

OTC 20012

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

Kok Kuen Lee, Mark F. Randolph, Mark J. Cassidy, University of Western Australia

Copyright 2009, Offshore Technology Conference

This paper was prepared for presentation at the 2009 Offshore Technology Conference held in Houston, Texas, USA, 4–7 May 2009.

This paper was selected for presentation by an OTC program committee following review of information contained in an abstract submitted by the author(s). Contents of the paper have not been reviewed by the Offshore Technology Conference and are subject to correction by the author(s). The material does not necessarily reflect any position of the Offshore Technology Conference, its officers, or members. Electronic reproduction, distribution, or storage of any part of this paper without the written consent of the Offshore Technology Conference is prohibited. Permission to reproduce in print is restricted to an abstract of not more than 300 words; illustrations may not be copied. The abstract must contain conspicuous acknowledgment of OTC copyright.

## 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.

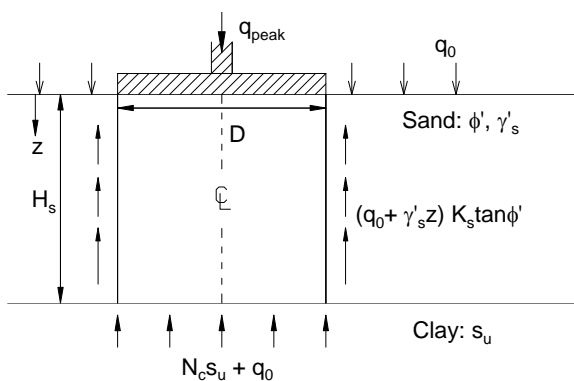


Figure 1. Punching shear method

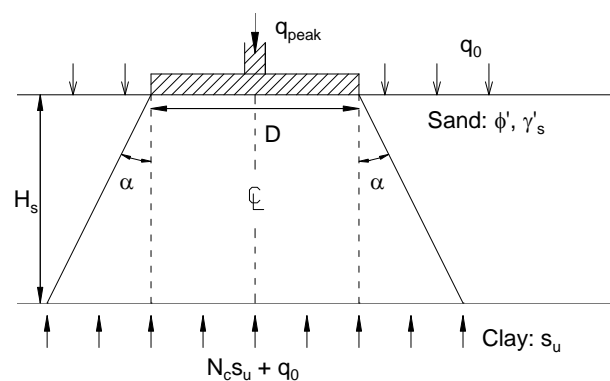


Figure 2. Projected area method