The Capacity Characteristics of Pile and Suction Caisson in Deep Water

Sa Li
The Civil Engineering Department, Tianjin University, Tianjin, China
Zhonggang Li
China Ship Design & Research Center Co.,Ltd., Beijing, China
Zhiqiang Han
Tianjin Branch of China Classification Society, Tianjin, China
Shengqiang Wang
China National Offshore Oil Corp., Beijing, China

ABSTRACT

This paper reports a three dimensional finite element study of piles and suction anchors in normally consolidated clay subject to inclined loading. The angle of loading and the corresponding maximum load capacity for piles with length 30m, 60m and 80m and for suction anchors with length to diameter ratios of 2, 4, 6 and 8 are reported. The influence of the soil condition, length (or L/D), loading angle on capacity of piles and suction anchors are analyzed respectively. The shape of the failure envelopes of these two kinds of anchors is compared to analyze the capacity characteristics.

KEY WORDS: Pile; suction caisson; clay; finite element analysis; inclined loading; load angle; length.

INTRODUCTION

The rapidly growing offshore activity in deep waters requires the need to increase the mooring capability. The selection of the mooring system for a given floating unit has become a key factor in deep waters. To date, the driven pile is still the main type of foundation or anchor for the TLP and SPAR. At the same time, suction caissons also have been used extensively for anchoring applications in deep water. In general, the need for alternative solution is related to the cost. A significant advantage of suction caissons is cost effectiveness, which is perhaps the most important factor in their consideration for offshore use (Tjelta, 2001). Besides the financial consideration, these two kinds of foundation also show the different capacity characteristics in normally consolidated clay subjecting to inclined loading.

Many people have done analysis for pile or suction caisson. Numerical analysis of pile and caisson capacity under inclined loading has been reported (Lehar et al., 1997; Zdravkovic et al., 2001; Maniar, D., 2004, Randolph, 2004, Young, 2007). The present study concentrates on comparing the capacity characteristics of pile and suction caisson. Piles and suction anchors have been used extensively for anchoring applications in deep water. The availability of recognized capacity characteristics of these two kinds of foundation will facilitate further applications of piles and suction anchors in deepwater moorings.

PROBLEM DESCRIPTION

A schematic representative of the pile and caisson geometry investigated in the study is shown in Figure 1. Each pile is defined by its diameter D, length L and wall thickness t. The pile diameter has been taken as 2.134m and the length is 30m, 60m, 80m respectively. A wall thickness of 28mm is used in all cases. The load attachment point is at a depth one-forth along the pile shaft downwards from the top. Loads are applied at an angle \( \theta \) from the horizontal.

Each caisson is also defined by its diameter D, length L and wall thickness t. The caisson diameter has been taken as 5m and the length varied to give aspect ratios, L/D=2, L/D=4, L/D=6, L/D=8. A wall thickness is 50mm. The load attachment point is at a depth two-third of the length of the caisson downwards from the caisson top.

![Figure 1 Schematic representation of the pile and suction caisson](image)

FINITE ELEMENT METHOD

The finite element analysis were carried out using PLAXIS 3D. The pile and caisson was represented as a linear elastic body and \( E=2.1 \times 10^5 \text{MPa}, \, \nu=0.1 \). The soil response was taken as elastic perfectly plastic...