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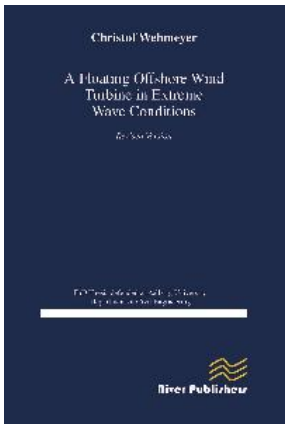

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A Floating OffshoreWind Turbine in Extreme Wave Conditions

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Description:

The PhD work evaluated the performance of engineering procedures, used in the design of bottom fixed offshore wind turbines, for the hydrodynamic ULS analysis of a FOWT tension leg platform (TLP). Dynamically sensitive topsides have been included and water depths were considered, where wave shapes in the extreme sea states deviated from the 1st order description. In detail the industrial PhD project comprised four work packages:

1. A design basis was developed, which defined the hydrodynamic environmental design parameters. The aim was to define a sensible set of extreme sea state parameters, i.e. Hm0, Tp and peak enhancement factors, based on cyclonic storm conditions (Wehmeyer et al., 2012).

2. Based on Wehmeyer et al. (2012), a physical model test campaign was drafted, where an industry inspired floating offshore wind turbine was tested (Wehmeyer et al., 2013).

3. A comparison of measured pitch responses versus responses from an in-house developed numerical tool, as well as a code to code comparison in regular non-linear waves served as initial key performance indicator of numerical model quality and good agreement was found (Wehmeyer et al., 2014).

4. As a final step, the numerical model was extended in order to include non-linear irregular incident waves as well as non-linear irregular incident waves with an embedded Stream-function wave. A linear background sea state into which a Stream-function wave was embedded was assumed no longer appropriate. Therefore a 2nd order sea state model was developed and served as well as the background sea state in which the Stream-function wave was embedded. The combined sea state was then applied in the numerical model in order to investigate the bow tendon responses of the FOWT TLP. A comparison of measured bow mooring responses and the numerically predicted bow mooring responses served again as key performance indicator of numerical model quality (Wehmeyer and Rasmussen, 2014).

The numerical model combined linear inertial excitation forces - obtained by potential flow – with nonlinear hydrodynamic viscous drag forces, obtained from the relative velocities between linear and nonlinear sea state kinematics and the floater. The maximum bow tendon loads were over predicted by the numerical model by 34% and 32% for the nonlinear and linear sea state generation, respectively. The embedded wave approach resulted in an over prediction of 37% to 23 % depending on the different crest front steepness values of the single wave, which is embedded in the nonlinear irregular background sea state. It was concluded that the embedded wave approach provided a controlled and time efficient engineering tool also for the floating offshore wind turbine generators.

Keywords: Tension Leg Platform, 2nd Order Sea State, Embedded Stream Function Wave, Floating Wind Turbine, Mooring Loads, non-linear waves, physical model test, ultimate limit state