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OC5 Project Phase Ib: Validation of Hydrodynamic Loading on a Fixed, Flexible Cylinder for Offshore Wind Applications

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Abstract

This paper summarizes the findings from Phase Ib of the Offshore Code Comparison, Collaboration, Continued with Correlation (OC5) project. OC5 is a project run under the International Energy Agency (IEA) Wind Research Task 30, and is focused on validating the tools used for modelling offshore wind systems through the comparison of simulated responses of select offshore wind systems (and components) to physical test data. For Phase Ib of the project, simulated hydrodynamic loads on a flexible cylinder fixed to a sloped bed were validated against test measurements made in the shallow water basin at the Danish Hydraulic Institute (DHI) with support from the Technical University of Denmark (DTU). The first phase of OC5 examined two simple cylinder structures (Phase Ia and Ib) to focus on validation of hydrodynamic models used in the various tools before moving on to more complex offshore wind systems and the associated coupled physics. Verification and validation activities such as these lead to improvement of offshore wind modelling tools, which will enable the development of more innovative and cost-effective offshore wind designs.

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1. Introduction

Offshore wind turbines (OWTs) are designed and analyzed using comprehensive simulation tools (or codes) that account for the coupled dynamics of the wind inflow, aerodynamics, elasticity, and controls of the turbine, along with the incident waves, sea current, hydrodynamics, mooring dynamics, and foundation dynamics of the support structure. The OC3 and OC4 projects (Offshore Code Comparison Collaboration and Offshore Code Comparison Collaboration Continuation), which operated under IEA Wind Tasks 23 and 30, were established to verify the accuracy of OWT modelling tools through code-to-code comparisons. These projects were successful in showing the influence of different modelling approaches on the simulated response of offshore wind systems. Code-to-code comparisons, though, can only identify differences. They do not determine which solution is the most accurate. To address this limitation, an extension of Task 30 was initiated, which is called OC5. This project's objective is validating offshore wind modelling tools through the comparison of simulated responses to physical response data from actual measurements. The project will involve three phases using data from both floating and fixed-bottom systems, and from both scaled tank testing and full-scale, open-ocean testing.

The first phase of OC5 is focused on examining the hydrodynamic loads on fixed cylinders. No wind turbine is present in these tests because the purpose is to examine hydrodynamic loads only, before moving on to the complexity of coupled wind/wave loads and dynamic system response. Because this is the first time the group has used measured test data, a simple structure is chosen to ease into the complications involved when using real data. The first phase is also used to develop the model calibration and validation processes that will be used by the group throughout the project. Two different sets of data were examined in this phase, and this paper focuses on the validation work for the second data set, which came from DHI. A summary of the work done on the first data set from MARINTEK can be found in [1]. The first data set focused on examining a fixed, rigid cylinder suspended in a wave tank, whereas the second data set uses a flexible cylinder fixed to the floor of a wave tank, and uses a sloped floor to include nonlinear wave transformation from deep water to the structure in the experiments.

A number of academic and industrial project partners from 11 different countries participated in the task. Those actively involved in Phase Ib are: the National Renewable Energy Laboratory (NREL - USA), Technical University of Denmark (DTU), MARINTEK (Norway), 4Subsea (Norway), Norwegian University of Science and Technology (NTNU - Norway), Politecnico di Milano (PoliMi - Italy), Stuttgart Wind Energy (SWE - Germany), the Institute for Energy Technology (IFE - Norway), DNV GL (UK), GE Renewable Energy (Spain), IFP Energies nouvelles (France), PRINCIPIA (France), University of Ulsan (UOU - Korea), Wave Energy Center (WavEC - Portugal), and

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