MASTER THESIS PRESENTATION

Global Response Analysis for Semisubmersible Offshore Platform

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CONTENTS

INTRODUCTION

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- Offshore Industry moving to the deeper and harsher environments in search of oil and gas resources
- Motion response of the Offshore Structure is a critical factor for a lot of operations and maintenance work
- Challenge to ensure the structural integrity of the offshore platform being capable of withstanding the impact of extreme environmental wave loading

OBJECTIVE

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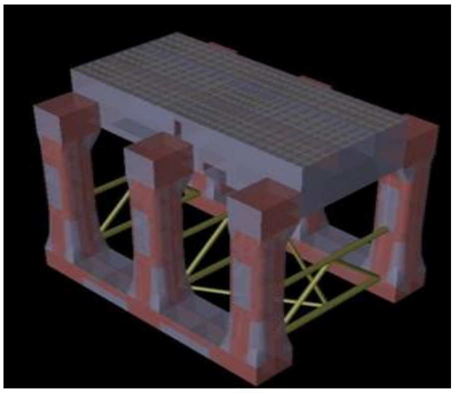
- To develop a global structural model of a case study semisubmersible platform
- Analyze of motions response of the platform
- Quantify the impact of extreme wave load on the offshore floating structure in terms of element average Von mises stress & identify critical structural regions



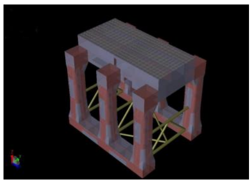
Parameters	Technical data
Length of pontoon	92.3m
Height of pontoon	8.45m
Width of pontoon	14.3m
Height (Deck Structures)	19.5m
Height of each Column Leg	52.5 m
Overall Width of the Structure	74.1m

METHODOLOGY

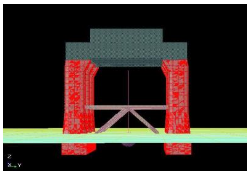
Approach

Software Tool Used

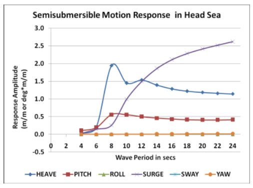
❖Global Structural FE Modelling of Beam & Shell Elements → **Sesam GeniE** →



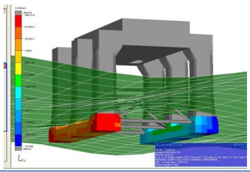
❖Hydrodynamic Analysis in HydroD(Wadam) → **Sesam HydroD** →



❖Post Processing Global Motion Response Variables → **Postresp** →



❖Post Processing Global Quasi Static Structural Strength Analysis → **Xtract** →



DESIGN CODES AND STANDARDS

DNV·GL	Det Norske Veritas (DNV) Offshore Standards	DNV-OS-C101 DNV-OS-C103 DNV-OS-C201 DNV-OS-C205 DNV-OS-C103
energy API	American Petroleum Institute(API) Offshore Standards	API RP 2A-WSD API RP 2FPS
standard.no	Norwegian (NORSOK) Offshore Standards	NORSOK -N-001 NORSOK -N-003 NORSOK -N-004
ISO	International Standard Organisation (ISO) Offshore Standards	ISO19901 ISO19902 ISO19904_1

ANALYSIS OVERVIEW : Structural Modelling

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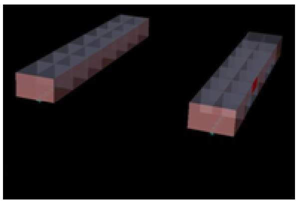
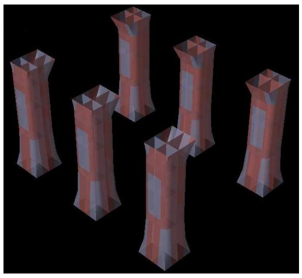
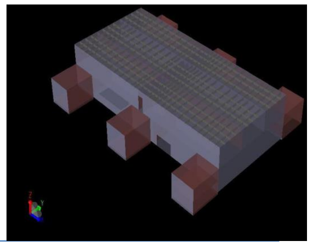
- ❖Global structural model made of combination of beam and shell elements representing the stiffness similar of the actual structure
- ❖Key sub-assemblies of the semisubmersible platform : Pontoons, Column, Deck & Bracing
- ❖Longitudinal stiffness of the pontoons, Stiffness of the braces in axial direction, Stiffness in vertical direction of the columns, Stiffness of the main bulkheads as well as the shear and bending stiffness of the upper hull
- ❖Modelling with the help of structural technical drawing provided by DNV Gdynia Office







