Verification and Validation of the New Dynamic Mooring Modules Available in FAST v8

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ABSTRACT

The open-source, aero-hydro-servo-elastic wind turbine simulation software FAST v8 (created by the National Renewable Energy Laboratory) was recently coupled to two newly developed mooring dynamics modules: MoorDyn and FEAMooring. MoorDyn is a lumped-mass-based mooring dynamics module developed by the University of Maine, and FEAMooring is a finite-element-based mooring dynamics module developed by Texas A&M University. This paper summarizes the work performed to verify and validate these modules compared to other mooring models and measured test data to assess their reliability and accuracy. The quality of the fairlead load predictions by the open-source mooring modules MoorDyn and FEAMooring appears to be largely equivalent to that predicted by the commercial tool OrcaFlex. Both mooring dynamic model predictions agree well with the experimental data considering the given limitations in the accuracy of the platform hydrodynamic load calculation and the quality of the measurement data.

KEY WORDS: Floating offshore wind turbine; mooring dynamics; modeling; verification; validation; FAST; MoorDyn; FEAMooring

INTRODUCTION

The analysis and design of a mooring system in floating offshore wind turbines requires reliable predictions of mooring line loads during a broad spectrum of environmental and operating conditions. Fatigue damage is often an important design driver for mooring systems, which makes the reliable prediction of load amplitudes even more important. Prior to the release of FAST v8.12.00a-bjj (October 6, 2015), the only mooring line module available in FAST was MAP++ (Masciola, Jonkman, and Robertson, 2013). MAP++ is a quasi-static mooring module that considers the average mooring line loads and nonlinear geometric restoring, but it does not consider any dynamics that are important for capturing the mooring line extreme and fatigue loads. Therefore, to improve the predictive capabilities in FAST for mooring line loads, recent development efforts have focused on coupling FAST v8 to two dynamic mooring line modules: MoorDyn and FEAMooring.

The improved predictive accuracy of these modules should allow FAST v8 to be used for effective mooring system design and analysis and thus enhance its use as a tool for the design and analysis of floating offshore wind systems.

This paper presents the two new dynamic mooring line modules that have been coupled to FAST, and it validates their load predictions against 1:50-scale wave tank test data obtained from the 2013 DeepCwind test campaign (Helder and Pietersma, 2013). This campaign was conducted at the Maritime Research Institute Netherlands (MARIN) under the direction of the University of Maine. Simulation results from the commercial maritime engineering software OrcaFlex, which has recently been interfaced to FAST v8, are added to the validation to verify the agreement of FAST’s new dynamic mooring line modules with an established and widely used commercial design software. Further, the comparison of MoorDyn, FEAMooring, and OrcaFlex modeling results to the results obtained with MAP++ show the improvements that can be obtained with the mooring dynamics modeling capability compared to the quasi-static approach. Only wave cases are considered for the validation and verification conducted in this paper (no cases involved a turbine operating in wind).

MOORING CODE DESCRIPTIONS

The following subsections describe the various mooring codes that will be examined in this paper.

MoorDyn

MoorDyn was developed by Matthew Hall at the University of Maine (Hall, 2015). It is based on a lumped-mass modeling approach that is able to capture mooring stiffness, inertia and damping forces in the axial direction, weight and buoyancy effects, seabed contact forces, and hydrodynamic loads from mooring motion using Morison’s equation. Bending and torsional cable stiffness, as well as seabed friction, are not considered. Though not applied here, MoorDyn also allows for modeling segmented cables with multiline connection points (e.g., bridle configurations). MoorDyn has been successfully validated against wave tank test data from a previous 2011 test campaign of the DeepCwind system (Hall and Goupee, 2015).