Some geotechnical aspects of jack-up site assessments
Subsea UK Networking Event – 17th January 2017
Great Yarmouth
Introduction to Jack-up, Geotech and Metocean Team

We are:

- Part of Noble Denton marine services
- Based in London with a ‘satellite’ team in Singapore
- 23 engineers (7 geotechnical + many more)
- Combined >110 years of experience
- Primarily focused on
  - Providing engineering basis/support for Jack-up Location Approvals
  - Jack-up site-specific assessments
  - Advanced engineering and geotechnical consultancy for jack-up installations and operations
  - Geotechnical consultancy for Oil & Gas and renewables projects
Introduction to Jack-up, Geotech and Metocean Team

- Deep and broad expertise:
  - Structural engineers
  - Mechanical engineers
  - Geotechnical engineers
  - Metocean engineers
  - Mariners and warranty surveyors
  - Naval architects

- We use our combined ingenuity to overcome challenges and provide smart solutions and a positive outcome wherever possible.
Actively participate in latest developments

We are / have been involved with:

- Development of the SNAME Recommended Practice for Jack-ups
- Development of the ISO Standard for assessment of Jack-ups
- Benchmarking and ‘Go-by’ document for the ISO Standard
- Development of forthcoming DNV Recommended Practice: RP-C-212 “Offshore soil mechanics and geotechnical engineering”
- Chairing the ISO Standard for jack-ups going on and off location
- Updating RenewableUK Guideline for Windfarm Jack-up Operations
- InSafeJIP
- Spudcan-footprint interaction JIP
- Providing training courses to jack-up organisations, rig owners and operators
Geotechnical analysis for jack-ups

- Jack-ups are supported by spudcan shallow foundations
- Spudcans can penetrate into the seabed to significant depths
- We calculate:
  - Penetrations that will occur during installation
  - Foundation Capacities
  - Foundation Stiffnesses
  - Force required to extract spudcans from the seabed
Geotechnical analysis for jack-ups

**Punch-through failure**

- Occurs during installation
- Significant vertical footing penetration occurs very quickly
- Caused by spudcan pushing on a strong layer over weaker layer
- Can cause serious damage and even loss of jack-up unit
Expected spudcan tip penetration = 1.8m (6ft).
Range = 1.7m (6ft) to 8.3m (27ft)

Risk of rapid spudcan penetrations

Spudcan stillwater reaction
Spudcan preload reaction
Expected spudcan tip penetration = 1.8m (6ft).
Range = 1.7m (6ft) to 8.3m (27ft)
**Good seabed data**

**Seabed information should comprise:**
- Recent bathymetry and debris survey
- Shallow seismic survey geophysical site survey
- Geotechnical borehole to an adequate depth (and Cone Penetrometer Tests?)
- Number of boreholes depends on potential for lateral soil variability
- Loads, penetrations and locations of previous rig installations

**What constitutes good quality data?**

Please refer to our Guideline ST-N002: "Site specific assessment of mobile offshore units for marine warranty”

Free to download from: [https://my.dnvgl.com](https://my.dnvgl.com) using the DNVGL Noble Denton marine services warranty standards wizard.
### Geotechnical risks for jack-ups

- We check the seabed conditions for risks, such as:

<table>
<thead>
<tr>
<th>Risk</th>
<th>Risk</th>
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<tbody>
<tr>
<td>Punch-through</td>
<td>Boulders</td>
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<tr>
<td>Scour</td>
<td>Unexploded Ordnance</td>
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<td>Squeezing of clay layers</td>
<td>Buried channels</td>
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<tr>
<td>Lateral variability of soil layers</td>
<td>Uneven rock</td>
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<tr>
<td>Spudcan footprints</td>
<td>Pipelines / cables</td>
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<tr>
<td>Seabed slopes / unevenness</td>
<td>Spudcan-pile interaction</td>
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<tr>
<td>Shallow gas</td>
<td>Leg extraction problems</td>
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<td>Rack phase differences (RPDs)</td>
<td>Limited penetration / fixity</td>
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<tr>
<td>Insufficient bearing capacity</td>
<td>Debris</td>
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<td>Deep spudcan penetrations (insufficient leg length)</td>
<td>Insufficient sliding capacity</td>
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Seabed analysis

- 24/7 review of soil data as it’s acquired
- Review of seabed geohazards – buried channel features, slopes, etc.
- Spudcan-footprint interaction
- Seabed scour assessments
- Spudcan-slope interaction
- Spudcan-pile interaction
- Spudcan-quayside interaction
- Punch-through survivability
- Seabed remediation/modification advice

SAND

CLAY
Seabed analysis

- ABAQUS geotechnical FE analysis of:
  - Punch-through capacity,
  - foundation stiffness and capacity,
  - skirted spudcans,
  - mat foundations, etc.

- Correct failure mechanism modelled in layered soils
- More refined estimate of safe foundation load compared to design code equations
Seabed analysis

- ABAQUS geotechnical FE analysis of:
  - Punch-through capacity,
  - foundation stiffness and capacity,
  - skirted spudcans,
  - mat foundations – all kinds of foundations
Other Geotechnical Projects

- 3rd Party and Independent technical reviews
- Pile driveability and axial capacity
- Pile and/or oil well conductor lateral capacities and p-y springs
- Anchor and anchor chain assessments
- World-leading expertise in drag-embedment anchors in clay
- Slope stability issues
- Seabed remediation and modification
- Dredging and underwater excavations
- Foundation capacity reliability

All the methods and expertise you have seen here for jack-up foundations can also be applied to all kinds of foundations
Thank you for your attention

David Edwards
david.edwards@dnvgl.com
+44 203 816 4603

www.dnvgl.com

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