ANALYSIS OVERVIEW : Structural Modelling

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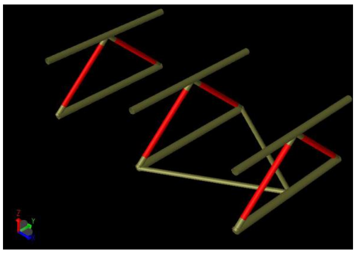
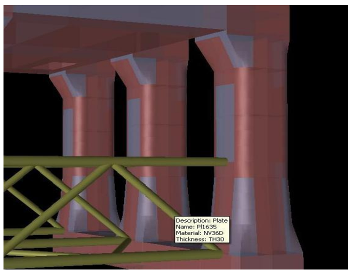
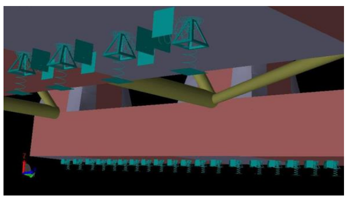
- ❖Simplified structural model
- ❖Local details such as brackets, buckling stiffeners, smaller cut-out like doors neglected
- ❖Bracing System modelled using pipe section with geometrical diameter and thickness
- ❖Connections between the upper hull/columns, column/braces and column/pontoons etc. are modelled along with bulkheads and decks frames as they are vital to the global stiffness
- ❖ Boundary condition as super nodes primarily with vertical spring stiffness to avoid stress concentration around support points







ANALYSIS OVERVIEW : Structural Modelling

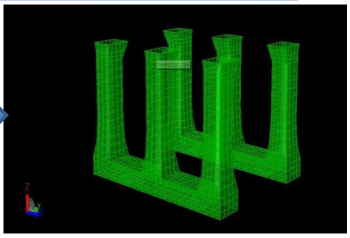
❖Finite Element Model of the Panel, Morison and Global structure required to set up the Global Response analysis

❖8-noded quadrilateral elements have been used for meshing the structure, 6-noded triangular elements have been used sporadically in areas

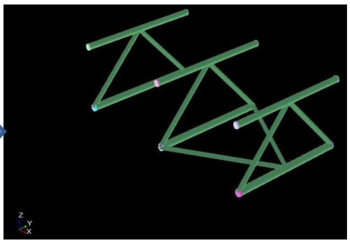
❖The structural model of the shell structures of pontoons, columns exposed to the water surface have been used for the panel model

❖The Morison model is a structural finite element model that consists of the cross bracing beam elements

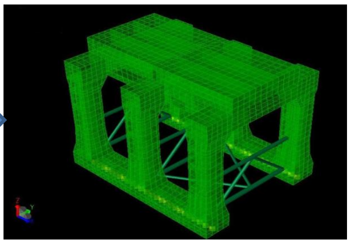
Panel Model



Morison Model



Structural Mesh Model



ANALYSIS OVERVIEW : Hydrodynamic Analysis Set up

❖Frequency domain analysis using the 3D potential theory program SESAM HYDRO-D Wadam

❖Hydrostatic calculations, in which the hydrostatic and inertia properties of structure are calculated

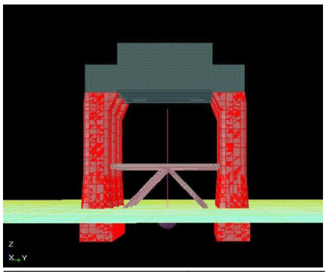
❖ Load calculations, in which the detailed pressure distribution on element level calculated is transferred to the structural FEM model for analysis

❖One set of wave loading and one mass distribution with the operating condition draft 13.33m analyzed.

❖ Wind & current loading assumed negligible

❖Semisubmersible analyzed as a free floating body, without considering effect of the mooring lines and risers on the structure response

❖Loading with no heel and trim of the platform



Parameter	Value
Mass Global Structure Model (in kg)	9.77×10^6
Buoyancy Volume (in m^3)	9.54×10^3
Centre of Buoyancy (x, y, z) (in m)	(0, 0, -3.52m)
Centre of Gravity (x, y, z) (in m)	(0.3, 0, -4.77m)
Radius of Gyration for Roll, Pitch, Yaw (x, y, z) (in m)	(36.6, 40.6, 48.13)

