Mooring Line Dynamics Experiments and Computations. Effects on Floating Wind Turbine Fatigue Life and Extreme Loads.

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José Azcona[1] and Tor Anders Nygaard[2]
[1]Renewable Energy National Center, CENER, Spain
[2]Institute for Energy Technology, IFE, Norway

IFE Institute for Energy Technology

Introduction

The OPASS code [1] is a dynamic mooring lines simulation tool based on the Finite Element Method (FEM), that considers the hydrodynamic drag, the added mass, the axial stiffness, the structural damping and the seabed contact and friction. 3DFloat is an aero-servo-hydro-elastic FEM code by IFE that also includes bending and torsion of the mooring lines [2].

The objective of this work is to quantify the effect of mooring line dynamics on offshore wind turbine fatigue and ultimate loads with high-fidelity simulation tools validated against wave tank experiments.

Experimental validation

A chain was submerged into the water basin (see Figure 1), forming a catenary shape with the bottom end anchored to the tank floor and the fairlead connected to a mechanical actuator that excites the line with a harmonic motion with three different frequencies (1.58s, 3.16s and 4.74s).

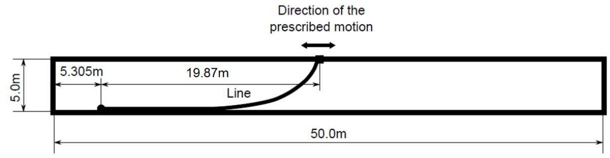

Figure 1. Experimental setup of the line at ECN, Nantes

Equivalent simulations of the chain setup were launched with OPASS and 3DFloat to compare against the experimental results. Figure 2 compares the chain fairlead tension with computations for the three excitation frequencies. The black lines represent the computations using the values for the chain drag coefficients provided by DNV [3]. The gray lines are the same computations with OPASS but increasing and decreasing the drag values in 20%, to evaluate the sensitivity of computations to this parameter.

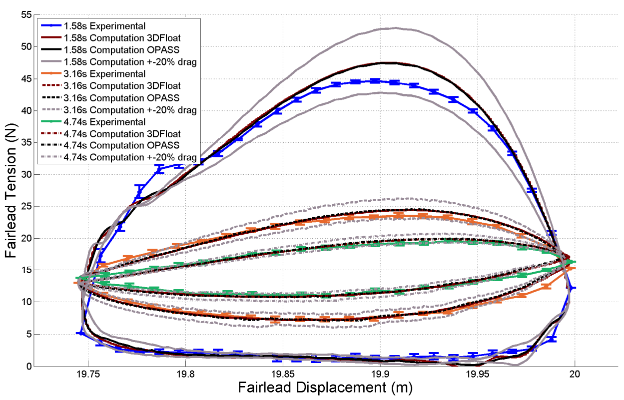

Figure 2. isometric view of the design

The agreement of computations with experiments is very good for the three frequencies, particularly when the reference DNV drag coefficients values are used. For the lowest excitation period, the chain totally loses tension. The agreement for this case is also good although the maximum tension provided by DNV drag coefficients is 4.5% higher than the experiments. This suggests that for high frequency motions, the drag coefficients are slightly conservative.

Effect of mooring dynamics on loads

The fatigue and ultimate loads of three different floating wind turbines (Figure 3) have been computed using the OPASS dynamic mooring model and a quasi-static approach to evaluate the effect on the results. The load calculations included all the case groups defined by the IEC 61400-3 guideline.

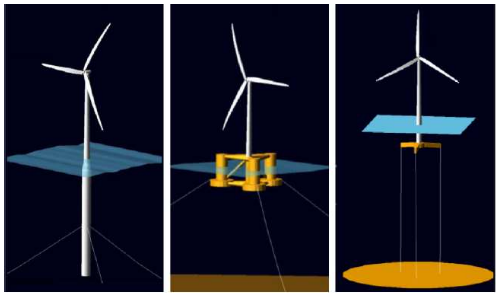

Figure 3. Platform concepts considered in this study [4]

In general, the influence of mooring dynamics both on fatigue and ultimate loads increases as elements located closer to the platform are evaluated. The blade and the shaft loads are only slightly modified by the mooring dynamics. Figure 4 shows that mooring dynamics significantly decrease the tower loads for the semisubmersible and the TLP concepts when compared with results using quasi-static mooring model..

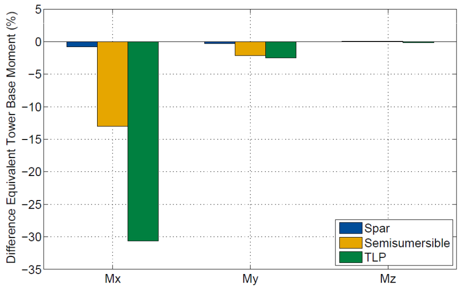

Figure 4. Relative difference of the tower base fatigue loads computed with dynamic mooring lines, with respect to quasi-static

Figure 5 reveals that the mooring dynamics have a significant effect (decrease around 30%) on the computation of the TLP's tower base extreme loads in comparison with quasi-static.

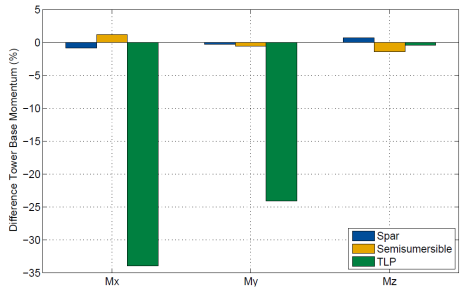

Figure 5. Relative difference in the tower base extreme loads computed dynamic mooring lines, with respect to quasi-static

Results also show that mooring lines tension strongly depends on the lines dynamics both in fatigue and extreme loads for all the platforms.

References

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