Geotechnical considerations throughout the entire project lifecycle: from perception to execution

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Equinor: shaping the future of energy

«We aim to be the world's most carbon-efficient oil and gas producer, and are investing actively in renewables.»

Turning natural resources into energy for people and progress for society
How can we ensure that considerations do not become challenges?

challenge = unidentified risk
The Compliance and Leadership model
The Compliance and Leadership model

CONTINUOUS IMPROVEMENT

A - STANDARD
- Understand task and risk
- Understand requirements and expectations
- Manage risk
- Execute
- Extract learning

INTERACTION

LEADERSHIP
- Be a visible leader and role model. Set direction, observe and support
- Train and empower your team
- Take full accountability for the desired result and secure continuous improvement

TASK

DESIR ED RESULT
Project Lifecycle: «The Capital Value Process»

Prospect

- DG0: Business identification
- DG1: Business planning
- DG2: Concept planning
- DG3: Definition
- DG4: Execution
- DG5: Operation

Early Phase

- DG2: approval to start Front-End Engineering and Design (FEED) based on selected concept

Engineering

- DG3: project sanction
Early Phase: Understanding the Soil

• “Memory”: the soil response depends on the geological and man-made past (has it been loaded before? decreased porosity and water content)

• “Mood”: the soil response depends on how we treat it and load it (how much drainage is expected)

• “Temper”: it is possible to trigger an unexpected failure if the bigger picture is not well understood (regional geology)

• Important to perform a good quality soil investigation to assess the above and construct a ground model that presents the complete picture
Early Phase: Geohazards

- Pore pressure modelling
- Slope stability
- Shallow gas and other drilling hazards
- Earthquakes
Desktop Study

- Information sources typically available during the desktop study phase for a new project development in a mature area (e.g. North Sea):
  - Geological setting
  - Preliminary geophysical information
  - Geotechnical information from the larger development area
  - Installation experience
Desktop Study

- Information sources typically available during the desktop study phase for a new project development in a new area (e.g., Tanzania):
  - Geological setting
  - Preliminary geophysical information
Early Phase: Soil Investigation Scope of Work Definition

“The scope of work for the ABC Development Area soil investigation consists of:

- A detailed soil investigation at TEMPLATE X where geotechnical information is required for foundation design purposes
- Optional soil investigation at an additional template location
- Optional soil investigation for an UnMannedWellhead Platform
- Pipeline routes between the new template locations and existing infrastructure to determine pipe soil interaction properties and to assess trenchability”
Early Phase (and beyond): Operations

- Selection of geotechnical drilling equipment:
  - Remoteness
  - Water depth
  - Expected soil conditions
  - Potential geohazards

- Design and selection of foundation concept
  - All of the above
  - Installation / penetration
Early Phase: Soil Investigation Challenges / Lab Testing Considerations

Early Phase: Lab Testing

- Worldwide Offshore Database
- Dogger Bank

Loss of memory

100 data pairs - 30 sites worldwide
Engineering: Natural Variability

Distance: 3m
Engineering: Natural Variability

- Data from boreholes kilometers apart in a completely different geological setting
A Moving Target?

Facilities layout updated once the subsurface information is further matured.
Execution: What you see is not what you get!

*Top up: the farm’s 100 turbines were erected in just 200 days*  
Photo: Vattenfall
What you see is not what you get!

- Natural erosion of the seabed due to scour
3.3m thick clay layer present at 8.7m BML which could cause differential leg settlement

WARNING:
- Scour induced settlements should be expected for shallow embedded legs

Footings Installation Load
- Anticipated Installation Behaviour
- Possible Reduction of Bearing Capacity due to scour (conservatively low - requires further consideration)

3.3m thick clay layer present at 8.7m BML which could cause differential leg settlement

WARNING:
- Scour induced settlements should be expected for shallow embedded legs

Footings Installation Load
- Anticipated Bearing Capacity - as Installed Behaviour
- Anticipated Bearing Capacity - with Subsequent Scour
What you see is not what you get!

• Manmade erosion of the seabed due to drilling
What you see is not what you get!

- Manmade erosion of the seabed due to drilling
ISO 13628-15:2011 Subsea Structures and Manifolds

5.5.2 Requirements

5.5.2.1 General

The foundation design should be able to withstand loads from tie-in of flowlines, spool-pieces, pipelines, umbilicals and other flowlines. For templates, all such loads should be accommodated prior to drilling and completion.

A system for measuring well growth and settlement should be considered based on project requirements.

Erosion/washout due to drilling should be accounted for in the design. If the distance between foundation and the well is short and soil conditions are sensitive to erosion/washout, 25% of the circumference of one foundation should be considered eroded when drilling through the same conductor (i.e. 25% of outer skirt area).
The reis however one consideration which will always remain a challenge...

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