Numerical Study of Piping Limits for Suction Installation of Offshore Skirted Foundations an Anchors in Layered Sand

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Numerical study of piping limits for suction installation of offshore skirted foundations and anchors in layered sand

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Abstracts

Skirted foundations and anchors have proved to be competitive solutions for various types of fixed offshore platforms, subsea systems and an attractive foundation alternative for offshore wind turbines. One main design challenge for skirted structures in sand is to penetrate the skirted deep enough to obtain the required capacity. In order to overcome the high penetration resistance in sand suction assisted penetration is needed. Suction installation may cause the formation of piping channels, which break down the hydraulic seal and prevent further installation. This paper presents a numerical study of failure limits during suction installation in respect to both homogenous and layered soil profile. A numerical flow analysis is performed to determine the hydraulic gradients developing in response to the suction applied, and the results are presented as simple closed form solutions useful for evaluation of suction thresholds against piping. These closed form solutions are compared with large scale tests, performed in a natural seabed at a test site in Frederikshavn, Denmark. These solutions are also valid for penetration studies of other offshore skirted foundations and anchors using suction assisted penetration in homogeneous or layered sand.

Due to the complexity of the domain and the governing differential equation, the problem is solved numerically. A numerical solution can be obtained using either finite difference or finite element methods. In this paper, the problem is solved using the commercial finite difference program FLAC3D (Itasca, 2005).

Conclusion

By comparing the numerical studies with the installation tests it is shown that it is the exit gradient next to the skirt which controls when piping will occur.

For installation in homogeneous sand, the internal hydraulic gradients have been investigated by several researchers using computer programmes such as Plaxis, SEEP and FLAC. These studies have resulted in different formulations, but the empirical expressions predict similar critical suctions for skirt penetrations of practical interest.

However, experience from installation of prototype foundations have shown that gradients close to critical, predicted by the expressions for homogenous sand, can be applied without significant consequences.

The same was observed in the field test reported in this paper. It is stated that the presence of thin silt layers will act as flow boundaries and increase the suction thresholds against piping.

The influence of the flow boundary was studied in this paper. The results are presented as simple closed form solutions and shown to predict thresholds against piping in homogeneous or layered sand.

Future studies have to be performed in order to establish the thresholds against piping when the skirt penetrates through a flow boundary.