DRAFT – Offshore monopile decommissioning on a scaled basis

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Summary

1. Introduction

The German offshore wind industry has historically grown since the first offshore wind farm (OWF) “alpha ventus” was completed in 2010. Since the end of 2017 a total number of 18 OWF with a capacity of about 5 GW have been operating in the German Exclusive Economic Zone (EEZ). While the majority of the population and the industry focus on new projects, it appears the life cycle observation and especially the decommissioning phase remain largely unattended. This narrow view can lead to unexpected and expensive consequences in the future. The decommissioning of a complex structure as an offshore wind turbine (OWT) needs to be planned well in advance. There are numerous aspects that make the decommissioning a challenge, such as the federal regulations, the marine environment and the technical limitations of offshore operations.
The Institute of Foundation Engineering and Soil Mechanics of the Technische Universität Braunschweig (IGB-TUBS) is developing and testing methods to remove offshore monopiles completely. This paper will summarise the findings of the decommissioning investigation and will outline possibilities for future decommissioning challenges.

2. Test setup

Scale model investigations are carried out in cylindrical testing buckets at IGB-TUBS. The dimensions of the buckets are shown in figure 1. The bucket was filled with saturated fine sand.
A steel pipe with a length of 3 m, a diameter of 0.61 m, a wall thickness of 3 mm and mass of 132 kg is used as model pile.

2.1 Vibratory decommissioning
Vibratory pile driving is considered as one of the most promising methods for offshore monopile installation.

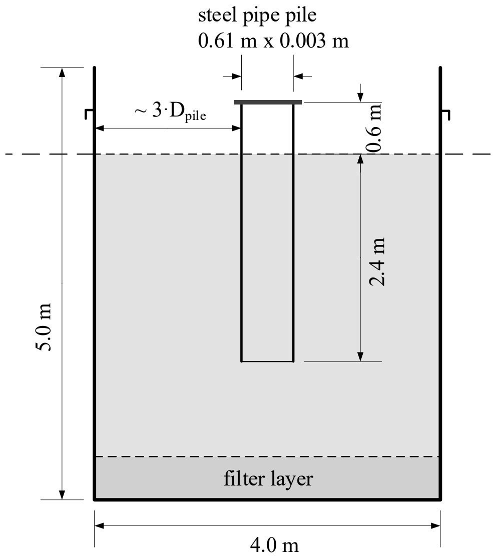

Fig. 1: sketch of the geotechnical testing buckets (cylindrical) at IGB-TUBS and model pile

The decommissioning of a steel pile by means of a vibrator is using the same physical phenomena as for installation. The vibrator generates a frequent up and down movement of the pile and the surrounding soil. Due to the acceleration of the soil particles around the pile, the soil may reach a state of liquefaction and the shaft resistance is reduced drastically.
For the decommissioning tests, two different vibrators (APE Model 3, J&M Model 23) were used. During the tests a variety of sensors were monitoring the acceleration and frequency of the vibrator, the strain along the pile shaft and the required line pull.

Fig. 2: pile extraction with APE Model 3

2.2 Over pressure decommissioning

During another test an alternative setup was used to overcame the total breakout resistance. For this, the pile head and all existing holes and gaps were sealed. The barometric pressure inside the pile was increased until the air overcame the hydrostatic pressure of the water column. The escaping air lead to a soil degradation around the pile shaft which drastically reduced the pile's breakout resistance. The over pressure test setup is shown in figure 3.

Fig. 3 pile extraction with over pressure

2.3. Static load test

To validate the effectiveness of the used decommissioning techniques and to determine the maximum breakout resistance of the model pile, a static load test was carried out. The experimental setup is displayed in figure 4.

Fig. 4: static load test to determine the breakout resistance

The proposed paper will give detailed information on the test setup and the different techniques used for decommissioning tests. From the recorded measurement data, conclusions regarding the effectiveness of the methods and the most important parameters will be drawn. Finally, considerations on the feasibility for offshore applications will be undertaken.