ANALYSIS OVERVIEW : Extreme Environmental Wave Loading

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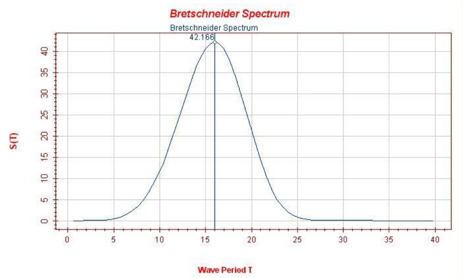
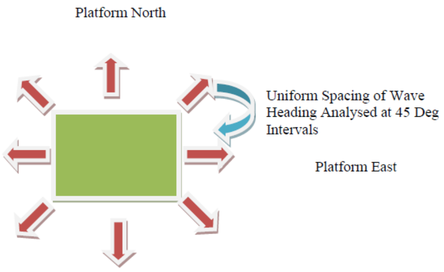
❖Design wave parameter selected for one of most extreme climates i.e. in the North Sea with 100 year return period
❖Water depth to be uniform 300 m
❖Sea state defined for 3 hour duration
❖Wave period/frequency applied 4 sec to 24 sec with an interval of 2 sec
❖8 Wave heading at regular interval of 45 deg considered with respect to the Platform
❖Wave spectrum was modelled as Bretschneider spectrum which is denoted as a 2 parameter Pierson-Moskowitz spectrum with the significant wave height being 13.6m and peak period being 16 sec



Met ocean parameter	Data
Return Period	100
Significant wave height (m)	13.6
Spectral peak period (s)	16



ANALYSIS OVERVIEW : Global Motion Response Analysis

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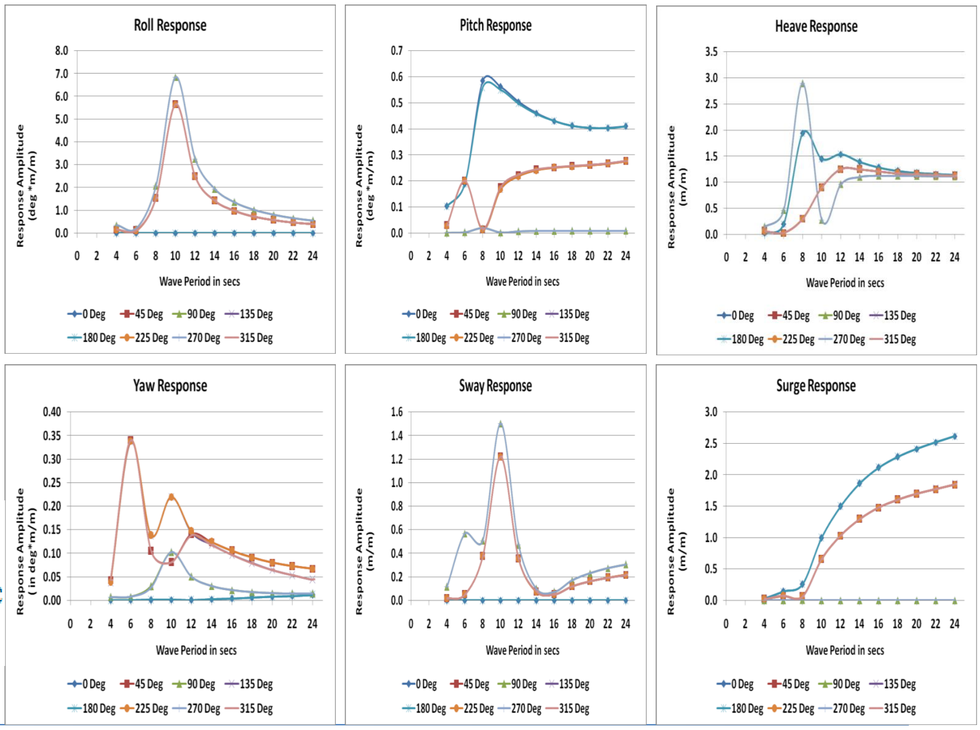
❖Response of the platform measured in terms of (RAOs) for the 6 DOF
❖The natural heave period resulting in resonance

$$Tn_3 = \frac{\sqrt{(M+A33)}}{\sqrt{(\rho * g * Aw)}} x 2\pi = 7.95 \text{ sec}$$



