Introduction

In most geotechnical problems the prediction of ultimate capacity and initial stiffness is of great importance. While bearing capacity drives the pile dimensions, the initial stiffness plays a role in the entire sub-structure system for instance in the so-called superelement analysis (Thieken et al., 2016). A straightforward method for the estimation of the initial stiffness of axially loaded piles are the load transfer curves also called t-z curves (API 2011; Fleming, 1992; Bohn et al., 2016).

Experimental work

The Test Center for Support Structures of the Leibniz Universität Hannover offers ideal conditions for high quality pile testing. Through large-scale physical modelling design methods can be validated or new design approaches can be tested and calibrated. The Fraunhofer IWES has been carrying out numerous experimental campaigns concerning instrumented and non-instrumented axially loaded piles. In Figure 1 the installation and the test phase of a piled foundation is shown. The database assembled through public funded projects by the Fraunhofer IWES and additional existing well-documented databases (Yang et al. 2015) will be used within the GIGAWIND project in order to validate and possibly put forward load transfer curves.

Motivation

In water depths larger than 40 m offshore wind converters are likely to be supported by jacket structures founded on pile foundations. To gain new knowledge on both ultimate capacity and load displacement behaviour of piles in tension a number of experimental campaign are being conducted at the Test Centre for Support Structures of the Leibniz University Hannover. Load transfer curves, as straightforward tool to estimate the load-displacement of axially loaded piles, are crucial to the design of jacket sub-structures. This poster reports on the research objectives of Fraunhofer IWES, Section Support Structures, within the project GIGAWIND in regards to load transfer curves for axially loaded piles.

Implementation of load transfer curves

The formulations of load transfer curves are rather heterogeneous. A specific t-z curve may involve deformation parameters as well as ultimate skin friction values. The data interpretation conducted so far showed promising results. In this contribution, only a selection of three representative t-z curves is reported. The best fit of the initial stiffness is displayed by the load transfer curves of Fleming (1992) which are able to retrospectively simulate the load displacement experimental curves until at least 50% of the ultimate load. Further in the development of load-displacement curve the predictions present overestimations of the experimental data. The curve of Bohn et al. (2016) captures the overall shape of the experimental data acceptably well. However, the initial stiffness is not well reproduced. The prediction of API (2011) cannot match the experimental curve and shows a conservative initial stiffness and a stiff response thereafter.

Conclusions and outlook

Load transfer curves for axially loaded piles are crucial to the determination of the overall stiffness of jacket sub-structures for offshore wind turbines (e.g. the so-called superelement simulations). Large-scale geotechnical physical modelling gives irreplaceable chances for testing or proposing new load transfer curves. Within the project GIGAWIND the following objectives are being pursued:

- to examine existing well-documented database such as Yang et al. (2015) and Fraunhofer IWES’ in relation to general load bearing behaviour;
- to understand whether the stiffness of the piled foundations system is affected by the presence of sensors on the pile shaft and if so estimate how significantly and how alternative instrumentation techniques could be adopted;

Good estimation of the load transfer curves are also possible with finite element methods. Though the lack of well-established contact models defining the interface between pile shaft and soil medium limits their usage. Advancements in this direction would also be desired.

References


Fig. 1: Photos of the large-scale experimental tests carried out at the Test Centre for Support Structures. a) detail of a pile during the installation test; b) detail of Pile 4 during the tensile load test. Campaign conducted within the European project IRPWind.