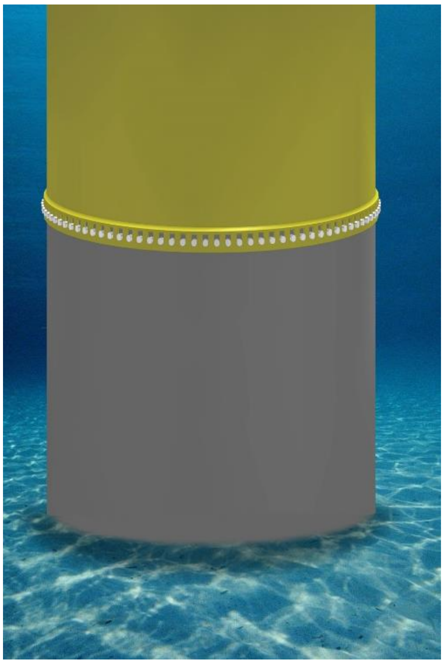
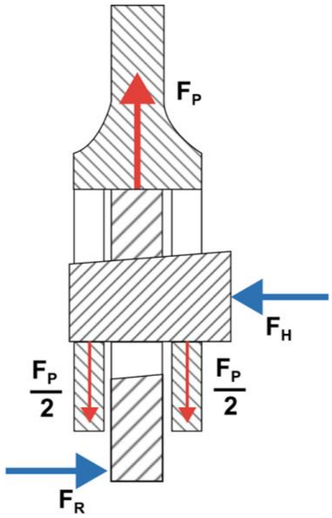
The field of wind energy has experienced significant expansion and development driven by the need to reduce reliance on fossil fuels. Offshore wind turbines have become increasingly popular leading to larger turbines with greater energy output to match the growing demand. The most common foundation type of offshore wind turbines is the monopile foundation, consisting of two large diameter steel tubulars, the monopile (MP) and the transition piece (TP).



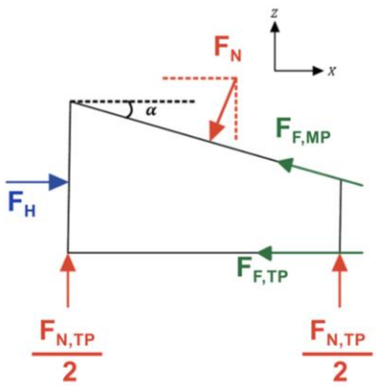
As wind turbine generators (WTGs) increase in size, the transportation and installation of MP foundations becomes more complex and expensive, requiring specialized vessels with adequate lifting capacity. This research investigates a new connection – the underwater wedge connection – as a method of connecting an MP to a TP underwater. By having an underwater connection, the size of the MP can be reduced as it no longer has to exceed the waterline.

The wedge connection consists of a dowel with an inclined plane and two flanges. A number of dowels will be placed around the circumference of the connection, fitted onto flanges on both the MP and TP. As the dowels are pushed into position, the inclined plane creates a vertical preload between the two flanges. This allows a tensile load on a segment of the connection (caused by the bending moment in the foundation) to be transferred to the foundation via two load paths: reduction of the preload, and by loading the dowel itself in shear.



First an analysis on the current state of art and relevant design codes was carried out. This analysis highlighted the requirements the connection needed to satisfy, in order to serve as starting points to make decisions regarding the design. The preliminary design of the connection is made using analytical calculations. The structural integrity of the flanges and the dowel at the Ultimate Limit State (ULS) was verified. A 3D model of the connection was then created to perform numerical analyses using ANSYS Static Structural. The behaviour of the connection under ULS and Fatigue Limit State (FLS) loading is studied. The opening and failure point of the connection along with the sensitivity of various parameters are also investigated.

The results show that connection was able to effectively transfer both tension and compression loads. The connection has a mechanical advantage of 1.95, meaning that it achieves the same preload as the ULS load by applying only 51.3% of the ULS segment load during installation. The connection opens gradually and only opens at a load higher than the ULS load. Even after opening, it continues to transmit loads effectively, with ultimate failure governed by the yielding of the lower flange. Additionally, the connection exhibits good fatigue resistance, with a low fatigue damage level of 3.8%.



It is recommended to conduct experiments to validate the numerical model employed in this study. Further studies should also be carried out to investigate the impact of structural imperfections on the behaviour of the connection.

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