ANALYSIS OVERVIEW : Pressure Loading

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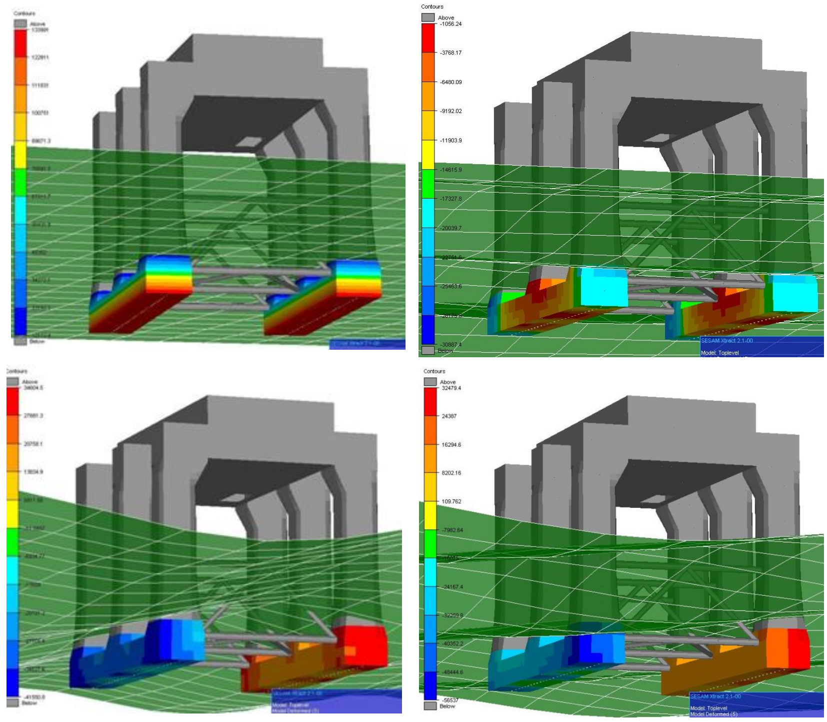
❖Hydrodynamic & hydrostatic pressure loading response of the platform

❖Pressure distribution on element level calculated is transferred to the structural FEM model



ANALYSIS OVERVIEW : Global Structural Response

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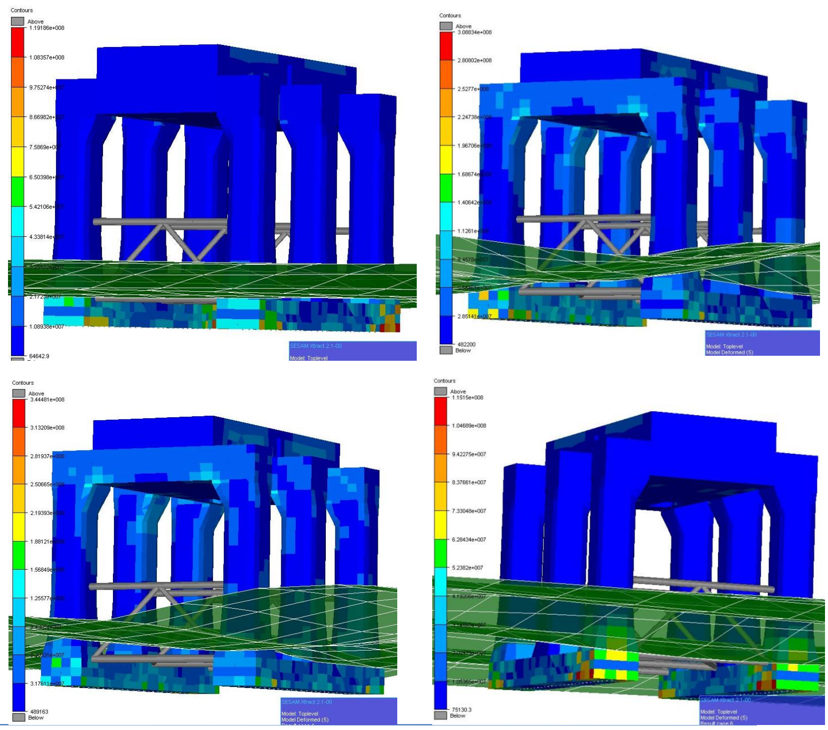
❖Hydrodynamic loads with mass inertia loads applied

❖Structural integrity checked based on shell von Mises stress

❖ULS-b limit state from WSD/LRFD synonymous with the present loading case & empirical formulation to quantify the environmental load contribution



ANALYSIS OVERVIEW : Safety Factor Concept

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Standards give two different strength design philosophies, the WSD (Workable Stress Design) or the LRFD (Load Resistance Factor Design)

LRFD

Combination of design loads	Load Categories		
	G	Q	E
ULS a	1.3	1.3	0.7
ULS b	1.0	1.0	1.3

G= Permanent Loadings
Q= Variable Functional Loads
E= Environmental Loads

$$((\Sigma\gamma_G G + \Sigma\gamma_Q Q + \Sigma\gamma_E E)) \leq\leq \phi Ru$$

γ= Load Factor,
ϕ= Resistance Factor
Typical Value for Steel Structure =1/1.15

WSD

Limit state	Action combination factor		
	Action category		
	G	Q	E
ULS a	1.0	1.0	-
ULS b	1.0	1.0	1.0

