Tubular Pile Pull-Out Test JIP - update April 2023

Reducing cost of offshore foundations

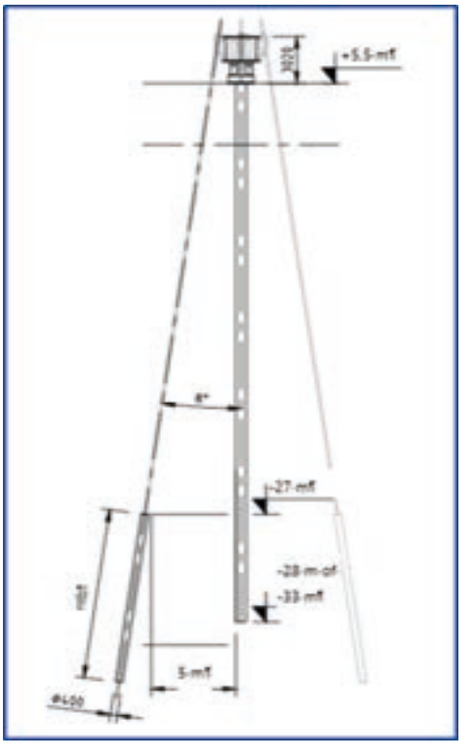
The Tubular Pile Pull-Out Test (TPPT) project has executed field tests on four fully instrumented open steel tubular anchor piles at the Maasvlakte. These tests have been successfully completed in Q1 2023, resulting in a large amount of interesting pile pull as well as pile push capacity data. Better understanding of the pile capacities will reduce the cost of offshore foundations, which is vital for the required acceleration in deployment of offshore wind. See below QR code for a project update on LinkedIn.

Picture of tension test set-up

In the next phase of the JIP project, the collected data will be investigated. The data will be processed, evaluated and interpreted to draw conclusions for pile design and to provide input to new international codes and standards.

This research project is set up by the current JIP participants, and the technical advisors Deltares, NGI and TU Delft.

Through this JIP participants will obtain early access to all collected and confidential test data. JIP participants are directly involved in the research steps to achieve the update of industry guidelines.



Schematic overview of the compression test set-up

Do you want to join?

The JIP is open for new participants to join:

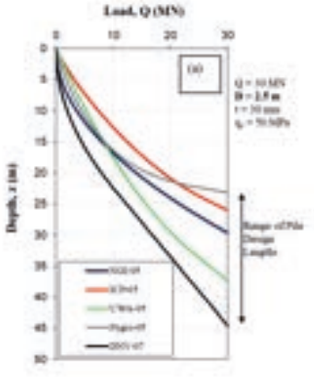
- JIP contribution for Industry and offshore wind developers is € 91,000
- JIP contribution for classification and certification societies is € 42,500

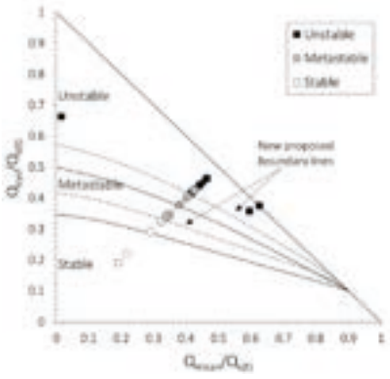
The TPPT Joint Industry Project (JIP) was set-up under a GROW initiative (Growth through Research, development & demonstration in Offshore Wind).

This project is supported by Energy Innovation NL and TKI Offshore Energy.

Background information

Research efforts executed in recent years have led to improved design methods to estimate the short-term (unaged) ultimate compression and tensile capacity of piles, being the reason for the participants to join this large-scale testing program. Under environmental loads, the effects of friction fatigue can lead to a failure mechanism in which cyclical environmental loads far below the maximum pile capacity can still lead to pile failure. Igoe and Gavin (2021) developed cyclic loading interaction diagrams of the form shown in the figure below from tests performed on open-ended piles with diameters ranging from 340mm to 508mm. The data show that failure can occur at cyclic load levels of only 20% of the tensile capacity of a pile in sand.





Very limited data is available for piles loaded in tension under (partial) cyclic loads for validating various foundation design models. It is likely that new factual data on the behaviour of tubular piles in sand subject to cyclical tension loads can lead to improved designs.

Open-ended steel pipe piles with Ø1.22 m are commonly used offshore to support jackets or for mooring of floating structures due to the rapid means of installation with the least risk. Often, once in use these piles are getting cyclic axial loaded and the tensile shaft resistance governs the design. Determining the optimal required pile length to meet the ultimate tensile capacity is one of the greatest uncertainties in offshore design which leads to unknown risks.

A total of four piles (O.D Ø1.22 m with lengths of 33 m (2 piles) and 38 m (2 piles)) were tested. The piles were equipped with fibre optic sensors along the full pile length. The tests were executed in accordance with NPC072 standards, class A1. In total in excess of 300 hrs of Compression and Tension (Combination of Static and Cyclic) load test data has been collected from the fibre optic cables.

The uniqueness of the TPPT project executed on the Maasvlakte is how the piles are instrumented. This has enabled the participants to collect a large set of factual data of pile behaviour in two different campaigns. In 2022 the piles were loaded under compression while in Q1 2023 the loading was under tension (combination of a static and cyclic load). The factual data set will provide more insight into the effects of cyclic degradation occurring on the soil-pile interface versus pile penetration depth. Besides, with the UBC and UHC being defined by using various commonly in place design methods and with the Unified CPT method the TPPT data set provides the factual proof of the suitability of the method for the design of offshore renewable foundations.

Overall it is expected that the better understanding of the soil-pile interface behaviour would result that certification authorities will lower their set of factors of safety in the design and verification of the multiple anchor point structures. The data set will improve reliability in offshore engineering and positively contribute to reducing offshore (renewable) foundations‘ carbon footprint and cost.