# CAISSON FOUNDATION DESIGN EXPERIENCE

Representative Projects:

<table>
<thead>
<tr>
<th>Project</th>
<th>Client</th>
<th>Stratigraphy / Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ophir WHP, South China Sea, Offshore Malaysia (2016)</td>
<td>SPT / Muhibbah Engineering (M) Bhd / Ophir Production Sdn. Bhd.</td>
<td>3 m NC clay drape underlain by LOC clays. WD ≈ 70 m. Jacket supported by three suction caissons, one per jacket leg. High risk item included 18 m diameter D jack-up spudcan likely to achieve 14 m tip penetration at close (&lt; 1 D clearance) from closest caisson prior to conductor well drilling. Review SPT conceptual design, design basis and in-house procedures, particularly those for assessing foundation stiffness VHMT matrices and lateral spudcan – foundation interaction using a decoupled y-shift model.</td>
</tr>
<tr>
<td>Pierce Field FPSO, Blocks 23/22 and 23/27, UK Sector, North Sea (2015)</td>
<td>Jumbo Offshore / Bluewater</td>
<td>Mainly dense / very dense fine sands. Opinions to Jumbo about (a) sensitivity of lateral pile response of pipe piles (L=25.5m,OD=84in) installed with an impact hammer compared to a vibratory hammer and (b) FPSO anchor piles designed according to the API RP 2GEO (2014) cyclic PY method.</td>
</tr>
<tr>
<td>Unmanned Wellhead Platform, Oseberg Field, Norwegian Sector, North Sea (2015)</td>
<td>FEBV / HFG / Statoil</td>
<td>Very dense sand (q, up to ≈ 90 MPa), WD ≈ 110 m. Tender bid. Assisted FEBV with feasibility-level verification of preliminary suction caisson design (12 m diameter and 6 m embedded length). Challenges included installation (self-weight penetration and plug liquefaction) and in-place resistance to withstand significant tensile axial storm load.</td>
</tr>
<tr>
<td>Offshore Cape Three Points (OCTP) Block Offshore FPSO, Gulf of Guinea (2015)</td>
<td>SPT / Inson / ENI Ghana</td>
<td>Structured NC clay with traces of pellets. WD 800 - 950 m. Review conceptual design. Caissons 6 m diameter and ≈ 18 m embedded length to resist 8 MN lateral load. High risk items included taut line mooring system and possible seafloor trenching post installation. Developed method for incorporating 3D FEA of caisson + trench within CAISSON_VHM optimisation software. Reviewed SPT procedures, FEA results and detailed geotechnical design report.</td>
</tr>
<tr>
<td>Prelude FLNG FPSO Anchors, NW Shelf, Offshore Australia (2013)</td>
<td>Shell Global Solutions BV, The Hague</td>
<td>Weak carbonate mixed sand/clay profiles. WD 220 – 250 m. Review conceptual design. Caissons 18.5 m diameter and up to 14.5 m embedded length to resist 20 MN lateral load. High risk items included soil plug heave and clay/sand soil plug separation during suction installation.</td>
</tr>
<tr>
<td>Innogy Nordsee, German Sector, North Sea. (2012)</td>
<td>SPT / VSO</td>
<td>Predominantly dense to very dense sands. WD ≈ 25 m. Tender bid, preliminary calculations for WTG steel braced tripod substructures at 3 locations. Supported by suction caisson foundations approximately 10 m OD, target penetration around 7.5 m bsf. Key items studied included installation and additional ballast in order to ensure an adequate factor of safety on in-place axial tensile capacity. Expert opinion on which locations were most suitable for suction caissons.</td>
</tr>
<tr>
<td>N5162 UK Sector, North Sea (2011)</td>
<td>HMC</td>
<td>Weak to competent soils and rock at subject locations. WD 15 – 35 m. Guidance on geotechnical considerations / how to rank sites for suitability for wind farm suction foundations.</td>
</tr>
<tr>
<td>N5142 Dutch and UK Sectors, Southern North Sea</td>
<td>KCI / Shell UK</td>
<td>Variable weak and competent clays and sands. WD 22 – 37 m. Six platform locations; generic suction caisson foundation design. Static</td>
</tr>
</tbody>
</table>
(2010) and cyclic undrained strength and permeability laboratory tests to assess soil pore water pressure build-up / dissipation and liquefaction potential of loose to medium dense sands to 13 m depth at location A.

N4983 Shtokman gas condensate field phase 1, seabed structures, Barents Sea, Russia

Peter Gaz Ltd. Competent glacial till / outwash overlain by normally consolidated clay drape. WD 150 – 300 m. Conceptual design of seabed infrastructure. Ground conditions, caisson capacity, installation and settlement. Risk assessment of seafloor features (e.g. furrows and depressions formed by iceberg keels).

N4974 Block B13, Dutch Sector, North Sea (2009)

KCI Preliminary geotechnical engineering for two platform options (self-installing and mono–tower). Characterisation of ground conditions, caisson capacity, installation and foundation stiffness. Risk assessment of driving conductors in or outside, near the caisson. Foundations up to 13.5 m diameter and 11.5 m penetration.

N4970 Berbice River Crossing, Guyana (2008)

Bosch Rexroth BV, Boxtel, The Netherlands NC clay underlain by competent marine clays. WD ≈ 10 m. Suction Embedded Anchor foundations for pontoon bridge. Client Representative and Auditor during supplementary geotechnical investigation. Consultancy during subsequent claim against subcontractor.

