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Reliability analysis of offshore wind turbine foundations under lateral cyclic loading

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The design of foundations for offshore wind turbines (OWT) requires assessment of the soil-structure interaction (SSI) during cyclic loading conditions. It must be ensured that the rotational accumulation does not exceed the limit prescribed by the wind turbine manufacturer (usually 0.5°). Being able to accurately verify these requirements will lead to an improved risk assessment and a better optimization of the design of offshore foundations.

It is a common practice to gather information about the cyclic behaviour of soil by means of cyclic laboratory tests. A numerical model is needed to apply the obtained information from the laboratory test campaign to predict the behaviour of the soil under various design load scenarios (i.e. significant storm event or earthquake event). Occasionally, a "soil fatigue model" is used in geotechnical engineering projects [1]. One model of this type, also recommended from DNV-GL, is the cyclic contour diagram established from laboratory testing of the investigated soil material. The construction of cyclic contour diagrams is a challenge because it is usually derived from a three-dimensional interpolation of few cyclic laboratory tests. Laboratory tests show large scatter showing different sources of epistemic and aleatory uncertainties. A probabilistic approach along with reliability framework is very useful in such cases to quantify all possible uncertainties (soil model and loads) and design the foundation of OWT to a specific target reliability level.

The current paper presents such a reliability framework for the design assessment of OWT foundations, with emphasis on evaluating structural safety during cyclic loading conditions. This reliability framework includes stochastic modelling of soil cyclic behaviour based on large set of laboratory tests, integrated time-domain aeroelastic simulations of OWT loads, limit states formulation, and structural reliability analyses.

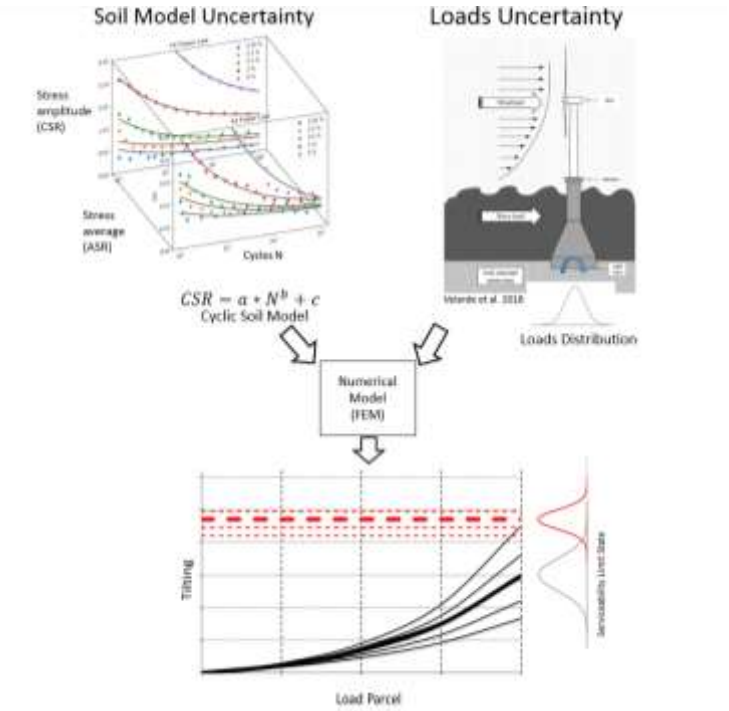

Figure 1: Workflow of the reliability analysis.

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[1] Zorzi et al. Isope (2018).