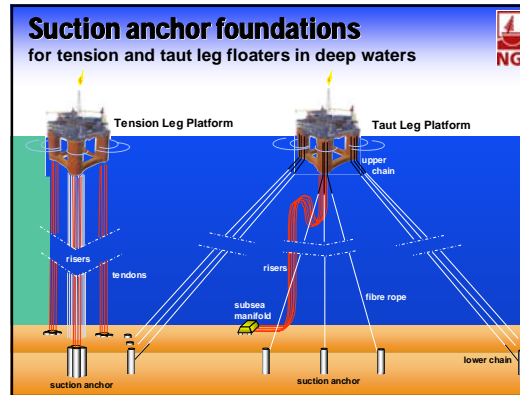


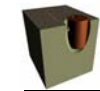
Case history: Soil investigation for offshore suction anchors

Over last 5 - 6 years anchoring of floating and fixed structures have to an increasing extent been done with suction anchors

- much quicker installation
- cost effective
- reliable design procedures
- require reliable soil parameters for optimal design of suction anchor dimensions



Alternative anchors for floating structures



Suction pile



Driven pile

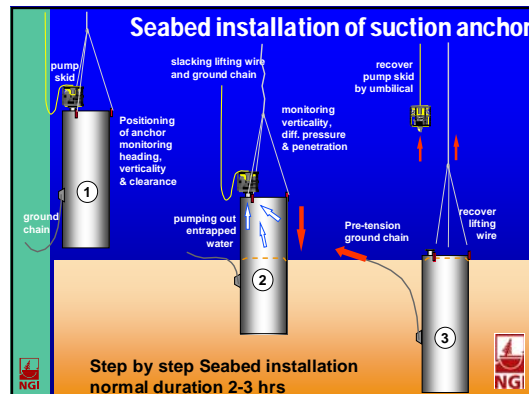
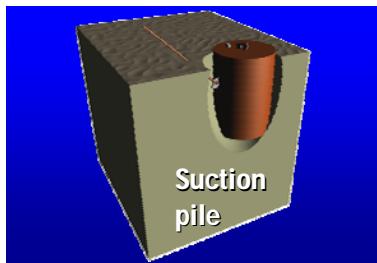


Fluke anchor

Driven Plate anchors



Basic principle



Suction anchors in deep waters

- Main foundation problems
 - penetration of skirts (must get to required depth)
 - bearing capacity for pull out forces (including cyclic loading in some cases)
 - Soil parameters required
 - shear strength for penetration analyses
 - shear strength for bearing capacity
- Depth for which soil information is required : suction pile length + 1 diameter



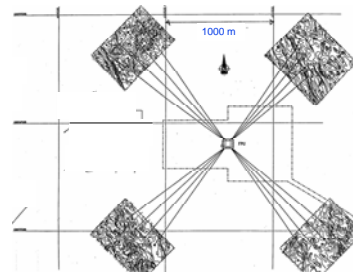
Floating structure with suction anchors

Project information:

- Water depth : 340 m
- Four clusters, each with 4 anchors
- Overall anchor pattern diameter : 2,300 m
- Expected suction anchor dimensions
 - diameter : 5 m ; length : 11 - 13 m
- Main geotechnical problems
 - penetration of skirts to required depth below seabed
 - bearing capacity in terms of pull out resistance



Anchor pattern for North Sea Floating Production Unit



Floating structure with suction anchors

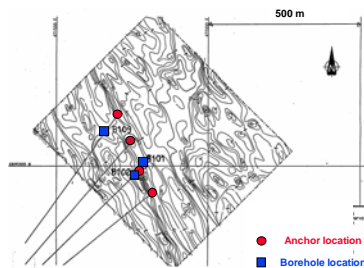
Soil investigation program:

- Nine boreholes to 15 m
- Intermittent CPTUs and sampling
- Laboratory tests including CAUC, CAUE and DSS

Soil design parameters based on correlations between CPTU and laboratory tests



Example borehole locations for one anchor cluster



Down-hole insitu testing

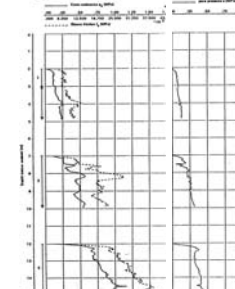


Operation with umbilical, hydraulic cylinder pushes tool below bottom of borehole. Data acquisition through cable and real time display of test results. Depth limitation about 700 m.

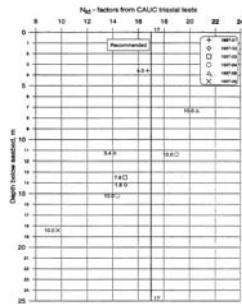


From Fugro brochure

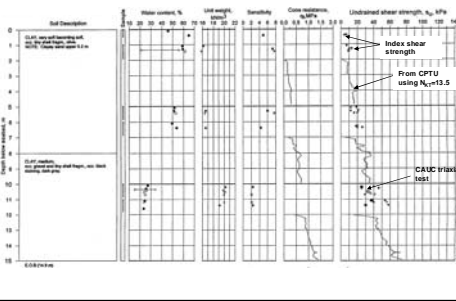
Investigation for floating structure - example down-hole CPTU results



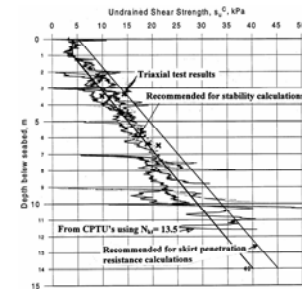
Selection of N_{kt} factors for CPTU interpretation



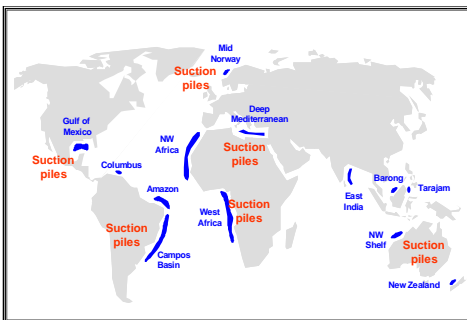
Investigation for suction anchors- results form combined borehole with CPTU and sampling



Recommended design shear strengths for suction anchors



Deep-water sites around the world



Exxon Diana - Suction Pile anchors



Exxon Diana - Suction Pile anchors

- 12 anchors, each with 1500 ton holding capacity - Highest!
- 220 ton weight, 30.5 m penetration and 6.4 m diameter- Largest!
- 1500 m water depth - Deepest!
- First permanent suction pile mooring in the Gulf of Mexico

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