N4508 Millom West, Block 113/26, Irish Sea (2004)

Burlington Resources / British Gas 3 m loose sand, thereafter medium dense to very dense. 35 m WD. Significant scour around caissons. Rock dump and hazard assessment. Revised in-place capacity.

N4184 West Patricia Platform, SK309 Field, Offshore Sarawak, Malaysia (2002)

SPT / Murphy Oil NC clays underlain by competent clays and sands; infilled channels. 39 m WD. SIPI II platform. Preliminary geotechnical foundation engineering design of suction caissons penetrating up to 10 m at various locations.

N4159 ABO field, offshore Nigeria (2002)

SPT NC high plasticity clays. WD 475 – 600 m. Final geotechnical engineering design of FPSO suction anchor piles 3.5 m OD, 14.5 m total length.


SPT Predominantly sandy soils.30 m WD. Final Geotechnical foundation engineering design of 9.25 m diameter suction caissons penetrating up to 5.5 m. Items studied included installation, in-place resistance, and jack-up rig – suction can interaction effects.

N4045 Sunrise Field, Timor Sea (2001)

MSC NC carbonate clays. 160 m WD. Preliminary foundation engineering for 40 m diameter spudcans with 7.5 m long skirts. Items studied included the shape of the VHM yield surface, moment capacity and initial rotational stiffness.

N3967 Galata, offshore Bulgaria (2001)

SPT NC calcareous clay. 34 m WD. Preliminary foundation design for SIP II platform. 10 m diameter caissons penetrating up to 19.25 m withstand 100 year storm loads. Assessment of total and differential leg settlements. Recommendations for final design included detailed geotechnical investigation and earthquake loading.

N3936 Barracuda and Caratinga Fields , Campos Basin, Brazil (2000)

Halliburton Subsea Ltd NC clay. WD 650 – 1150 m. Desk study and preliminary suction pile anchor capacity calculations. Review geohazards (e.g. corals) that may influence project planning and survey.

N3846 Millom West, Block 113/26, Irish Sea (2000)

SPT 3 m loose sand, thereafter medium dense to very dense. 35 m WD. Final geotechnical engineering for 7 m diameter suction caissons penetrating up to 9.5 m below seafloor. Key items studied included installation, in-place can/soil resistance to ship collision and environmental loading, and interaction effects between jack-up rig and caisson.

N3840 North Sea N3840 (2000)

Delft Technical Stage I Offshore Wind Turbines at Exposed Sites North Sea. Assessment of pile head stiffness matrices for reference monopile,
University Institute for Wind Energy

various soil conditions and soil support models; assessment of the first two eigen frequencies for the complete reference wind turbine.


N3284 Blocks P2 and P6, Dutch Sector, North Sea (1996) Clyde Petroleum Mainly very dense sands with some very stiff clay layers. WD 27 – 31 m. Jack-up well platforms, 3 locations. Centrifuge studies of soil plug heave at most adverse location.

N3119 Epsilon West on Sleipner B, Norwegian Sector, North Sea (1993) MSC Competent glacial till. WD ≈ 120 m. Skirted spudcans / caissons. 3-D finite element analyses of foundation stiffness, particularly moment rotation.

Notation:
bsf – below seafloor
LOC – Lightly Over Consolidated
NC – Normally Consolidated
WD – water depth

Client Abbreviations:
HMC – Heerema Marine Contractors, Leiden, The Netherlands
KCI - Korndörffer Contracting International BV, Rotterdam, The Netherlands
MSC - Marine Structure Consultants BV, Schiedam, The Netherlands

Software:

<table>
<thead>
<tr>
<th>Codename</th>
<th>Client</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAISSON_VHM (2012 - date)</td>
<td>Geotechnical specialists</td>
<td>Caisson/can capacity in undrained soils. Yield function approach. Support and anchor pile foundations. The latter includes anchor chain inverse catenary profile.</td>
</tr>
<tr>
<td>OFFSET (2010)</td>
<td>Fugro</td>
<td>Offshore foundation settlement analysis in layered clay. Settlement components include immediate and consolidation. Foundation types are shallow and intermediate caisson.</td>
</tr>
<tr>
<td>CANNI (2000)</td>
<td>Fugro</td>
<td>Caisson installation in multi-layered soils, both drained and undrained. Inverse analysis of installation data also possible.</td>
</tr>
</tbody>
</table>

Training/Courses:

<table>
<thead>
<tr>
<th>Project</th>
<th>Client</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>API/ISO Shallow Foundations Task Group</td>
<td>Delivery of topics / ideas / text+references for discussion by intermediate foundations sub committee (Susan Gourvenec)</td>
</tr>
<tr>
<td>2016, 2013 and 2012</td>
<td>SPT / VSO</td>
<td>Suction Foundations Course. Preparation of Lecture Notes, PowerPoint slides, and giving lectures to engineers (geotechnical, structural and naval) and managers</td>
</tr>
<tr>
<td>2014</td>
<td>Fugro Academy</td>
<td>Caisson Foundation Course. Review / improvement of PowerPoint slides and workshop calculations</td>
</tr>
</tbody>
</table>
RESUME

Miscellaneous:

Over forty years as a geotechnical specialist, mainly in the oil & gas industry, both with Contractors and Consultants. Expert in designing shallow and intermediate foundations. Extensive worldwide experience in offshore, nearshore and land geotechnics including: planning, supervising and auditing site investigation and laboratory testing; supervision of installation activities; peer assist, risk assessments and high level reviews of foundation designs and geotechnical reports.

PUBLICATIONS


