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Case study of preliminary cyclic load evaluation and triaxial soil testing in offshore wind farm planning

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In 2020 Germany aims to produce 20% of its electrical power trough renewable energy sources. Assigned Offshore Wind farms in the German exclusive economic zone of the North- and the Baltic Sea are important step toward a fulfilment of this goal. However the save erecting of 5-6 MW wind power plants (total construction size: > 200m) in water depth of around 40 m is related to unprecedented technical, logistical and financial challenges. With an intended lifetime expectation of 50 years for the foundations, construction materials and the soils around the foundation are subject to high and continued stresses from self-weight, waves, wind and current. These stresses are not only static, but have also a significant cyclic component. An estimated 250 million cyclic load changes may lead to an accumulation of plastic deformation in the soil that potentially may affect operability or lifespan of the plant. During a preliminary geotechnical site survey of one of the largest (∼150 km2) offshore wind project sites within the German Bight (∼45 km North off the island Juist) a total of 16 drill cores with in situ cone penetration data and a total sample length of ∼800 m where recovered. Preliminary foundation designs and static self weight and lateral load calculations were used to design a cycling triaxial lab testing program on discrete natural soil samples. Individual tests were performed by foundation type and at vertical and lateral load maxima to evaluate the long-term soil behaviour under cyclic load. Tests have been performed on granular, cohesive and intermediate natural soils. Following an introduction to the unique MARUM triaxial apparatus and testing conditions, the cyclic triaxial test results are shown and explained. Furthermore cyclic shear strength and stiffness are compared to their static counterparts. Unique soil behaviour like abrupt partial failure, pore pressure response and unexpected in part load independent cyclic deformation behaviour is discussed and compared to literature results. The shown case study is intended to demonstrate a feasible procedure for evaluating cyclic loads, designing test procedures, presenting results and interpreting data in a so far unregulated field without common standards. The presented data has been produced within the framework of germanwind, a science industry partnership including RWE-Innogy, ENOVA and MARUM.