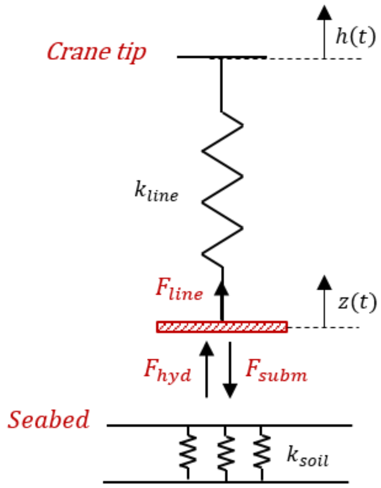
Technische Universiteit Delft

Offshore & Dredging Engineering

Analysis of the set-down of structures onto the seabed

During an offshore installation procedure, a structure is lifted of the barge, lowered through the wave zone and water column and eventually set down on the seabed. As the structure reaches the seafloor with certain set-down velocity, water will move out of the way resulting in soil being washed away underneath the structure. The resulting hydrodynamic pressure and potentially disturbed soil play a role in the structure's set-down, motion behaviour and stability. It is expected that the allowable set-down velocity, for which safe installation can be guaranteed, is related to the occurring hydrodynamic force and to the (allowable) soil deformation. To acquire more insight in this relation, the objective of this thesis is to increase the understanding how the set-down of structures on the seabed is influenced by the soil. To achieve this, a simplified dynamic model (figure 1) describing the lowering to and installation onto the seabed of a structure is established. Throughout this study the structure has been simplified to a disk.



The hydrodynamic or added mass force acting on the disk is similar to the method described in literature by Brennen. Brennen's flat plate analogy has been applied and used to derive a force acting on a closed disk (1D model) and one for an open disk (2D model). Whereas the 1D model includes only horizontal fluid flow velocity, the 2D model also takes vertical flow velocity into account.

From the analysis on the behaviour of the hydrodynamic force it was observed that the force rises with increasing proximity to the seabed. This is explained by the dominance of an extra added mass term in the derived function. Once R/z >> 1 applies, the force starts to behave like a water cushion, complicating the structure's landing procedure onto the seabed.

In the analysis of the closed 1D model, it became clear that the significant increase in the hydrodynamic force leads to a reduction in the structure’s velocity as it nearly reaches the seabed. After landing onto the seabed the structure, connected in a kinematic manner with the soil, starts to settle. The results for the 2D model, including a valve (R_v = 0.75 m) with actual vertical flow velocity, showed a lower magnitude in hydrodynamic force. The magnitude of the vertical flow velocity is expected to depend on the valve radius and structure’s motion.

The conducted sensitivity analysis proved that the size of a valve has a clear impact on the hydrodynamic force. Larger valves result in lower magnitudes of the hydrodynamic force, corresponding to a smaller estimated amount of soil disturbance. No significant difference in the vertical flow velocity for different valve sizes was observed. The force's sensitivity for phasing and frequency was emphasized by the analysis for various crane tip heave motions. Rough heave motions correspond to the largest momentum of the force engendering the highest amount of soil disturbance. Even in favourable conditions, the momentum varies considerably for different phases. The influence of the structural mass and soil type is relatively small compared to the impact of the crane tip heave motions and the valve size.

Further work includes additional research on the expression for the 2D hydrodynamic force and analyzing the relation between the vertical and horizontal flow velocity. By including the skirts and a real suction pile, a more realistic analysis of the set-down of suction piles onto the seabed is obtained. By varying the constant crane lowering velocity, optimizing the valve size and determining acceptable weather conditions, the most favourable scenario for the set-down of a suction pile on the seabed can be acquired.

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April 20th, 2017

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