G= Permanent Loadings
Q= Variable Functional Loads
E= Environmental Loads

Loading Conditions	a)	b)
Usage factor	0.60	0.80

a) functional loads = Equivalent to ULS (a)
b) maximum combination of environmental loads and associated functional loads= Equivalent to ULS (b)

$$\Sigma G + \Sigma Q + \Sigma E + .. \leq Ru / FS$$

FS = Usage Factor

ANALYSIS OVERVIEW : Global Structural Response Results

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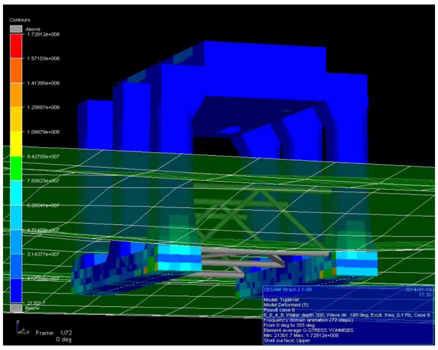
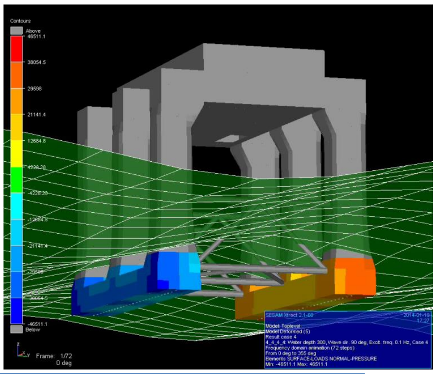
Wave Heading	Panel	Quasi-Static Structural Stress [MPa]	Yield Utilisation WSD	Yield Utilisation LRFD	Load Case Description
Head Sea (Wave 180 Deg)	Pontoon	115.55	0.41	0.49	6_4
	Column	62.84	0.22	0.26	6_4
	Deck	52.38	0.19	0.22	6_4
Following Sea(Wave 0 Deg)	Pontoon	119.19	0.42	0.50	2_4
	Column	65.04	0.23	0.27	2_4
	Deck	54.21	0.19	0.23	2_4
Beam Sea (Wave 90 Deg)	Pontoon	281.94	1.00	1.19	4_4
	Column	344.48	1.22	1.45	4_4
	Deck	156.84	0.55	0.66	4_4
Quarter Sea(Wave 135 Deg)	Pontoon	252.77	0.89	1.06	5_4
	Column	308.83	1.09	1.30	5_4
	Deck	140.642	0.50	0.59	5_4





$$UF_{WSD} = (\sigma v - m)/(\sigma y/1.67) * 1.33)$$

$$UF_{LFRD} = (\sigma v - m) * 1.3/(\sigma y/1.15\ )$$

CONCLUSION

❖Maximum stress due to wave induced loading occurs in frequency range (T= 8-10 sec, f = 0.125-0.1Hz). Result in accordance with theoretical behaviour of structure as the natural resonance period of motion response of the vessel lies in the same frequency range

❖Connection column/pontoons & bracing/column/pontoons have been found critical to wave loading. Worst case scenario in terms of stress distribution (344 MPa) to occur in beam sea

❖LRFD as compared to the WSD approach based on Von Mises Stress produces 16 % higher values for yield utilization in the structural elements for extreme environmental wave loading

RECOMMENDATIONS AND FUTURE SCOPE OF WORK

❖Global structural might have stress concentration caused by the modelling simplifications or lack of the local reinforcements

❖Detailed local non-linear finite element analysis recommended for precise information regarding structural strength in the critical zones

❖Case studies of different environmental loading scenarios including wind, current effects and effects of mooring lines/riser system would add considerable value to the global response analysis

❖Similar set of concepts could be used to perform the global response analysis on other types of offshore floating structures like TLP, Spars and FPSO etc

REFERENCES

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- ❖ A Deep Draft Semisubmersible with a Retractable Heave Plate by J. Halkyard, J. Chao, P. Abbott, J. Dagleish, H. Banon
- ❖Static and dynamic analysis of the Semisubmersible type floaters for Offshore wind turbine by C. Mayilvahanan and R.P. Selvam
- ❖Technical drawings of the Semisubmersible Platform by DNV Poland , Gdynia Office (Confidential)

Dziękuję Thank you धन्यवाद