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COUPLED WAVE, CURRENT AND WIND LOADS ON FLOATING ELASTIC OFFSHORE WIND TURBINES

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ABSTRACT

Coupled hydro- and aeroelastic responses of floating offshore wind turbines (FOWT) to waves, current and steady wind loads are investigated in frequency domain. The wave-current interaction with the substructure is studied by use of the linear diffraction theory for combined waves and current. The aerodynamic loads are determined by the steady blade element momentum theory. The hydrodynamic and aerodynamic components are integrated with the finite element method for the structural analysis of the entire FOWT, including blades and the tower of the wind turbine and the substructure. The complete system of equations is solved simultaneously to determine the motion and deformation of the FOWT in frequency domain. Results of the model are compared with available laboratory measurements for wave-current-wind interaction for various rigid and elastic bodies, and overall, very good agreement is observed. Discussion is provided on the importance of the elasticity of the floating structure on the overall responses of various FOWTs. Next, the model is used to investigate the motion and elastic responses of emerging concept of FOWTs where multiple towers are placed on the same floating platform, namely the wind-tracing FOWT. The concept consists of an equilateral triangular platform that supports three 5 MW NREL wind turbines on its corners. The FOWT is attached to the seabed with a turret-bearing system that allows for the rotation of the structure in response to the environmental loads. A parametric study is performed to identify the optimum location of the turret of the mooring system. The rigid and elastic responses of the wind-tracing FOWT under regular and irregular sea states, combined with current and wind are determined and discussed. It is found that the elasticity of the structure results in significant changes of its responses when compared to the rigid body motions. It is concluded that the combined hydroelasticity and aeroelasticity should be considered in analysis and design of similar floating concepts.