ISSMGE TC209 Workshop on Challenges of Offshore Geotechnical Engineering 25 September 2019 Bodrum - Turkey
Offshore Projects

- Transportation Projects
  - Railway Projects
  - Highway Projects
- Pipeline Projects
  - Water transmission
  - Oil and Gas Pipelines
- Oil and Gas offshore platform
- Port, Jetty and Break Water Projects
- Offshore Wind Farms
Owner’s Goals

- Reduce project related uncertainties;
- Reduce bid contingencies;
- Reduce schedule and cost risks;
- Provide a robust bid basis to contractors;
- Facilitate project financing.
Project Challenges

What are the surface/subsurface conditions
What are the primary geohazards

Deep Soft and Liquefiable Soils Present At Site?
Integrated Site Characterization

Work Sequence

1. Existing Information/ Desktop Study
2. Area-wide Bathy / Geophysical Surveys
3. Develop and Execute Project-Specific Geotechnical Exploration Program
4. Data Integration and Interpretation
5. Project GIS database
6. 3D Model of the Subsurface
Bathymetric and Geophysical Surveys
Bathy – Geophysical Surveys

- Bathymetry – Multibeam Echosounder (MBES)
- Seabed Features - Side Scan Sonar (SSS)
- Buried metallic objects (UXO, cables, etc.) - Magnetometer
- Shallow Stratigraphy – Sub-bottom Profiler
- Deeper Stratigraphy – Ultra high Resolution Seismic (Multichannel Seismic Survey)
Bathy – Geophysical Surveys

Multi-channel Seismic

Side Scan Sonar
Magnetometer
Pinger SBP
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Bathy – Geophysical Surveys
Bathy – Geophysical Surveys

- Multibeam Echo Sounder
- Side Scan Sonar
- Laser Line scanner
UHR Seismic Reflection Geophysical Survey

Different sources: Boomer, Sparker, Airgun, Chirp
Different Receivers: single/ multi channel/ digital/ analogue

Ultra High Resolution

Sub Bottom Profiler
Geotechnical Investigations
Geotechnical Survey - Vessels

Dynamically Positioned (DP2) Vessels

Semi-Submersible Drilling Vessels

Jack-ups (Lift-Barges)
Seacalf: Seabed CPT
- Continuous data
- Maximum depths 40m depending on water depth and ground conditions

Wison XP : Downhole CPT/ undisturbed sampling
- Discontinuous data – 3m strokes
- Much higher penetration depths
- Alternation between in situ testing and sampling
Geotechnical Survey – Drilling

Piggyback Drill on Roosterbox

Wireline deployed Geobor S core barrel

Bit Guide

Mudline

Wireline Core Barrel Recovery System

Soil – gravel, sand, silt or clay

Bit Guide

Rock Head

Bedrock

Drill

Geobor S Core Barrel

Drag Bits

Roller Bits

Full Face Bits
Geotechnical Survey – In situ testing

Marine CPT
- Downhole and Seabed Techniques
- Isolation from Vessel Movement
- Superior Penetration Capability
- High Production Rate

sleeve friction
pore water pressure
cone tip resistance

In situ Shear Vane Test

reaction blade
shear blade
Geotechnical Survey – In situ testing

Seismic CPT – S wave velocity profile

P-S Suspension Logging
Onboard Core Logging and Laboratory Testing

**Onboard Soils Testing Laboratory:**

- expedites investigation results
- improves quality of test results, and
- provides real time QC of drilling program
Application of Standard Land-based Techniques Can Result in Underprediction of Shear Strengths by on the order of 25 to 50 percent!
Comparison of Computed Pile Capacity Standard “Land” vs “Marine”
Skyway Foundation:
- 28 Footing Locations
- 160 piles

The savings decrease in pile length alone exceeds the additional costs for the offshore SI
Site Investigation Challenges

- Site Conditions
  - Boat Traffic (Bosporus, Çanakkale Straits)
  - Currents
  - Weather
  - Shallow Gas
  - Seabed Conditions (UXO, Cables, Shipwrecks etc)
Site Investigation Challenges

- Logistics - Multidisciplinary projects, work sequence limitations
- Schedule - Very tight schedules especially for BOT and EPC projects.
- Costs - High costs due to mobilization and using most modern techniques and equipment. High returns due to saving time and obtaining good quality data.
Site Characterization
Integrated Site Characterization

Available Information:

- Geology of the Project Area
- Bathymetry (MBES, SSS)
- Geophysics (UHRS, SBP)
- Geotechnical Survey (Downhole Drilling/ Sampling and Testing, Seabed CPT, Seismic CPT)
- Borehole Geophysics (P-S Logging)
- Laboratory Tests (Onboard and in external Laboratories, conventional and advanced)

A very large GIS database that allows synthesis, comparison, analyses and output of the data.
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Integrated Site Characterization - Stratigraphy
Integrated Site Characterization
Integrated Site Characterization – Engineering Properties

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Integrated Site Characterization – Engineering Properties

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Geohazards
Geohazard Identification - Faults

- Area of No Recognized Faulting
- Tertiary Deformation Zone
- Secondary Fault Zone
- Primary Fault Zone

Notes:
1) Line BM417 is approximately 3.5km south of Hanuk Peninsula.
2) Faults are interpreted only to depth of seafloor multiple reflection except at north end.
3) Hole in faulted channel and inactive fault.

Legend:
- Blue = Seafloor
- Violet = Base of buried channel
- Red = Seafloor Multiple Reflection
- Red = Interpreted fault
Geohazard Identification – Slope Instabilities

Northernmost Headscarp

Linear features possibly associated with slumping

Base of Disturbed Sediments
Mega Offshore Projects in Turkey

- Izmit Bay Bridge – 3000m long suspension bridge spanning the plate boundary between the Anatolian and the Eurasian plates (4 months for SI, Lab testing and SC)
- Marmaray – the deepest immersed tube tunnel in the world: 1600m (3 months for SI, Lab testing and SC)
- Eurasia Tunnel – 5400m twin deck bored motorway tunnel
- Turkstream Project – Nearshore section of the Southstream pipeline in Turkey (2 months)
- 1915 Çanakkale Bridge - the world’s longest suspension bridge: main span: 2023 m, total length: 4608 m
- Sinop Nuclear Power Plant – Identification of faults and age dating
- Bosporus 3-Storey Tunnel – Feasibility Study
Conclusions

Use of specialized marine techniques and equipment developed for the offshore industry

Collection of high-quality data

Execution in very short time-frame

High mobilization cost is overcome by schedule savings and data quality improvement
Thank You!
Questions?