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Simulation of Offshore Wind Turbines with a Coupled Multi-Physics Model

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Abstract

Presently there are quite a few projects in various stages of planning and construction which aim at placing wind turbines offshore for electricity generation. There the usually higher wind speeds can be exploited, but the turbines are also subjected to the offshore environment, i.e. especially wave loading. Fatigue calculations of wind turbine structures usually involve Monte Carlo Simulations of their operation in turbulent wind. In the offshore environment, we have to consider a coupled system, consisting of the structure, foundation, surrounding soil, the aeroelastic system for the wind model, and the hydroelastic system for the wave model.

In this work, the models have been developed initially separately, and are consistently coupled here to give the whole system. They consist of:

1) the structural subsystem, which is a nonlinear large displacement finite element model (FEM);

2) the aerodynamic subsystem, with prescribed stochastic wind characteristics and an instationary dynamic stall model for the aeroelastic blade loading;

3) the hydrodynamic subsystem, modeled mainly as potential flow and coupled to the stochastic wave field to describe the real sea state, and take the far-field into account. The computation on this part is based on the boundary element method (BEM);

4) the soil dynamic subsystem, modeled as the near-field soil close to the underground structure and discretised by the FEM, and the far-field effect which is described by the scaled boundary finite element method (SBFEM).

All of these models are coupled in the time domain, and the consistent simulation of the offshore wind turbine is presented. As the computational cost is high, reduction methods are used to reduce the amount of computation.

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