Investigating the installation of innovative suction caisson anchors to support offshore renewable energy structures, a feasibility study

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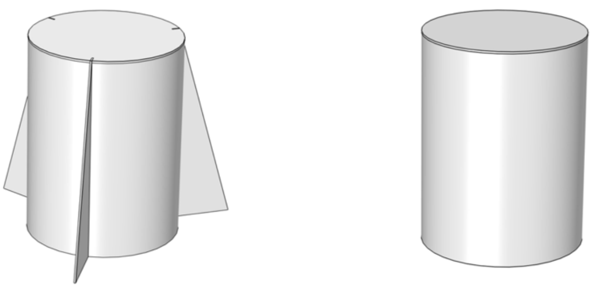
Foundations and mooring systems can be accounted for >20% of total costs of offshore structures including costs of their installation; this cost is likely to increase nonlinearly the further we go offshore [1]. Therefore, innovative solutions that can reduce costs associated with offshore foundations including costs of materials, transportation of structures and equipment, and costs of machinery for installation are vital in sustainable developments of future offshore wind farms. Suction caisson anchors (SCAs) are considered as a highly attractive solution for deep waters and their advantages over other types of offshore foundations have been extensively documented [2-3]. They have simple installation and easy removal processes and offer significant cost saving due to lower material requirements compared with other offshore foundations (e.g., piles).

Previous studies have demonstrated benefits of adding structural elements to caisson anchors to improve their pull-out [4-6] through numerical modelling. These studies have reported potential of additional capacity in orders of 30-40% compared with standard caisson anchors through generating additional pull-out capacity. However, so far, no studies have examined the mere feasibility and impacts of these additional structural elements on the installation process of the enhanced anchors. This has hindered their potential as an innovative solution to support offshore wind structures, thereby preventing their uptake by industry.

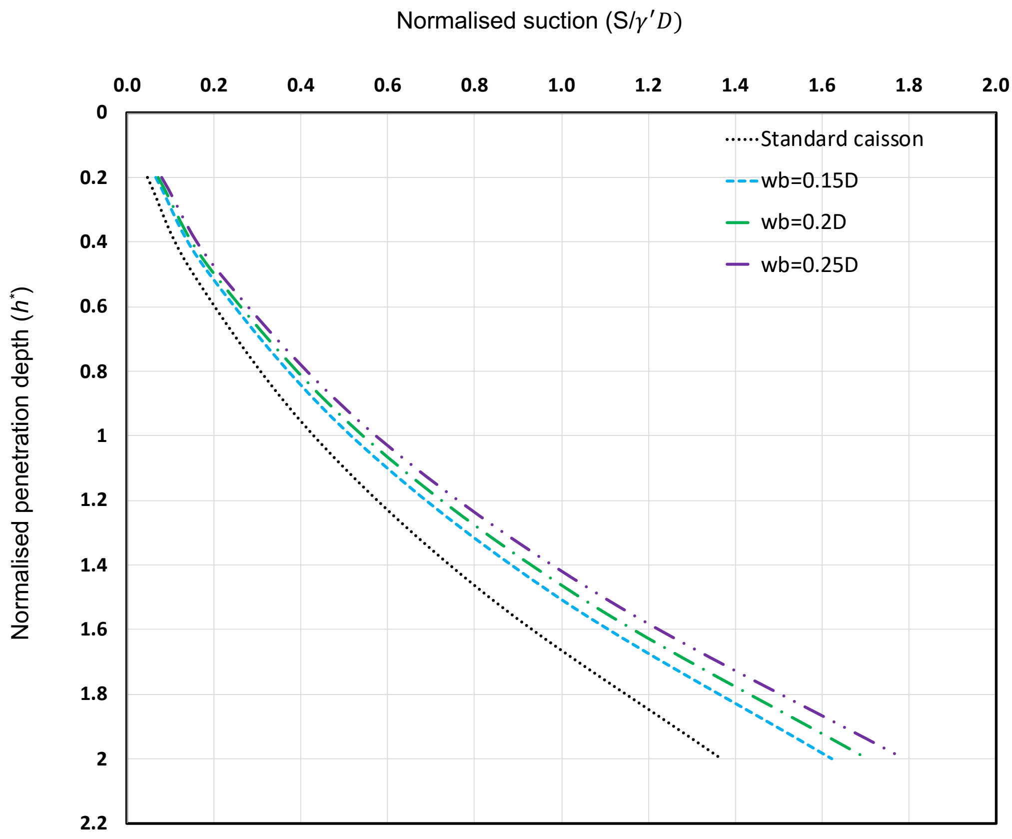
This project was motivated by the need for a novel offshore caisson anchor that potentially can increase pull-out resistance and torsion bearing capacity compared to a standard caisson anchor. First part of this project focused mainly on the feasibility and safety of the installation process by means of numerical simulations. To this aim, the installation performance of a series of structurally enhanced suction caisson anchors were investigated (Fig. 1) in various sands.



(a) (b)

Figure 1. (a) Schematic 3D drawing of a structurally enhanced suction caisson, (b) Standard caisson

A full numerical procedure was defined and implemented in COMSOL Multiphysics. The numerical modelling prediction for the required suction for installation of a standard suction caisson anchor were validated against a couple of field trials. Using the developed numerical model, the impacts of the added structural elements (flanges) on the required suction for installation (soil resistances) during installation were extensively investigated. The results of this study quantified the soil resistances hence the required suction to installation the suction caisson anchors with various flange base sizes relative to the case of a standard caisson. For instance, in compared to a standard caisson (without any additional structural elements), a structurally enhanced caisson with a flange base size of 0.15D, 0.2D and 0.25D, require an increase of suction magnitude by about 18%, 25% and 30%, respectively, at their full installation process (Please see figure 2.).



The SUPERGEN ECR funding has helped us to set up a small scale 1g experiment for further validation of the above numerical model in addition to investigation of further geometries (e.g., different number of flanges with various shape such as rectangular). The results of the experimental part will be made available once we finalised all the experiments. It should be highlighted that the results of the numerical part have been submitted to a prestigious journal and will be published soon.

References: [1] Bosma et al., Proc. of 11th EU Wave & Tidal Energy, France, 2015. [2] Houlsby GT, Ibsen LB, Byrne B., Australia. 2005, 75-93. [3] Byrne et al. Wind Engineering. 2002; 26(3):145-55. [4] Na et al., Proc. of the 7th international conference on Asian and Pacific coasts, 860-865 [5] Kwag et al. J. Offshore Mech. Arct. Eng 2010, 132(2) [6] Monajemi and Abdul Razek. 12th Int. Conf. of Association for Computer Methods and Advances in Geomechanics, 1-6 Oct, 2008.[7] Harireche O, Mehravar M, Alani AM. Ocean engineering. 2014, 88:164-73. [8] Mehravar M, Harireche O, Faramarzi A, Alani AM. Ships and Offshore Structures. 2017;12(7): 893-9. [9] Houlsby, G. T; Byrne, B. W. Proceedings of the Institution of Civil Engineers, Geotechnical Engineering. 2005, 158(3), 135-144.