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Centrifuge Testing on Suction Anchors: Double-Wall, Over-Consolidated Clay, and Layered Soil Profile

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Abstract

This paper presents partial results of two series of centrifuge tests that were performed on suction anchors.

The first series addressed the specific conditions of the Mad Dog Cluster 2 anchors on the Sigsbee Escarpment (Berger et al 2006, Jeanjean et al 2006, and Schroeder et al 2006). Tests were performed for soil conditions, anchor geometry, attachment points, and loading angles closely matching the Mad Dog design parameters. The results provided a means of calibrating and validating the design method and failure mechanisms.

The second series of tests was performed on double-wall anchors and allowed the separation of the three components of capacity: outside friction, inside friction, and reverse end bearing. Results gave insights into the failure mechanism of vertically loaded anchors and suggest that the traditional procedures for determining outside skin friction appear to be conservative.

Introduction

When describing the centrifuge tests, all units in the text, tables and figures refer to model dimensions, unless otherwise noted.

Purpose of the centrifuge tests

This paper presents partial results from two separate series of centrifuge tests to investigate the holding capacity of suction anchors in soil profile representative of the Mad Dog Cluster 2 conditions (see Schroeder et al, 2006) and to separate the components of total vertical capacity: outside friction, inside friction, and end bearing.

Centrifuge tests on stiff clays and layered soil profile

As described in companion papers (Berger et al 2006, Jeanjean et al 2006, Liedtke et al 2006, and Schroeder et al 2006), the geotechnical conditions at the Mad Dog suction anchor sites for the four anchors in Cluster 2, the ones on the Sigsbee Escarpment, clearly fall outside the range of commonly encountered soil properties in the Gulf of Mexico. Centrifuge tests were therefore performed at the University of Colorado at Boulder with the purpose of obtaining load test data to verify the design methodology for soil conditions relevant to the Mad Dog Cluster 2 profiles. The failure mechanism of the anchor was also predicted.

Centrifuge tests on double wall anchors in soft clays

Secondly, a series of centrifuge tests were performed at C-CORE, in St John's, Newfoundland, on a specially manufactured double-wall anchor. The anchor was loaded vertically and the intent of these tests was to separate the various components of vertical holding capacity: external friction, internal friction, and reverse end-bearing. It was suspected before the test that, contrary to what is commonly assumed when interpreting load test data, the inside friction and outside friction in the anchor might not be equal. The tests were also intended to provide measurements of the end bearing capacity factor, N_c , without having to assume an alpha factor, or speculate as to how much friction was generated inside the anchor, when pulled with the top closed.

Centrifuge tests on overconsolidated clays and layered soil profile

Description of testing facility

The centrifuge at the University of Colorado at Boulder is a 400 g-ton centrifuge (Fig. 1). It has an asymmetrical rotor arm with a swinging payload platform on one end and a fixed counterweight compartment on the other. The operating radius, with the swing platform extended, is 5.5m. A payload volume and mass of 1.2x1.2x0.9 m and 160 kg respectively can be accommodated by the centrifuge. At the time of the tests, the centrifuge was capable of accelerating a payload to a maximum of 200g in about 14 minutes. Four large pneumatically actuated disk brakes are used to stop the centrifuge in emergency situations.