Oil & Gas, Australia - Timeline

1982

NORTH RANKIN A PLATFORM FOUNDATIONS INSTALLATION

First offshore oil and gas platform off the North-West coast of Australia. Observations and measurements during pile installation, together with well conductor tests, indicated pile skin frictions are substantially lower than assumed for design.

The underestimation of pile skin friction had a severe negative impact on the project - full 'built-for-purpose' certification of the platform was not obtained without modifications to the 'as-bulit' foundations.

1986 – 1988

MODIFICATIONS TO NORTH RANKIN A PLATFORM FOUNDATIONS

Implementation of a complex scope of work to modify the 'as-built' platform foundations to meet certification requirements and agreed industry standards.

The programme of investigation, design and construction for the platform foundation modification works generated new standards for the offshore oil and gas industry with respect to foundations designed in calcareous sediments.

1987

GROUTED SECTION TESTS AT OVERLAND CORNER, SOUTH AUSTRALIA

Following the North Rankin A platform foundations experience and to inform the Goodwyn A platform foundations design, a comprehensive testing programme comprising constant normal stiffness element tests and field-scale grouted section tests was undertaken. Data from the Overland Corner tests were used to calibrate design parameters for implementation to the Goodwyn A platform foundation design.

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1992

GOODWYN A PLATFORM FOUNDATIONS INSTALLATION

After completion of driving the primary foundation piles it was found that most of the pile tips had buckled to the extent that the secondary insert piles could not be installed.

The remedial work required to repair the primary piles (prior to installation of the insert piles) resulted in significant delays to platform hook-up and comissioning.

1996

WEST TUNA, BREAM B & WANDOO B PLATFORMS

The only examples of the use of subsea concrete gravity structures in Australian waters.

Examples include the use of a solid ballast to provide sliding stability under storm loading and an underbase drainage system developed to aid dissipation of excess porewater pressures generated by cyclic shear loading.

1999

LAMINARIA SUCTION PILES

The first use of suction anchors in the calcareous soils offshore of Australia.

Analysis of model suction anchor centrifuge test data and back-analysis of the suction anchor installation provided valuable insight into the performance of suction anchors in fine grained calcareous soils.

OTC 16441

A New Method for the Design of Laterally Loaded Anchor Piles in Soft Rock

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This paper was prepared for presentation at the Offshore Technology Conference held in Houston, Texas, U.S.A., 3–6 May 2004.

Abstract

This paper will discuss a new design method (termed the CHIPPER method) that has been specially developed to assess the performance of laterally loaded anchor piles in soft rock (both carbonate and non-carbonate). The theoretical basis for the model will be presented along with the results of full 3D FE analyses that were used to calibrate a number of the key input parameters. A program of centrifuge model tests was also undertaken to verify the model, and the results from these will also be described. Finally, application of the CHIPPER model to the detailed design of anchor piles for two moorings will be outlined (Bayu Undan FSO in the Timor Sea and Legendre CALM buoy mooring on the North West Shelf).

Introduction

This paper presents a new design model for assessing the behaviour of laterally loaded anchor piles in soft rocks. Such materials are commonly found in offshore environments around the world, including Australia, South Africa and the Middle East.

The key features of the CHIPPER model will be described, which includes an algorithm to model the development of a fractured ('chipped') zone near the surface of the rock, an algorithm to model compressibility beyond the materials yield pressure and an algorithm to explicitly model the effect of cyclic loading. The form of the 'p-y' curves that are used in the CHIPPER model have been developed based on the results from full 3D FE analyses of typical anchor piles using a non-linear constitutive model accounting for different levels of compressibility and shear strength. These results will be presented. Results from centrifuge model tests of anchor piles under monotonic and cyclic loading will also be discussed and compared with predictions made using the CHIPPER model.

The new model is believed to have a better theoretical basis than previous models and is backed up by model test results. It has been found that the new model gives a more optimistic load displacement response than earlier models enabling smaller piles to be adopted confidently. In regions such as offshore Australia, where often only small construction spreads are available, the ability to adopt smaller piles can have substantial economic benefits.

Background to Method

The lateral pile analysis problem under consideration is presented schematically on Fig. 1. The new method is a p-y curve based approach and has been implemented into a proprietary spreadsheet program. Various input parameters that define the shape of the p-y curves have been established from 2D and 3D finite element (FE) analysis, plasticity analyses and centrifuge model tests.

The model used is essentially a 'cohesive - compressible' model. The ultimate capacity is solely determined from the cohesive strength and takes no account of frictional components. This is fundamentally conservative for drained conditions but reasonable for undrained conditions. Weakly cemented but high void ratio carbonate rocks generally exhibit a soft compressive response under drained conditions and this is also accounted for when appropriate.

Breakout of the upper rock material will occur progressively, with 'chipping' of near surface material leading to a highly brittle stress-strain response. At greater depths, the chipping mechanism will be suppressed and a deep 'flow around' failure mechanism will occur, which is expected to be a largely ductile failure mechanism.

