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Study of the Soil-Structure Interaction of Suction Caissons with Advanced Finite-Element Methods

Shin-Tower Wang [1*], Lisa J. Novak [2], H. Theodore Lin [3]

[1] *Project Manager, Ensoft, Inc./Lymon C. Reese & Associates, P. O. Box 180348, Austin, Texas*
[2] *Project Engineer, Ensoft, Inc./Lymon C. Reese & Associates, P. O. Box 180348, Austin, Texas*
[3] *AMPS Technologies Company, 1138 Fox Chapel Road, Pittsburgh, PA 15238*
e-mail: stw@ensoftinc.com, lisa@ensoftinc.com, tedlin@ampstech.com

Abstract

The term "suction caisson" originated in the offshore industry where engineers conceived the idea of installing the bucket foundation for offshore structures using the self-weight and suction pressure inside the bucket. The suction caisson typically is made of steel and has a diameter of 8 to 12 meters with skirts around the periphery, rather like an upturned bucket. The installation is completed by reducing the water pressure inside the bucket, thus forcing the skirts into the seafloor. The in-service performance, particularly when combined vertical, lateral, and moment loads are applied, must be studied so that a safe design can be achieved.

Many proposals have been made for methods of analysis for the suction caisson. In general, there were three broad classes of methods of analysis: simplified limit-state methods; approximate computer-based semi-empirical methods; and more rigorous nonlinear finite-element methods (FEM). Two strong reasons dictate the use of the FEM: (1) the problem is so complex that simplified methods cannot model the soil-structure interaction correctly; and (2) codes for the FEM are available, powerful, and capable of being run on the personal computer. The three-dimensional FEM computer program is available for solving those complicated problems involving different soil behaviors inside and outside the bucket foundation.

One critical element in design of suction caissons in different environments is to analyze the penetration needed for the suction piles to sustain wave loads created by the maximum storm. With regard to modeling the problem, the vertical load coupled with the overturning moment on the foundation requires the soil to provide sufficient contact friction on the skirts. The excessive horizontal movement of the caisson pushed by the lateral load may leave a "gap" behind between the steel and the surrounding soil. All these special problems are beyond the capability of any simplified method. Thus, modeling of the suction caisson and supporting soil as a nonlinear/plasticity problem using FEM is a preferable method. Furthermore, the designer can easily investigate alternate geometries, can study the influence of the various parameters on a solution, and can produce results that are instructive and valuable.

REFERENCES

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