Simplified method for the assessment of cyclic degradation of coarse-grained material

Large monopile foundations for offshore wind turbines are exposed to cyclic loading induced by wind and wave. During a storm event in an offshore environment, the foundation must resist high level of cyclic loading which damage the soil around the foundation and leads to reductions in soil mechanical properties in terms of both stiffness and strength. The design of the foundation is based on degraded soil properties, and the assessment of how much the soil strength is reduced during a storm is a key aspect for the design. An overlyconservative estimate of soil degradation results in heavier foundations which translate into increased fabrication and installation costs. On the other hand, an underestimation of the degradation of soil properties results in an increased risk of foundation failure or a reduction of the lifetime of the offshore wind turbine.

Available methodologies for the assessments of soil degradation to cyclic loading are either too simplified incorporating several assumptions, or they are very complex and highly time-consuming, such that they cannot efficiently be implemented in modern iterative design processes of new/future offshore foundations. This limitation has led to inaccurate or conservative design resulting in higher costs for offshore wind energy structures.

The research project attempts to first provide an overview on the available established methods including an assessment of their performance and limitations. Secondly, it aims to provide a simplified regression model derived from comprehensive parametric analysis, which can be used immediately for designing and optimizing XL monopiles foundations of offshore wind turbines in industry practice.

The project is performed in collaboration with Aalborg University (Denmark) and University of Bremen (Germany). The University of Bremen will provide a researcher working on the advanced numerical simulation of the monopile under cyclic loading. This approach will be more advanced and serves as a scientific tool to validate the simplified approach developed for industry practice. Aalborg University will contribute with a PhD student focusing on both small-scale testing of a pile in the big test chamber at Aalborg University. They also collect advanced laboratory cyclic loading tests which are still few in number in the industry to develop a database of cyclic behaviour for different typical offshore soils.

This joint project aims to improve the design practice for offshore monopile foundation for wind turbines to reduce the risk, cost, and carbon footprint of these critical infrastructures.