The Influence of Disturbed Zone on Capacity of Suction Embedded Plate Anchors

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ABSTRACT

During the installation of Suction Embedded Plate Anchors (SEPLAs), soil in the vicinity of the suction caisson can be disturbed. The effect of the soil disturbed zone on the capacity of plate anchors was investigated in this paper. Both finite element analysis and centrifuge tests were conducted. In finite element analysis, the soil disturbed zone varied from 3 times of the caisson wall thickness to a full area inside a caisson. Centrifuge tests of suction embedded plate anchors were conducted in normally consolidated Kaolin clay (NC clay) and transparent uniform soil. In Kaolin clay tests, short term and long term anchor capacities after installation were measured. In transparent soil tests, suction caisson installation and jack-in installation were conducted. It can be concluded that the reduction in anchor capacity due to soil disturbance after suction caisson installation depends on re-consolidation time and soil sensitivity. The soil disturbance also reduces the loss of embedment during anchor keying process.

KEY WORDS: Plate anchor; Finite element analysis; Centrifuge test, suction caisson

INTRODUCTION

In recent years oil and gas mining has moved into increasingly deeper water in search of undeveloped fields. For water depths in excess of 500 m, conventional platforms are replaced by floating facilities, anchored to the seabed using catenary or taut-wire moorings. The latter type of mooring imparts significant vertical loading to the anchor, and consequently many different types of anchoring systems have been developed (Ehlers et al. 2004). The SEPLA (Suction Embedded Plate Anchor) is one of such systems, which comprises a plate anchor that is penetrated in a vertical orientation using a caisson, and subsequently rotated by applying the anchoring force at some eccentricity until the plate becomes perpendicular to the applied force. This process is schematically illustrated in Fig. 1 (Aubeny et al. 2001). It has been conceived to combine the advantage of suction caissons (known penetration depth and geographical location) and vertical loaded anchors (geotechnical efficiency and low cost).

Over the last four decades a number of researchers have proposed approximate techniques to estimate the uplift capacity of plate anchors in various types of soil (Vesic 1971; Meyerhof and Adams 1968; Das 1978, 1980, 1985; Das et al. 1994; Rowe and Davis 1982; Merifield et. al. 2001; Merifield et. al. 2003) with a limited number of studies dealing with inclined plate anchors (e.g. Meyerhof 1973; Das and Puri, 1989 and Merifield et. al. 2005). Most of these studies were in clay and led to either simple analytical solutions or empirical correlations based on laboratory model tests.

More recently, Song and Hu (2005) performed large deformation numerical analyses of vertical pullout of plate anchors in clay. Results were presented as breakout factors for both fully attached and vented (immediate breakaway) conditions. A simple equation was suggested to determine the critical depth where the suction force underneath the plate was lost. This critical depth is dependent on the anchor size, soil undrained strength and soil effective unit weight.

When a plate anchor is vertically embedded, the anchor will rotate to be perpendicular to the pullout direction. This rotation is termed “keying”. The keying process has been studied numerically (Song et al., 2005) and experimentally (O’Loughlin et al., 2006) in Kaolin clay. The