Several methods have been developed previously to address the brittle near surface failure mechanisms [1,2] but none of these is rigorously defined or has been tested against quality experimental data. For the current work, an alternative model has been developed that is considered a more realistic representation of the actual mechanical processes involved.

Cyclic loading is explicitly addressed in the method through a 'y-shift' algorithm which has been calibrated to results obtained from the centrifuge model tests.

Model Description

The basic features of the lateral response model used for this work are shown on Fig. 1 and outlined below. Subsequent sections present more details on some of these features.

Ultimate Lateral Capacity. The ultimate peak lateral capacity, p_u, (force per unit length) has been defined at any depth based on the plasticity model developed by Murff and Hamilton [3]:

$$p_u = N_c c D$$

2008

ANGEL PLATFORM

Permanent piled foundations comprising a two-stage pile configuration, with both primary and insert piles being installed using the drilling and grouting method.

Seabed conditions comprised a combination of calcarenite and variably cemented carbonate soil extending to a depth of 48 m. Solution was to install a drilled and grouted pile in two stages: a primary pile through the upper calcarenite and hence avoiding refusal or damage to the pile tip. An insert pile connected to the primary pile and extending to the maximum required penetration depth of 62 m.

The design made use of a novel soil model for lateral response analysis developed for cemented calcareous soils. The model assumes that breakout of the upper rock material will occur progressively with 'chipping' of the surfical material, leading to a highly brittle stress-strain response.

2010 – 2015

GREATER GORGON DEVELOPMENT

Significant change in focus of offshore activities in Australia with respect to the Jansz-Io reservoirs, which are in water depths of approximately 1200 m.

The development adopted a subsea approach with relatively large manifolds near the well locations to direct the flow from the wells into an export pipeline to the processing plant at Barrow Island.

Frontiers in Offshore Geotechnics III – Meyer (Ed.)

Geotechnical design and construction aspects of a pipeline-escarpment crossing

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ABSTRACT: This paper describes geotechnical design and construction aspects of a large diameter pipeline which traverses a steep and tall escarpment in deep water on its route to shore from a hydrocarbon field offshore of Australia. Key geotechnical challenges of this crossing, which are discussed in this paper include (i) pipeline route selection, (ii) calcareous seabed conditions, (iii) deep-water earthworks necessary to profile the escarpment, (iv) overall stability assessment, and (v) evaluation of necessary pipe-soil interaction parameters in relation to pipeline performance when subject to imposed metocean and product-slugging loads. These data were also used to determine appropriate construction methods, earthworks profiling and to assess pipeline fatigue life at the crossing. Insights from escarpment profiling and pipeline installation are also presented.

1 INTRODUCTION

A 30″ production pipeline, an 8″ monoethylene glycol (MEG) pipeline and a 6″ utility pipeline for a deep water development offshore Australia cross a shelf-break escarpment (called "scarp" hereafter) located between approximately 500 m and 800 m water depth. The crossing location was selected from multiple potential routes based on a detailed geohazard assessment performed during FEED by the project team and its funding partners. An as-constructed representation of the crossing location is shown on Figure 1.

Extremely high natural slope angles at the scarp (greater than 80° for a significant section), result in significant pipeline freespans (more than 100 m long). Load cycles over the 50 year design life arise from tidal currents and, for the production line, high frequency fluctuations in the transmitted product density. These fluctuations occur as the mixed gas and liquid product may form liquid-trains (or "slugs") at the bottom of the scarp where the transported fluids coalesce. This results in a juddering effect on the pipeline.

Successful management of potential long term fatigue damage and geometry changes due to repeated loading required extensive and iterative interactions between geotechnical and pipeline engineering teams.

To control overall pipeline bending stresses an engineering solution to pipeline curvature control at the scarp crossing was implemented. In this case, a deep-

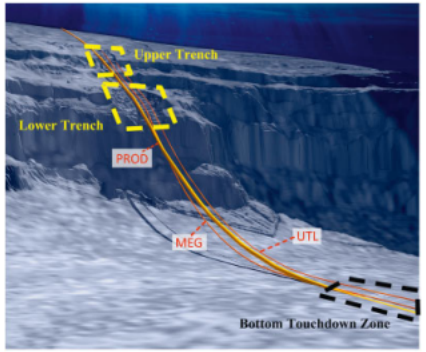


Figure 1. Overview of the escarpment crossing.

used to re-profile the scarp shoulder. The design and construction of such a crossing represents a significant achievement for the project.

This paper presents the main geotechnical work performed in support of the crossing design. The regional setting, the soil conditions and a local ground model will be briefly discussed, followed by observations from slope stability assessment and model testing on pipe-soil interaction at the pipeline touchdown zones.

2010 – 2015
GORGON SCARP CROSSING

Significant challenge in routing the export pipeline up the steep scarp separating the Gorgon field (200 m water depth) and the deep water Jansz and Io fields (1200 m water depth).

Extremely difficult to assess the natural slope stability of the scarp due to the combination of steel gradients and relatively low shear strengths. Geochronology played a major role in the assessment, evaluating historical slope failures in terms of deduced ages and estimated slope conditions at the time of failure.

