Proceedings of the Eighteenth (2008) International Offshore and Polar Engineering Conference
Vancouver, BC, Canada, July 6-11, 2008

ISBN 978-1-880653-70-8 (Set); ISBN 1-880653-68-0 (Set)

A Parametric Study on the Installation of Tapered Suction Caissons in Clay

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ABSTRACT

Some recent investigations indicated that tapered suction caissons may achieve pull-out capacities several times higher than that from their equivalent upright caissons. This paper reports results from a numerical approach to study the installation of tapered suction caissons in clay. It has been noticed that, in general, tapered caissons of positive wall slope need extra forces, in comparison to their equivalent upright caissons, to achieve a full penetration. However, with models examined in clay, it has been noticed that the total force required for the full penetration of the tapered caisson is not significantly higher than that for the equivalent upright one. The variation has been about a few ten percents. The numerical model has then been used to examine the effects from variations in soil properties and the caisson's geometry on the total efforts required for the installation of tapered suction caisson.

KEY WORDS: suction caisson, installation, tapered caissons, finite element method, offshore structures, clay.

NOMENCLATURE

c: soil cohesion
φ: soil friction angle
ψ: soil dilatancy angle
γ: soil wet unit weight
ν: Poisson's ratio
E: Young's modulus of elasticity
$R_{int.}$: soil-caisson interface strength reduction factor
L: caisson length
D: caisson diameter
L/D: aspect ratio
t: caisson wall thickness
F: total force needed for the full-length penetration of the caisson

INTRODUCTION

During the last two decades suction caissons have provided innovative solutions to deep water foundation and anchoring problems. Suction caisson is a large-diameter hollow cylinder that is closed at the top and open at the bottom. Installation is based on the principle that the cylinder penetrates partly into the soil under its own weight, allowing free water outflow through an outlet in the top cap. Further penetration is achieved by closing the water outlet in the top cap and pumping water out from the top of the cylinder, creating an underpressure inside the cylinder. The difference between the hydrostatic water pressure outside the cylinder and the reduced inside water pressure provides a driving penetration force in addition to the weight (Fig. 1). After penetration, the water outlet is normally closed and, as a suction anchor, this system may achieve a substantial pull-out capacity.

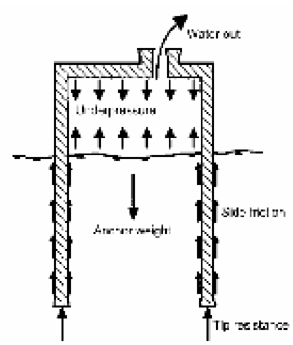

Fig. 1: Free body diagram of suction caisson during installation by undrepressure (Andersen and Jostad, 1999)

Important design aspects in connection with the installation of suction anchors are (Andersen et al. 2005) to:

i. make sure that the skirts can be penetrated to the depth required to achieve the design holding capacity,
ii. determine the underpressure that is necessary to achieve the required penetration in order to have sufficient pump capacity and to provide input to the structural design
iii. determine the amount of soil heave inside the cylinder during penetration, and
iv. determine the maximum depth to diameter ratio that can be penetrated.

Suction caisson's installation performance in different soils has been studied by means of numerical simulation (Erbrich and Tjelta, 1999; Maniar et al., 2005), analytical approaches (House et al, 1999), laboratory studies of small-scale model caissons at 1-g (El-Gharbawy