Effect of Skirt Geometry Variation on Uplift Capacity of Skirted Foundation

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ABSTRACT

Skirted foundations are an alternative to pile foundations in offshore and oil and gas facilities. In this paper, a new idea for geometry improvement for skirted foundations is presented. For this purpose, numerical investigation has been used to explore the load carrying capacity of skirted foundations with non-vertical walls in respect to the vertical axis. The soil-foundation system is modeled in an axisymmetric fashion. The material of the circular skirted foundation is assumed to be linear and elastic. The soil is assumed to be fine and soft and its failure stage obeys the Drucker-Prager criterion. In this study, the effect of wall stiffness on the bearing capacity is investigated. Results were presented as applied relations and graphs. The results of studies show that the bearing capacity of skirted foundations increases proportionally with increase of the wall face angle with respect to the vertical direction. In addition, it has been found to achieve the greater pull out bearing capacity, greater displacements are required. Numerical analysis has been performed to investigate the uplift behavior of skirted foundation with inclined surface. Based on the results obtained, some of the general findings are as follows: Noticeable bearing capacity is achieved through the optimization of the skirted foundation geometry. The pullout capacity of skirted foundations with inclined sides is achieved at greater displacements compared with the case for vertical sided foundations. With increasing the soil undrained shear strength (Su), the bearing capacity increases especially for foundations with inclined skirt surface. In clay with low undrained shear strength, the influence of the inclined surface in skirted foundations is greater. With increasing length/diameter ratio for skirted foundations, the pullout capacity increases due to holding greater soil mass in plug and due to greater soil-foundation contact surfaces. Since the increase in skirt length needs greater forces in order to dissipate induced negative pore pressures, the undrained bearing capacity will grow up.

KEY WORDS: Skirted foundation; Drucker-Prager; Numerical Analysis; Uplift Capacity; ABAQUS.

INTRODUCTION

In the last 50 years, the new sources of energy with economic advantages have been looked up in oceans. Petroleum and gas have gained more importance among other sources in oceans and seas. Investigations indicate that almost 30% of the octane re-sources in the world are located in offshore areas and the most of these resources are unsought (Tran, 2005). Skirted foundations, caissons and mat foundations for gravity platform and spudcan are widely used in offshore areas. Skirted foundations are usually circular with skirt or multiple concentric circular skirts that are located under the foundation to increase the contact bearing area. In such foundations, the plug load is transferred down to lower underlying layers. Lateral load capacity is improved by the skirt lateral resistance. The moment load capacity is improved due to suctions developed within the skirt during undrained moment loading, which resist uplift. Skirted foundations have been used extensively for anchoring applications in deep waters. Early applications tended to fall into categories of quasi-vertical loading, such as for the snore tension-leg platform (Stove et al. 1992), or quasi-horizontal loading from anchors such as what was used at Nkossa (Colliat et al. 1996). However, for the common water depths in excess of 1000 m, taut wire moorings are being used increasingly, leading to inclined loading of the foundation where the interaction between vertical and horizontal failure is critical.

The contribution of the present article is to establish a design methodology for skirted foundations with inclined sides. Former studies reported in the literature have focused on the capacity of skirted foundation with vertical walls (Sukumaran et al. 1999; Deng & Carter 2000; McCarron and Sukumaran 2000; Cao et al. 2002). The skirted foundation capacity under vertical loading has mainly been addressed using simplifying assumptions based on limit analysis method (Andersen et al. 1993; Randolph & House, 2002; Aubeny et al. 2003), limit equilibrium method (Cho & Bang 2002), and finite element method (Zdravkovic et al. 2001; Senders & Kay 2002). In soft consolidated sediments and usually in sea sediments, big settlements occur before acquiring a considerable bearing capacity that can be obtained by using the skirted foundation without deep foundations. While its installation is not complicated and expensive, it is providing the bearing capacity against sliding and uplift. Skirted foundations are in-stalled in shallow depths thus they are driven into the soil by self-weight. Subsequently, water is pumped out from the foundation and it causes a pressure difference between inside and outside of the foundation. This in turn, causes suction. As a result, the