Innovative solutions for the scarp crossing included trenching the upper part of the scarp to alleviate pipeline curvature using mechanical grabs. The lower scarp was bridged by a 270-m long suspended section of pipeline, aptly referred to as super-span. Sophisticated engineering studies were undertaken to address design issues associated with the super-span, including fatigue due to VIV induced by transverse currents and embedment at the lower end of the span due to pipe weight, and cyclic loading due to 'slugging' of mixed phase pipe components.

2010

PLUTO PLATFORM

The seabed at the selected site for the Pluto riser platform was relatively uneven and therefore the mudmats providing temporary support were designed with different shapes and elevations to conform to the natural seabed contours. In addition, ground conditions at the site led to a one-stage drilled and grouted pile configuration to be adopted as the permanent foundation for the Pluto platform.

Axial capacity relied upon a relatively strong limestone layer where reliance on natural roughening from drilling was insufficient. A reaming tool was designed and used to roughen the hole wall by gouging circumferential 'grooves' in the hole wall at regular intervals.

2012

ICHTHYS GAS/CONDENSATE FIELD SUBSEA UMBILICAL, RISER, FLOWLINE (SURF)

SURF work on a large scale.

2013

NORTH RANKIN B (NRB) PLATFORM

The North Rankin B platform is 274m tall and weighs 65,000 tonnes, with the platform sitting on a four-leg jacket which is connected to the seabed by 16 piles.

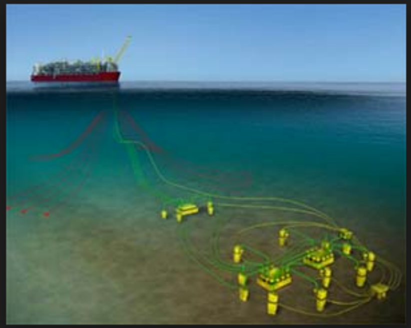
Following on from NRA and GWA experience, NRB involved state-of-the-art design (development/first use of pCyCOS and 'finalisation' of CYCLOPS from RATZ).

2014

WHEATSTONE PLATFORM

One of Australia's largest platforms for LNG production. The Wheatstone Platform comprises a steel substructure similar in form to a semi-submersible, and supported on corner shallow foundations located beneath the vertical columns.

Rock blanket is used to overcome unevenness in the seabed and solid ballat of high density to ensure foundation stability against cyclones and seismic events.



2014

PRELUDE FLOATING LNG ANCHORS

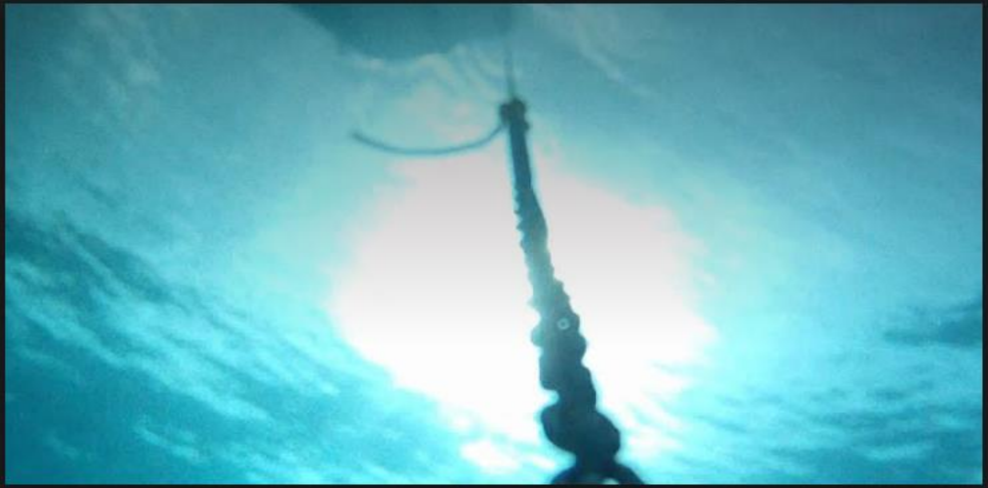
Design of the 5.5-m diameter anchor piles for the Prelude Floating LNG platform was a world first as it incorporated a combination of devices to limit free-fall speed through uncemented cabronate silts, and driving shoes and internal stiffeners to avoid pile tip damage.

Design of the anchor piles relied on state-of-the-art methodology to address dynamic pile-plug free-falling of the piles during driving through hard over weak layers. The piles also included thickened driving shoes and cruciform internal stiffeners to avoid pile tip damage during driving through cemented layers.

2014

ICHTHYS - RISER SUPPORT STRUCTURE (RSS)

Satisified a significant seismic design requirement.



2022

ICHTHYS ANCHOR PILES

Design of novel free-fall arrestors.

2022

BAYU-UNDAN PLATFORM, TIMOR SEA, AUSTRALIA

A pre-cursor to Wheastone's Steel GBS with 'small footings'. The main platforms included single piles at each leg for tension capacity.