TU Delft

Offshore & Dredging Engineering

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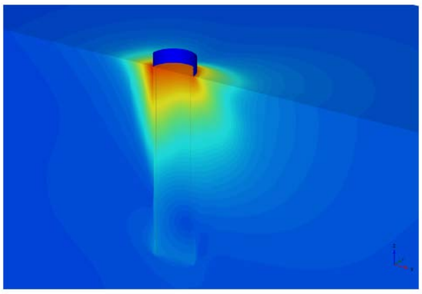
Lateral bearing capacity of GBM Vibro-drill installed monopiles

Offshore wind turbines are commonly supported by monopile foundations. Impact hammering is the conventional method for installing offshore monopiles but has several disadvantages. Time-consuming installation procedures, high noise emissions and steel fatigue due to the high impact are problems resulting from this installation procedure. GBM Works is a start-up that is currently developing the Vibro-drill: a new method for installing monopiles, aiming to solve the stated problems associated with the hammering method. The Vibro-drill is mounted at the bottom of monopile and uses vibrating elements that simultaneously jet water, aiming to reduce the soil resistance. As a result, the monopile can penetrate the soil to target depth under its own weight.
The monopile foundation is designed to support an offshore wind turbine throughout its lifetime of about 25 years. As the wind turbine is primarily subjected to lateral loads, one of the major design requirements is the stability of the pile in terms of lateral bearing capacity. Hammered piles have shown to provide sufficient lateral bearing capacity and this method has been used world-wide to install monopile foundations. Because the Vibro-drill machine is a unique and new concept, there is insufficient knowledge about the installation effects. Therefore, the lateral bearing capacity of a Vibro-drill installed pile is yet unknown.
Before this new method can enter the offshore wind market, it needs to be researched and demonstrated that this new method provides sufficient bearing capacity for an offshore wind turbine. To that end, this thesis contains a study regarding the possible soil effects and resulting bearing capacity of Vibro-drill installed monopiles.

Predictions of the monopile response were done with a finite element model in Plaxis 3D. The numerical model was verified based on data from monopile tests in Cuxhaven from 2014. During these full-scale field tests, three pile pairs were installed in dense sand by vibro-driving and hammering. The effect of the methods was quantified by lateral load tests on both piles. The input parameters for the Plaxis model were derived from CPT measurements using empirical relations based on relative density recommended for monopile design. The FEM predictions show a fit with the field-measurements during initial loading where after the curves start to deviate. The differences between the FEM prediction and the field measurements are discussed, expected is that they are caused by creep effects that occur in the field.

As no soil effects as result from Vibro-drill installation have yet been measured, a worst-case approach was taken to identify the risks concerning the lateral bearing capacity. A hypothetic soil disturbance as result of Vibro-drill installation was generated based on studies regarding soil effect due to existing vibrating and jetting methods. Different worst-case scenarios of possible soil effects were sketched to study the resulting pile reaction due to a horizontal applied load. This was done by comparing the monopile response of a hammered and vibro-drill installed pile and increasing the pile size of the Vibro-drilled pile iteratively until a similar reaction to the hammered pile was obtained. In this way, the effect of a Vibro-drill installation was quantified in terms of additional pile material. For the studied scenarios, an additional proportion ranging from 17% to 29% of the embedded pile material was required to compensate for the softer pile reaction. Also, a study on the effect of pile size has shown that for larger piles, a lower proportion of additional pile material is required to compensate for a possible softer pile response resulting from Vibro-drill installation.



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