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Advanced Characterisation of Soil Stiffness for Offshore Wind Foundations

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ABSTRACT

Nonlinear shear modulus degradation relationships are of great importance for many civil engineering projects, and in particular for offshore wind farm developments. With offshore wind turbines becoming larger and moving to greater depths, foundation design is now also driven by fatigue and serviceability limit states. As a result, soil-structure analyses at small to intermediate strains become increasingly important. New design methods, such as the Pile Soil Analysis (PISA) framework, directly apply the small strain shear modulus (G_0) as input. Furthermore, the finite element (FE) calibration of the PISA soil springs applies the full non-linear functions of shear modulus with soil strain as input for evaluation of the degradation of soil stiffness around the foundation. These non-linear functions are usually presented as normalized shear modulus (G/G_0) versus the logarithm of shear strain (γ), where the latter ranges from small strains (0.00001% to 0.001%) into the intermediate strain range (0.001% to 0.1%) up to large strains ($\approx$ 10%). The determination of representative shear modulus degradation curves is challenging and requires the use of various tests to piece the entire curve together.

G_0 can be measured *in situ* using seismic cone penetration tests (SCPTs) or down hole shear wave logging in single hole or cross-hole configurations. G_0 can also be measured in the laboratory using bender element or resonant column tests. The stiffness in the intermediate and large strain ranges is typically measured with triaxial and direct shear testing or alternatively using *in situ* techniques like pressuremeter testing. Results from

various testing methods obtained in several site investigations campaigns performed on wind farm sites have indicated significant scatter and uncertainty, compared to what is required for foundation design. Furthermore, it is generally recognized that the uncertainty increases going from onshore to offshore estimations of G_0.

The discussion of the challenges and potential solutions associated with soil stiffness property characterization is the main objective of the proposed mini symposium. The organizers aim to encourage researchers and practitioners to present improved methods to measure and interpret stiffness parameters and deriving shear modulus degradation relationships to allow the optimization of offshore wind structures and foundations.

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