P3 - Structural integrity of Marine Renewable Energy Devices: Fatigue effects

The design of marine renewable energy devices is based on two main loading mechanisms: fatigue loads and extreme loads. Fatigue loads are more frequent, but have lower consequences, while extreme events rarely occur, but may have serious even dramatic consequences. Fatigue analysis is usually carried out via probabilistic techniques using long simulations (3h approx..) and rather simple hydrodynamic models for wave or floating wind energy devices. However, extreme events are highly nonlinear events and require precise modelling techniques where these nonlinear effects are captured.

Numerical models of the marine renewable energy devices are, usually, relatively simple, where the computational cost is the main requirement. For the fatigue analysis, turbine blades, junctions and mooring lines are critical. In fact, wave, current and wind effects are important in these cases. Surface water waves experience frequency shifts and wave shape modification when traveling on underlying currents. The wave-current interactions are known to be important for the responses of offshore structures, however, they have not been considered in FOWT fatigue analysis.

In the hydrodynamics, drift effects need to be considered, nonlinear mooring models are also crucial to consider geometric nonlinearities in the cable and the effect of wind should also be included in the case of floating offshore wind turbines.

Hence, the student will design and implement a model with the capacity to study the structural response under three different cases: only waves, wave and current without and with interactions. The analysis will focus on the mooring lines and tower/blades (in case wind turbines are studied)

Objectives

- Understanding of the different environmental loadings
- Design of the aero-hydrodynamic mathematical model that considers all necessary environmental loads
- Estimation of the impact of fatigue effects
- Determination of the most suitable mathematical model

Tasks

i. Identification and classification of the different environmental loads that are relevant for fatigue effects (IEC standard)
ii. Design and implementation of wave, current and wind models
iii. Design and implementation of the hydro-aeroelastic model
iv. Comparison of the three different case studies (only waves, wave and current without and with interactions)
v. Quantification of the impact of each load

Bibliography

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