Tuesday 3/14/2017

1:15–2:45 p.m.

Offshore Foundation Systems

Chairs: Malay Ghose Hajra, University of New Orleans; Nina Stark, Virginia Tech

Numerical Study of the Effect of Pile Driving on the Position of the Neutral Plane

Arindam Dey, IIT Guwahati; Michael Conrad Koch, University of Hong Kong

The position of the Neutral Plane is required to be implicitly known for the accurate determination of the magnitude and profile of negative skin friction. In contrary to the conventional analysis of bored piles, this study reports the effect of pile installation procedure on the final position of the Neutral Plane. Two types of initial conditions are considered, one where the pile driving is simulated (actual) and the other where the pile is considered in place (in situ). Finite Element Analysis exhibited that the Neutral Plane is at a greater depth in the 'actual' case relative to the 'in situ' case. Contours of effective stress near the pile tip implied higher soil stiffness near the pile base in the driven pile (actual) simulation, resulting in a lesser settlement and is postulated as the reason for the lowering of the Neutral Plane in the latter (in situ) case.

Numerical Simulation of Lateral Loading Capacity of Bucket Foundation

Xu Yang, Xuefei Wang, and Xiangwu Zeng, Case Western Reserve University

Bucket foundation has been used extensively in offshore facilities to resist combined lateral and moment loading. The lateral loading capacity and interaction between the soil and foundation is of great interest to geotechnical engineers. In this paper, finite element models of a bucket foundation with two aspect ratios (L/D, where L is the skirt length and D is the foundation diameter) of 0.5, 1.33, were created using the ABAQUS program. Centrifuge model tests were also conducted on the two models. The load-displacement curves of the numerical analysis and test results had good agreement, which verified the reliability of the finite element analysis method for this type of problem. In addition, several 3D numerical models of aspect ratio varied from 0.2 to 2.0 were built to evaluate the effect of the aspect ratio on the lateral loading capacity. The development and distribution of stress and plastic strain were used to study the failure mechanism of bucket foundation for different L/D ratios. The influence of the position of the lateral load applied was analyzed. Sensitivity analysis for the parameters of material properties such as the internal friction angle, the Young's Modulus, and the friction coefficient between the bucket and soil were performed using non-linear analysis with the Mohr-Coulomb soil model.

Three Dimensional Finite Element Modeling for Spudcan Penetration into Clayey Seabed

Volkan Emren, Nejan Huvaj, and Kagan Tuncay, METU

In this study the penetration of spudcan foundation for "jack-up rig" type offshore oil platform into a uniform clayey seabed is investigated with three-dimensional finite element modeling (Abaqus 6.14) using Coupled Eulerian Lagrangian method that can handle large deformation problems. One of the goals of this study is to compare the penetration-bearing resistance behavior of spudcan obtained by numerical study with the method suggested in InSafeJIP design guideline. For the spudcan geometry and soil properties used in this study, based on the three dimensional finite element analyses, the required penetration depth for a target bearing capacity of spudcan is less than that required by analytical method in InSafeJIP guideline. The second goal of the study is to explore the effects of some geometrical

and soil variables on spudcan bearing resistance-penetration behavior. The variables in this study are spudcan diameter (7.5 to 15 m), the surface roughness of spudcan (roughness coefficient of 0 to 1.0) and undrained shear strength of clay (20 to 80 kPa). Understanding the relations between the factors and penetration behavior may help in future studies on enhanced and economical design of spudcans.

Offshore Anchor Penetration in Sands: Granular Simulations

Nan Zhang and T. Matthew Evans, Oregon State University

Torpedo anchors are a viable approach for mooring marine hydrokinetic (MHK) energy devices to the seafloor. These anchors will serve to maintain station and to provide the reaction force for the MHK device. The ability of the anchor to perform these duties is a strong function of its penetration depth during installation. This is a large-strain problem not amenable to typical continuum numerical approaches. In the current work, we propose that the discrete element method (DEM) is a more appropriate tool to investigate the shallow penetration of torpedo anchors in sands. The effects of anchor mass, impact velocity, and anchor geometry are considered in the DEM simulations. The relative maximum penetration depths under these factors are quantified and presented in the paper. Comparisons are also made between DEM simulations and the empirical equation developed by Young (1967). Granular material response at the microscale during penetration are used to provide insight into system response.

Drop Weight Dynamic Load Testing for Construction Monitoring and Quality Control of Offshore Drilled Foundations

Seth Robertson and Samuel Paikowsky, GeoDynamica Inc.

High strain drop weight dynamic load testing is an effective tool when evaluating the construction quality and axial capacity of offshore drilled deep foundations. This is a result of the complexity and cost of the alternative conventional static load tests. Drop weight systems can be designed for project specific needs, providing sufficient energy to mobilize the required resistance while permitting ease in transporting the device. Test shafts/piles can be instrumented and analyzed using the same dynamic testing techniques used for driven pile foundations. A case study is presented where drop weight dynamic load tests were utilized for offshore drilled shaft foundations. The project includes the design, construction, and quality control for a cement unloading pier at the Tema Port in Ghana, Africa. The foundations are unique, consisting of 0.8m outer diameter steel pipes embedded in 1.0m rock-socketed drilled shafts. Three dynamic load tests to failure and six load verification tests were performed offshore. The load verification tests were carried out due to construction difficulties and/or complex subsurface conditions. The piles' integrity and mobilized resistances were assessed using the signal matching analysis software CAPWAP. The underlying assumptions in the one-dimensional wave equation formulation on which CAPWAP is based are violated in these complex cases. Finite element analyses were therefore performed using the PLAXIS 2D software in order to examine the validity of the one-dimensional wave equation application under such conditions. This paper briefly describes the project, the associated difficulties, the unique foundations, example load tests and their analyses, as well as some initial processing in examining the validity of the one-dimensional wave equation analyses under the tested conditions.

Experimental Investigation of the Horizontal Resistance of Group Suction Piles with Different Pile Spacing

Juhyung Lee, Korea Institute of Civil Engineering and Building Technology; Jinung Do, North Carolina State University

In this study, a new type of suction pile foundation for floating structures, namely group suction piles, was proposed to improve the shortcomings of conventional single suction piles. Small-scale model tests were performed to estimate the horizontal behavior of single suction piles and group suction piles with different pile spacing (2, 3 and 4 times the pile diameter) under various loading conditions in terms of loading locations and inclinations. The horizontal behavior of group suction piles with different pile spacing was analyzed for various loading locations and load inclinations based on the model tests. For the given group pile configurations (a group pile having 9 component piles with a pile formation of 3 × 3), the horizontal resistance increased with increasing pile spacing. The maximum ultimate horizontal resistances were found at the loading locations of 50% of the embedded depth. Unlikely in the single suction pile case, the significantly maintained residual resistances were found for group suction piles. The residual resistances of group suction piles were at least higher than 40% of the corresponding ultimate horizontal resistances.