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D4.7 Models for advanced load effects and loads at component level

During the design process of floaters for large scale offshore wind turbines, models of varying fidelity are needed. The present deliverable of LIFES50+ Work Package 4 describes the development of five models at the advanced level. The developments are

- Inclusion of floater flexibility in dynamic response calculations
- Inclusion of second-order and fully nonlinear wave forcing
- Validation of an OpenFOAM based CFD solver for hydrodynamic analysis
- Coupling of Simpack and ANSYS CFX for hydrodynamic CFD coupled to structural motion
- Development of a free vortex method for aerodynamic load calculations.

For the inclusion of floater flexibility, a case study on the Triple Spar floater is presented. It is demonstrated that flexible floater properties can lead to global coupled natural modes within the wave frequency range and that these can be excited by the waves. This can lead to increased sectional loads for the tower top acceleration and the side-side tower bending moment – as demonstrated for an extreme wave group impact.

The study on second-order and nonlinear forcing presents several approaches to inclusion of nonlinear kinematics in FAST for the reproduction of wave tank tests of a TLP floating wind turbine configuration. It is found that for that study, the choice of ‘best model’ is unclear due to the uncertainty in reproduction of the nonlinear wave velocity field of the experimental data. It is suggested that a reasonable modelling approach would be to generate first-order wave kinematics from the measured signal when the corresponding test data are available and to employ nonlinear kinematics from the target signal otherwise. Also damping is discussed in this context.

For the OpenFOAM CFD model the forcing from regular waves at varying amplitude is analysed for higher-harmonic content. Next, a weak instability in the motion solver is discussed. A comparison of added mass and damping across varying frequency is provided and a good match against WAMIT results is found for surge. For heave motion – and likely owing to the presence of heave plates – the added mass is larger than for WAMITs and the damping is smaller. A case of regular wave motion for a moored floater is shown too.

The coupled Simpack-CFX solver is implemented with the ability to include rotor loads and a blade pitch control system. This enables advanced studies on control in harsh sea environments. The wave generation procedure is described in detail and an example application for the IDEOL floater is provided. It is demonstrated that the model can describe air trapped in cavities of the structure.

For the free vortex method, generic step tests are provided and shows a good comparison with a Blade Element Momentum model. For sinusoidal floater motion, a good match in thrust is obtained at low frequencies, while at higher frequencies, the hysteresis loop is found to be much larger with the vortex model. This is linked to the difference in aerodynamic inflow model.