P2 - Structural integrity of Marine Renewable Energy Devices: Extreme loading

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.

These high-fidelity modelling techniques are, usually, computationally very expensive models. Therefore, long simulations as in the fatigue analysis are prohibitive. In fact, when fully viscous and nonlinear Reynolds-Average Navier-Stokes (RANS) Computational Fluid Dynamic (CFD) models are employed, simulations are limited to a few seconds/minutes. This means, on the one hand, that extreme waves need to be modelled so that they include all the necessary information within short waves. This is usually achieved by means of focused waves .On the other hand, high-fidelity RANS-CFD simulations need to be carefully designed, so that results can be reliable.

Once the hydrodynamic behaviour is carefully designed, the impact of the hydrodynamic loadings on the structure are analysed by means of pure mechanical Finite Element Method (FEM) solvers in order to assess potential damages of these extreme events. The most critical components are the structure itself and the mooring lines.

The student's work will be divided into three main parts: the analysis of extreme waves modelling techniques based on IEC standards for extreme loading characterisation, design of high-fidelity RANS-CFD hydrodynamic modelling, and design of coupled CFD-FEM model for the analysis of the damages.

Objectives

- Understanding and implementing efficient extreme wave modelling in Matlab/Simulink and RANS-CFD solvers
- Design of an efficient RANS-CFD model in ANSYS Fluent to obtain hydrodynamic loadings under extreme events
- Coupling CFD-FEM solvers to study mechanical
- Assessment of a series of extreme events on the structural integrity of Marine Renewable Energy Devices

Tasks

i. Determination of extreme events characteristics from the IEC standard
ii. Classification of extreme wave modelling techniques
iii. Selection and design of two Marine Renewable Energy Devices: One wave energy converter a one floating offshore wind turbine platform
iv. Simple BEM-based hydrodynamic analysis of the devices in ANSYS Aqwa
v. Design of a Numerical Wave Tank in ANSYS Fluent
vi. Simulation of extreme events in the Numerical Wave Tank
vii. Design of the CFD-FEM coupled solver
viii. Final assessment of the structural integrity in

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