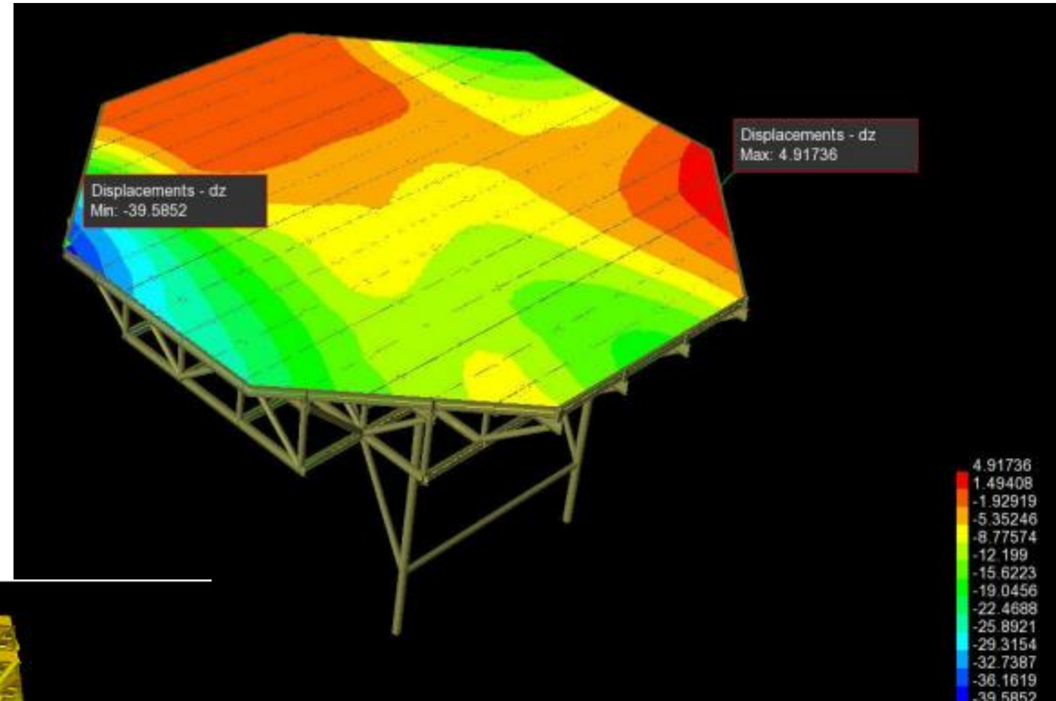
Aluminium to steel connection



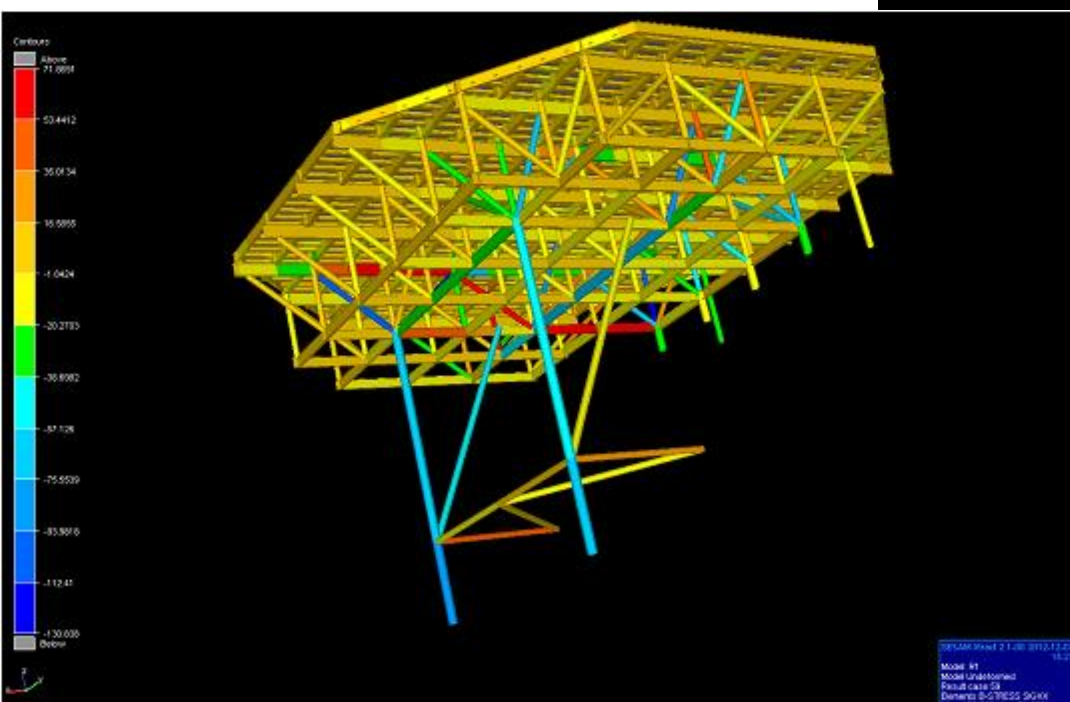
Results

- Normal stresses, shear stresses are checked.
- Normal stresses and axial forces are checked for slender members.
- Most of the maximum response occur under vertical and vertical+longitudinal motion conditions.

Results



Displacements - dz
Max: 4.91736
Displacements - dz
Min: -39.5852
4.91736
1.49408
-1.92919
-5.35246
-8.77574
-12.199
-15.6223
-19.0456
-22.4688
-25.8921
-29.3154
-32.7387
-36.1619
-39.5852



Contours
Above
Below

Conclusion

- Important to consider the material characteristics of aluminium alloys from the beginning of design process.
- Deck plate contributes large per cent of pancake structure and more efficient structure is possible by the use of special extrusion and connections.
- Section modulus of stiffeners required by rule is found to be conservative.
- Structural efficiency of pancake structure depends on proper arrangement of lower steel structures.
- Vertical motions can be assumed as most severe loading condition.
- Ice load is significant and de-icing equipment can be an option.

Recommendations

- Dynamic analysis of landing
- Wheel loading for aluminium panels
- Local analysis and detail FE models
- Optimization
- Design using extruded profiles

Thank you!