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New Simplified Conceptual Model for Spudcan Foundations on Sand Overlying Clay Soils

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Abstract

The paper reports the development of a new simplified conceptual model for evaluating the peak penetration resistance of spudcan foundations on sand overlying soft clay, where potential for punch-through exists. Observations of the failure mode for spudcans penetrating through a sand layer into soft clay have shown that at peak bearing resistance a frustum of sand is forced into the underlying clay, with the outer angle reflecting the dilation in the sand. This has formed the basis of the new analytical design approach. The analytical basis of the conceptual model follows the approach for silo analysis, and takes account of the stress level and dilatant response of the sand. It is therefore an advancement over the punching shear and load spread models advocated in the current SNAME (2002) approach, which do not consider the strength properties of the sand. Results from 47 centrifuge model tests spanning a wide range of foundation diameter and sand layer thickness are shown to match the new design method well. The experimental results are significantly underestimated by the design approach of the current design guidelines SNAME (2002). Although the new design method has been formulated for a surface sand layer overlying clay, it may be extended to cover the situation of an interbedded sand layer.

Introduction

Punch-through hazards of a jack-up foundation on sand overlying clay is a common problem in the industry. It has been reported that spudcan punch-through failures occur at an average rate of one incident per year, costing the industry between US$1 million and US$10 million per incident due to rig damage and loss of drilling time (Osborne and Paisley, 2002). Punch-through commonly occurs during the installation of the jack-up unit, where the spudcans are preloaded to ensure the foundation system is capable of resisting the design loads arising under extreme storm conditions. Punch-through hazard exists when the bearing capacity of the layered soil (referred to as peak penetration resistance, q_{peak}, in this paper) is lower than the preloading pressure.

The traditional analytical methods used to calculate the peak penetration resistance on sand overlying clay are the punching shear method as shown in Figure 1, which is based on Hanna and Meyerhof (1980), and the projected area method as shown in Figure 2.

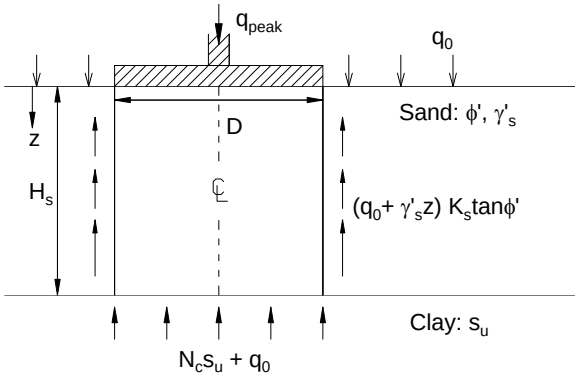

Figure 1. Punching shear method

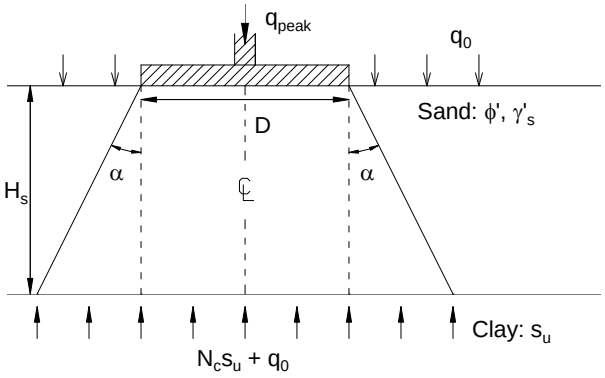

Figure 2. Projected area method