OIL & GAS

Site-Specific Assessment Analysis of Jack-Ups
Part 3: Key Features of an SSAA

Noble Denton marine services

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Overview

- Key Features of an SSAA.
  - Data gathering.
  - Site overview.
  - Geotechnical site investigation & spudcan penetration prediction.
  - Metocean data.
  - Geometry check.
  - Crunching the numbers.
  - Results.
  - Site-assessment “issues”.

- Topics that should be addressed in design.

- Some conclusions.
Data Gathering

- **Rig data:**
  - Be sure to have current “as-built” data.
  - Any deviations from MOM w.r.t. VDL and/or CoG?

- **Oil Company requirements:**
  - Airgap.
  - Position w.r.t. any existing infrastructure & jack-up rig heading.
  - Season.

- **Location Data:**
  - Bathymetry.
  - Geophysical.
  - Geotechnical.
  - Metocean.
  - Heading.
  - Infrastructure details.
Site Overview – Shallow Seismic

- Problematic shallow seismic

![Diagram of shallow seismic with labeled features such as possible pockmarks, proposed location, Forties C - Cruden Bay Pipelines, seabed, base laminated unit, Swatchway Fm?, base transparent unit, Coal Pit Fm?, near base Swatchway Fm., possible coarse deposits, and survey fix marks.](image)
Site Overview – Lateral Variability

Don’t forget to think about:

- The stand-off location.
- Footprints (which may be in-filled with sediment or buried beneath a weak layer).
- Seabed scour.
- Leg extraction.
Site Overview – Shallow Seismic Is Not Enough

These guys relied on geophysical data alone (Western Australia, 1996).

It was also their last time! – now they always obtain borehole data.
Site Overview – Footprints

- Can occur in sand or clay.
- May be visible on surface.
- May have been infilled – check for previous jack-up installation history.
- Infill may indicate a scour location.
- Avoid footprints or plan mitigations.
Operators can help (or hinder):
- Jack-up/spudcan-friendly position.
- Exploration footprints will not interfere with development footprints.
- “Friendly” approach face with no protrusions - cranes, etc., clear of cantilever.
- Piles & pipelines clear of spudcans.
- Wells reachable without over-tight positioning tolerances and platform clearances.
- Arrange rig program so that installation at more challenging locations is in more favourable season.
Site Overview – Other Issues

- Sand waves / slopes → seabed scour, eccentric spudcan support.
Spudcan Penetration Prediction (1)

- Ensure sufficient number & depth of boreholes/CPT’s & tests, e.g., per ISO Annex D / InSafe JIP.
- Get geotechnical experts to do load-penetration analysis to verify those of the site investigation contractor (if they did them).
Spudcan Penetration Prediction (2)

SAND over CLAY

Potential for rapid spudcan penetrations. Predrive cautiously.

SAND/CLAY layers

Potential for rapid spudcan penetrations. Predrive cautiously.
Metocean Data

- Seasonal data is permitted for short-duration operations.
- Directional data is permitted:
  - At open locations this allows the potential for optimising the jack-up heading.
  - At platform locations it may be possible to select the optimal face.
  - In most cases some benefit will be gained unless the worst weather is aligned with the most critical approach direction for the jack-up.
- The wind used is 1-minute mean (others, e.g., API use longer averaging period for global loading).

NOTE: ISO allows use of 50-year independent extremes with LF=1.15, or 100-yr joint-probability with LF=1.25.
We now (should) know:
- Max. predicted spudcan penetration.
- Water depth.
- Airgap (min. or per client).
- Distance keel to top upper-guide.

So … we can check that the legs are long enough.

When things are marginal, it is important that that max. predicted spudcan penetration is accurate.
Crunching the Numbers (1)

Environmental load calculations should account for:

- Chord-shape-specific $C_D$s & effect of marine growth on leg drag (12 mm default).

Can use equivalent $C_D$ for simplified model:

$$C_{Dei} = \left[ \sin^2 \beta_i + \cos^2 \beta_i \sin^2 \alpha_i \right]^{3/2} C_{Di}$$

Figure 4.4: Split tube chord and typical values for $C_{Di}$

Figure 4.5: Triangular chord and typical values of $C_D$

Figure 4.2: Flow angles appropriate to a lattice leg (after DNV Class Note 31.5, February 1992, [6])
Crunching the Numbers (2)

- Max and Min VDL levels and associated ranges of CoG in storm case (beware locations where the metocean will not trigger storm mode: in such cases the assessment must use operating mode VDL and CoG.) May be able to specify weight and CoG to optimize the results – but this must be properly documented and operationally enforced.

