Installation of Monopiles for Offshore Wind Turbine Foundations

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Introduction

In time of instabilities in oil prices and increasing energy demand, wind energy appears as a clean alternative with an enormous potential onshore and offshore. The European Union Directive 2009/28/EC sets the objective of reaching 20% of the EU´s energy consumption through renewable sources by 2020 (EU, 2009).

There are many advantages to **offshore wind energy** over its onshore counterpart: stronger winds offshore imply greater productivity, installing wind turbines sufficiently far from the shore can eliminate issues of visual impact and noise, vast areas available for the installation of wind farms, the possibility of different designs for the turbines, improving their efficiency. On the other hand, several challenges are met: investments in towers, foundations and underwater cabling, together with the installation costs make offshore wind energy more expensive than onshore (Breton & Moe, 2008).

In order to meet standards given by EU directive, where offshore wind plays a crucial role in securing clean and stable energy supply in the future, it is vital to address technical, economical and environmental challenges associated with this field.

Figure 1. Offshore wind farm locations in Europe in 2015 (European Atlas of Seas, 2015)

There are several solutions for offshore foundation design, mainly depending on water depth: gravity based foundation, monopile foundation, monopod bucket foundation and jacket foundation (Figure 2). **Today, more than 65% of offshore wind turbines are monopile structures.**

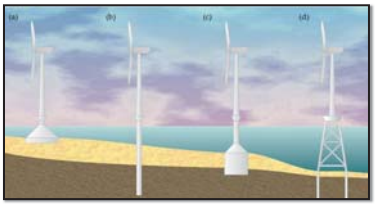


Figure 2. Bottom fixed offshore foundations: (a) gravity based; (b) monopile; (c) monopod bucket; (d) jacket (L.Andersen & Clausen)

Objectives

The objective of this PhD study is to provide better understanding of soil resistance to driving for large diameter piles. The goal is to come up with better predictions, ensuring essential information about how easy it would be to drive piles into the ground, resulting in accurate estimate of the project.

The research will focus on improvement and further development of empirical factors used to predict pile driveability, with special emphasis on **SRD (Static Resistance to Driving).**

Evaluation of correct input of static resistance, setting the right parameters for dynamic resistance, taking soil set up into consideration, are some of the requirements needed to achieve an accurate model.

Based on available SRD methods (Toolan & Fox, 1976; Semple & Gemeinhardt, 1981; Steven et al., 1982; Alm & Hamre, 1998), this research will provide an insight into the likelihood of achieving enhanced predictions by changes in soil interpretations and current methods, to scope an optimum offshore wind turbine foundation design.

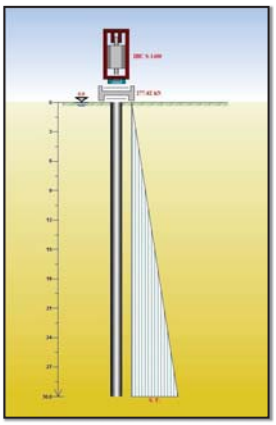
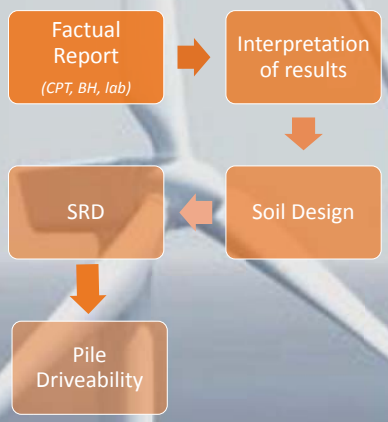


Figure 3. GRLWEAP model (hammer, driving system, pile, soil)



Research Process

The scope of literature study:

- To start from study of wave equation analysis and dynamic monitoring of pile driving, leading to a next step of assessing and reviewing several existing methods and theories for pile driveability predictions.
- Investigation of soil resistance and back calculation of the data collected during installation of numerous wind farms offshore (received from DONG Energy), will lead to adjustments made within **GRLWEAP** (Figure 3), a software most widely used for wave equation analysis.
- Possibility of extending research to weak and weathered rock should; a lot of uncertainties when predicting pile driving in chalk and mudstones.

Expected Outcome

- To improve the estimate of input parameters for **driveability predictions** based on back calculation of a quantity of data collected from the field. The research will be focused on **monopile foundations of large diameter**, as an optimum design to overcome larger depths at minimum cost.
- If the final result is successful, it means large contribution to offshore wind industry, making sure that a selected soil-pile-hammer system is feasible which leads to lowering the installation costs and possibly attracting more investments in this energy solution. Contribution is also made to the society whose enormous need of energy could be satisfied from a renewable source.

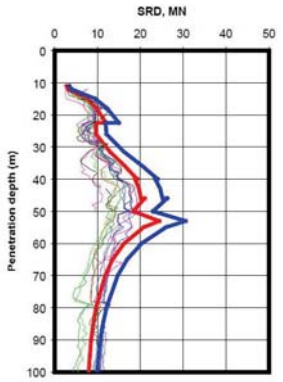


Figure 4. Example of results from back calculations and post predictions of SRD (Alm & Hamre)

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