Evolution of the dynamic response and its effects on serviceability of offshore wind turbines with stochastic loads and soil degradation

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ABSTRACT

Novel methods combined with an integrated simulation platform are suggested for the design of offshore wind turbines and substructures that ensure twenty-year lifespan. These methods enable us to estimate the long-term evolution of dynamic responses of offshore wind turbines due to the degradation of the soil modulus of the foundation under stochastic loading conditions. The results of this study show that random fluctuations of the soil stress caused by stochastic loads (i.e., aerodynamic and hydrodynamic loads acting on offshore wind turbines) can be described by a Rayleigh distribution and a Gaussian distribution. By using these probabilistic characteristics, the stochastic fluctuations in the soil stress can be rapidly calculated without using Monte-Carlo simulations. Moreover, a new method based on derivatives of degradation functions and on inverse functions of the degradation functions is also suggested to calculate the mean degradation index. These methods significantly decrease the required computational effort, thus overcoming a critical drawback of existing methods. Case studies demonstrate that the dimensions of substructures significantly affect the evolution of the dynamic response, suggesting that the evolution of the dynamic response should be considered in the design process to secure the serviceability of offshore wind turbines and substructures.

Keywords
offshore wind turbines; soil modulus degradation; suction caissons foundation; wind turbine serviceability