- Include drilling loads when applicable.

- Dynamic amplification for the predicted foundation spudcan fixity. Avoid wave-force cancellation and reinforcement effects.

- Consider range of penetrations & associated fixity where the UB-LB difference is significant.
Crunching the Numbers (3)

- Typically run as a 2 or 3-stage analysis:
  - **Stage 1** – Dynamics: Determine DAF’s from time-domains simulations using linearized foundation rotational (and vertical and horizontal) stiffness.
  
  - **Stage 2** – “Global Quasi-Static Analysis” Run same model with:
    - Inertial load-set for DAF’s from Stage 1.
    - Wind & wave-current loads (higher order wave theory).
    - Large displacement (P-delta) effects.
    - Degrading rotational foundation stiffness.
Crunching the Numbers (4)

- **Stage 3** – Leg Strength Analysis
  
  Apply critical loadings to detailed model of leg-to-hull interface.

- A one-stage approach is permitted, but more complex and less consistency between analysts. ISO provides better guidance than SNAME.
Numbers Crunched – Results (1)

- Given all that we have just done, we can report:
  - Predicted spudcan penetration range.
  - Leg reserve.
  - Preload utilization (but bearing check rules).
  - Overturning utilization.
  - Foundation checks – often the most critical.
  - Leg and holding system strength.
Numbers Crunched – Results (2)

- Foundation checks – often an issue ..... Step 3 Displacement check:

- What is the outcome?
Site Assessment “Issues”

- Jack-up is more a mechanism than a structure.
- Flexible, therefore susceptible to:
  - Large displacement effects.
  - Dynamic response.
- Economics dictate that jack-ups are pushed to the limit.
- Time available is often limited.
- Getting the necessary (quality of) foundation data.
- Previous jack-up operation does not guarantee future success.
## Site Assessment “Issues” – Past Experience

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<th>Spudcan area (m²)</th>
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Ungraded
Topics that Should be Addressed in Design (1)

- Practical Operability.
  - Enhanced preload capacity.
  - Reserve jacking capacity.
  - Effective spudcan jetting systems.
  - Practical limits for going-on and off location.
  - Center of buoyancy compatible with transit LCG.
  - Marine outfitting.

- Accidental Load-Cases.
  - Resilience against leg sliding / settlement / punch-through.
  - Supply-boat impact.

- Abnormal Load-Cases.
  - Earthquake (including cantilever & substructure hold-down, etc.).
Topics that Should be Addressed in Design (2)

- Practical Operability.
  - Enhanced preload capacity – (almost) ALWAYS A WINNER. Buys:
    - Enhanced foundation load capacity.
    - Therefore improved spudcan fixity.
    - Don’t use it when not needed.
Topics that Should be Addressed in Design (3)

- Practical Operability.
  - Reserve jacking capacity.
    - Improves the chances of getting out of trouble.
    - But .... without proper guidance can result in bad practice.

- Spudcan extraction.
  - Sufficient number and good placement of jetting nozzles that do not block easily and that are cleared before installation.
  - High flow generally more important than high pressure.
  - Hull needs sufficient freeboard to develop required “pull”.
Topics that Should be Addressed in Design (4)

- Practical Operability.
  - Practical limits for going-on and off location.
  - Single limiting wave height and period over-restrictive – need curve of allowable $H_s$ vs. $T_p$, e.g.:
Topics that Should be Addressed in Design (5)

- Practical Operability.
  - Centre of Buoyancy (CoB) compatible with transit LCG.
  - Unless the transit CoG and the hull CoB are aligned, time can be wasted adjusting the CoG when the hull is being lowered into the water.
  - If not done carefully, there is potential for pinion overload or severe trim.

- Accidental Load-Cases.
  - Resilience against leg sliding / settlement / punch-through / boat impact.
  - These events and “abuse” do happen.
  - Ensure that the leg can sustain resulting load levels.
  - Ensure can still jack without causing damage.
Topics that Should be Addressed in Design (6)

- Abnormal Load-Cases.
  - Seismic (earthquake) rating - including cantilever & substructure hold-down, etc.
  - ISO 19905-1 includes earthquake provisions.
  - Some Oil Companies have required they be applied.
  - Not yet required by London insurance underwriter.
  - Some evaluation required for Norway and UK.
Conclusions

We have reviewed the following.

– Data gathering for jack-up and site.
– The site overview.
– Geotechnical site investigation and spudcan penetration prediction.
– Metocean data.
– Geometry check.
– Crunching the numbers.
– The outputs.
– Some site assessment “issues”.
– Some aspects that should be considered in the design process.