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Calibrated Geotechnical Design Code for Suction Anchors in Clay

R. Dahlberg, K.O. Ronold, P.J. Strøm, and J. Mathisen, Det Norske Veritas, and K.H. Andersen and H.-P. Jostad, Norwegian Geotechnical Inst.

Abstract

The paper describes the first formal code for geotechnical design of suction anchors /1/. The procedures adopted in the calibration of the code are consistent with those used in the calibration of the corresponding design codes for plate anchors /2/ and fluke anchors /3/, which have been developed in the past.

None of the current design methods for suction anchors prescribe safety factors that relate to a known target annual failure probability. The new code provides designs with a known probability level, which is consistent with the corresponding mooring line design code.

The design code is based on an advanced design method which is frequently used for design of suction anchors in clay by the offshore industry. Quantities that need to be evaluated and modelled in the anchor design are briefly described with reference to published papers for details. The main contribution from the current work is the structural reliability analyses and calibration of safety factors to meet specified target annual failure probabilities. Anchor installation and removal are addressed only by references to relevant published papers.

The design code /1/ is applicable to both temporary and permanent moorings. Two limit states and two failure consequence classes are specified with requirements to partial safety factors on load and resistance specified for each combination. The allowance for use of reduced safety factors when the failure consequence is small is an advantage, particularly for mobile platforms, at the same time as higher safety factors can be applied for production platforms. Limitations in the applicability of the code are given.

Introduction

For many years suction anchors were used mainly in steel catenary mooring systems in moderate water depths, which gave predominantly horizontal loads on the anchor. In deeper water taut mooring systems with light-weight fibre rope segments is the preferred solution due to the high weight of steel catenary mooring systems. In taut mooring systems the anchors need to absorb a significant vertical load component in addition to the horizontal. Since vertical loads, and in particular cyclic vertical loads, are more critical to anchors than horizontal loads, it is important to focus attention on the reliability of these mooring components.

Calibrated codes for geotechnical design of plate anchors and fluke anchors in clay have been developed in the past, see /2/ /3/, and for consistency the same calibration procedures have been adopted for the calibration of the partial safety factors in the code for geotechnical design of suction anchors /1/, which is the subject of this paper.

The robustness of the code will increase as the scope of the calibration becomes broader, and in the future it may be necessary to broaden the the scope to include other design situations than those covered by the present code calibration.

Scope of Application

Application.

This design code applies to the geotechnical design and installation of suction anchors in normally consolidated clay for taut, semi-taut and catenary mooring systems. The design code is applicable to anchors for both temporary and permanent moorings.

The design code provides procedures for determination of the characteristic anchor resistance and (by reference) the characteristic load required by the code.

The code makes use of a relatively detailed resistance analysis. If a less detailed resistance analysis is applied, the designer should be aware of the limitations of the method and make sure that the effects of any simplifications are conservative in comparison with the results from the more advanced methods.

With reference to /4/ a number of existing 3D finite element methods meet the analysis requirements of this code. It was also reported in /4/ that the plane limit equilibrium method used in the calibration of this code, as well as a quasi 3D finite element model, where the 3D effects are accounted for by side shear on a 2D model, generally showed good agreement with the 3D finite element analyses. A plastic limit analysis using a function fitted to approximate upper bound results /5/ also gave good results. Available plastic limit analysis mechanisms that rigorously satisfied upper bound