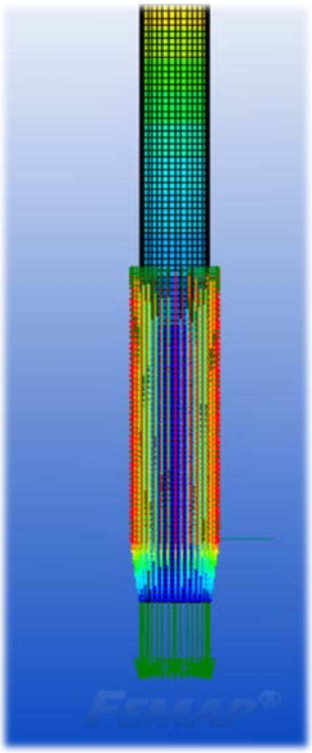
Offshore & Dredging Engineering

Technische Universiteit Delft

Development of an effective pile-soil reactin model to research the optimization of vibratory driving of monopile foundation pile with the GBM Vibrodrill system

As the offshore wind industry grows, the demand for larger wind turbines and foundations increases. The most common foundation type for a wind turbine is a monopile which is currently installed by large hydraulic hammers. This installation method generates a lot of underwater noise which may harm marine life. To solve this problem and its unwanted consequences, GBM aims to implement a new silent installation technique. By applying fluidization, jetting and by inducing vibrations by harmonically exciting the bottom of the pile, both the dynamic tip resistance and the shaft resistance are reduced so that the monopile can penetrate the soil. These techniques are aimed to produce less harmful underwater noise than conventional hammering.



Little is known about the penetration performance of a pile which is harmonically excited at the bottom. This thesis aims to provide more insight on the penetration performance when exciting a pile at the tip.
A literature study is performed on existing pile penetration models. From this study it is concluded that, currently, there are no available penetration models capable of describing the penetration performance of the pile when exciting the system at the bottom with varying harmonic excitations. Therefore, the aim of this thesis is to develop a new penetration model. The purpose of this model is to describe the penetration performance at different harmonic force parameters. The developed model is based on finite elements by using the FEMAP software. The pile is represented by shell elements. The interaction between the pile and the soil is modeled using multiple spring-damper-slider elements which are spread along the pile surface. The slider elements allow the relative motion between the pile and the surrounding soil. The different soil-structure interaction elements are uncoupled and the sliding resistance is assumed linearly elastic, perfectly plastic. Energy radiation due to elastic waves is captured by simple dashpot elements.

The developed model is used to analyze the effect of certain parameters on the penetration of the pile. This is done by changing the amplitude, the frequency or the direction of the harmonic force for a specific set of soil parameters. For each variation, the model calculates the pile displacement at a certain depth from which the penetration speed is determined. This penetration speed is then compared to the other results to determine the effect of each chosen parameter. Also, the location of excitation is analyzed. The model is used to analyze a pile which is excited from the top or at the bottom.

From the results it is concluded that an increase in the amplitude and the frequency of the excitation has a positive effect on the penetration speed. The dependence of the direction of the vibration on the pile penetration is complex. Therefore, a clear correlation between the two could not be obtained within the time framework of this research. Finally, it is concluded that exciting the pile from the top results in a faster penetration speed compared to a pile which is excited at the bottom.

This research provides is a first step towards understanding of the Vibro-drill system performance. As this is an investigation which is still in progress there are some recommendations for further research on this topic. One important recommendation is to improve the soil reaction in the model to a coupled system where it is now uncoupled. Furthermore field tests can be performed providing more knowledge on the effects of the soil and to validate the model.

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