Impact of turbulence induced loads and wave kinematic models on fatigue reliability estimates of offshore wind turbine monopiles - DTU Orbit (17/12/2018)

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The cost of offshore wind turbine substructures has a significant impact on competitiveness of the wind energy market and is affected by conservative safety margins adopted in the design phase. This implies that an accurate design load prediction, especially of those resulting in fatigue damage accumulation, may help achieve more cost-effective solutions. In this article, the impact of turbulence and wave loads on fatigue reliability of pile foundations is investigated for a 5-MW offshore wind turbine. Loads obtained by varying turbulence percentiles are compared with those obtained from the full joint probability distribution of wind speed and turbulence through Monte Carlo (MC) simulations, and from the equivalent turbulence level currently adopted by IEC standards. The analyses demonstrate that a lower equivalent turbulence percentile leads to a more realistic and less conservative estimation of fatigue loads. Subsequently, the research focuses on studying the effects of uncertain marine environments on the fatigue load distribution, showing that the latter is insensitive to the random variability of the hydrodynamic coefficients. With respect to the wave kinematic model, a comparison between nonlinear and linear waves clearly suggests that hydrodynamic forces depend significantly on the kinematic model adopted and the operational conditions of the turbine. Furthermore, a term is derived to correct the error introduced by Wheeler stretching at finite water depths. The respective model uncertainties that originate from the nonlinear irregular wave model and Wheeler correction are quantified and employed in a reliability analysis. In a case study, the results are finally compared in terms of estimated probability of failure, with the aim to quantify the influence of environmental models on monopile reliability.

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