TU Delft

Offshore & Dredging Engineering

Technische Universiteit Delft

Design optimisation of an adjustable Pre-Piling-Template for offshore wind-turbine installations

The demand for a substantial increase in renewable energy causes the need for more and bigger wind turbines. To counter the problem of available space, windfarms will move into deeper water. The challenge of deeper water in combination with higher turbines, require new developments in the wind industry. The often used monopiles make way for a new jacket-founded windturbine. Installation of these type of structures opens a market for a so called Pre-Piling Template.
This thesis aims to analyze the adjustability of the Pre-Piling Template for windturbine installation based on quasi-static calculations.

First a number of conceptual designs of a versatile adjustable Pre-Pilling Template are made. A wide variety of configurations is configured. The complicated part of the design is that the Pre-Piling Template must be viable for a three-legged and four-legged configurations with several centre-to-centre distances. Thereby, it should be possible to convert the entire system on deck of a vessel during given offshore conditions. From eleven concepts a selection of two alternatives has been made, based on listed criteria by the client: Robustness, Adjustability, Financial costs and Safety.

For two selected cross-centre alternatives a global structural analysis is performed under environmental loading. One cross-centre is a composed cross centre, with which a three- and four-legged configuration can be installed with the same cross-centre mid-frame of the PPT. The other alternative consist of two separate mid-frames, one for a three- and one for a four-legged configuration. To speed up the installation process, primarily all the piles to be installed will be stabbed into the Pre-Piling Template. After all piles have been stabbed into the frame, the hammering procedure will start. When all piles are stabbed significant forces arises from wind and especially hydrodynamic actions. The static deformations of the template induced during the multiple installation steps can cause overall displacements of the centre of each particular sleeve.

The added value of a Pre-Piling Template is the installation speed versus the required accuracy of the pile installation. A high installation speed only makes sense if piles can be installed within the required tolerances. Therefore the deformations of the frame and the corresponding displacements are governing. To determine the displacements, a 3D-model is constructed and a rotational and translational spring is implemented to model the soil-structure interaction. To consider this soil-structure interaction, a model by A.B. Cammaert et al (2011) is used to determine the required stiffnesses. The model is modelled using Matrix Frame software, with which the final displacements, at the height of the mid-frame, have been determined.

A detailed analysis of the static internal forces is worked out based on a bolted flange-flange connection. Checks are done conform Det Norske Veritas (2010) and based on a ULS-driven design. Two potential connection configurations are worked out; an alternative with less but more heavy bolts of M64, as well as an alternative with substantial more smaller bolts of M36.

Finally, several optimisations are identified to speed up the installation time of assembling and disassembling the adjustable Pre-Piling Template. Recommendations are made in cooperation with Breman Machinery and will result, in consultation with installation experts that are well known with the barge of the client, to a final design.

A clear conclusion, about the PPT-design, can not be made because the installation is site specific. If a project includes two different configurations, a three- and four-legged foundation design, a composed mid-frame that is viable for both configurations is recommended. For this composed mid-frame variant the operation to adjust the frame to another footprint can be done more efficient with a higher safety level on deck of the vessel.

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