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Master Thesis

Fatigue Analysis of Offshore Drilling Unit

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AGENDA

• Introduction
• Objective
• Methodology
• Analysis
• Conclusions
• Future Development
• Drilling extended further offshore into deeper water to access additional energy resources

• structures are largely exposed to stresses- induced by time variation- generated principally by sea waves

• Challenge to ensure integrity and structural safety of the offshore platform in extreme environment
- **Global Fatigue Analysis**
  - 3D FE- Modelling
  - Hydrodynamic Analysis
  - Structural Analysis
  - Identify Fatigue Critical Locations

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Technical Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristic Length</td>
<td>80.6 m</td>
</tr>
<tr>
<td>Height of Pontoon</td>
<td>7.5 m</td>
</tr>
<tr>
<td>Width of Pontoon</td>
<td>16 m</td>
</tr>
<tr>
<td>Height of Column</td>
<td>33.5 m</td>
</tr>
<tr>
<td>Diameter of Column</td>
<td>12.9 m</td>
</tr>
<tr>
<td>Height of Deck</td>
<td>8 m</td>
</tr>
<tr>
<td>Spacing of Columns</td>
<td>54.72 m</td>
</tr>
</tbody>
</table>

Analyzed Drilling Unit

OBJECTIVE


3D-Modelling
• Sesam-GeniE

Hydro-dynamic Analysis
• HydroD-Wadam

Global Motion Response
• Postresp

Structural Analysis
• Sestra

Global Fatigue Analysis
• Stofat
Key Sub-Assemblies: Pontoons, Columns, Deck and Bracing

Material: St52
Panel Meshed Model
- Wet Surface
- Potential Theory

Morison Meshed Model
- Beam Elements
- Morison Theory

Structural Mesh Model
- All structural Components
- Panel+Morison+Deck structure
Hydro-Model to compute Wave Loads

Analysis Setup

• Direction 0 to 315 with step value 45

• Period is set between 0.5 to 25 sec

• Bretshneider spectrum with $H_s=13.6\text{m}$ and $T_p=16\text{ s}$

• Design wave -North Sea with 100 year return period

• Spreading function of exponent 2 =short crested sea

• The water depth=$300\text{ m}$ and Operating Draft $13.5\text{ m}$
Structural design of a container ship approximately 3100 TEU according to the concept of general ship design B-178


GLOBAL MOTION RESPONSE

Peak Response Range $f = 0.041-0.047$ Hz or $T = 21-24$ sec

Worst direction – 270 and 180 degree

- Pitch RAO
- Heave RAO
- Roll RAO
- Surge RAO
- Sway RAO
- Yaw RAO
Load cases:

- Self-weight
- Equipment’s
- Hydrodynamic loads
- Mass points on Derrick
- Wind and current loads (negligible)

Critical Location: Pontoon-column connection (Max. Von-Mises Stress)
Spectral Fatigue Analysis

Inputs

- SN-Curve (DNVC-I)
- Scatter Diagram (North Atlantic)
- Response Spectrum

<table>
<thead>
<tr>
<th>Connections</th>
<th>Fatigue Life (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck to Column</td>
<td>Above 50</td>
</tr>
<tr>
<td>Column to Pontoon</td>
<td>Around 30</td>
</tr>
<tr>
<td>Column to Brace</td>
<td>Above 50</td>
</tr>
<tr>
<td>Deck to Derrick</td>
<td>Around 40</td>
</tr>
</tbody>
</table>
• Column to pontoon connections showed the worst fatigue life.

• The worst wave direction is found at 270 and 180 degrees.

• Maximum stress due to wave induced loading occurs in frequency range $f= 0.041-0.047$ Hz or $T= 21-24$ sec

• Heave is most significant motion response for the structure
• Analysis for local models can be performed

• More detailed non-linear finite element analysis and consideration of mooring lines & riser system can be done

• Other sources of excitation could be taken into account

• The effect of the weld can be considered
REFERENCES

• *Guidelines to Assess High-Frequency Hull Girder Response of Container Ships* by DNV-GL, 2014

• "Analysis and Design of Ship Structure”, Chapter 18, Philippe Rigo and Enrico Rizzuto

• “Probabilistic Fatigue of offshore structures”, G. Sigurdsson, University of Aalborg, Sohngaardsholmsvej 51, DK-9000 Aalborg, Denmark
THANK YOU