Title of MSc Thesis

Verification of Different Modelling Techniques of the Local Joint Flexibility and their Influence on Local Dynamics of a Jacket Support Structure for Offshore Wind Turbines

Author

Sofia Georgiadou

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ABSTRACT

Offshore wind energy represents one of the most promising sources of renewable energy in the future, due to the enormous energy potential available in the vast offshore areas. The installation of OWTs using jacket type support structure in deep water locations addresses effectively the well-known obstacles associated with the ones resulting from the application of other types of support structures (e.g. monopile, gravity based and/or tripod support structure). Thus, the development and adoption of new design concepts and modeling techniques for the jacket support structure is essential towards a successful performance of this kind of OWTs during their life-cycle. OWTs are designed using aero-hydro-servo-elastic simulation tools, which consider the interaction of the structure with all the environmental factors with the structure, as well as the entire structural assembly of the OWT. Most of these tools have significant limitations in modeling branched support structures. Consequently, in most of the previous research related to the dynamic analysis and the response assessment of a jacket supported OWT, simplified modeling techniques such as a beam model are used. By using beam models, the local behavior of the joints cannot be accurately represented. Thus, deflections at joints are underestimated, whereas bending moments are overestimated. In order to take into account the local joint flexibility, a substructuring or superelement approach can be used. This approach leads to a more accurate representation of the joints, considering the joints' local, and, therefore, to a better estimation of the fatigue life of the structure.

In this thesis, two different numerical models of the jacket support structure are used. The first model (beam model) considers beam elements, while the second one (superelement model) utilizes superelements for the joint's representation along with beam elements for the remaining parts of the structure. Initially, a modal analysis is conducted with the above mentioned models. The modal analysis is performed in the coupled aero-hydro-servo-elastic tool ADCoS-Offshore, as well as in ANSYS software. The frequency range of eigenmodes containing contribution of local vibration phenomena is detected and compared for both models. Slightly lower eigenfrequencies are observed in the case of the superelement model. Next, a time domain analysis is performed for both models using both simulation tools. A simple modelling approach is implemented in ANSYS, as far as the RNA is concerned. Based on the results of the time domain analysis, the dynamic response of various joints in terms of local vibration phenomena is initially identified for both models (beam and superlement). Then, results obtained for the two models are compared through Power Spectra Densities (PSD) diagrams. Finally, a fatigue analysis is performed. The results of the fatigue analysis are presented in terms of Damage Equivalent Loads (DEL) of the out of-plane bending moments, where the local vibrations were found to dominate. Finally, the effect of local vibration phenomena on fatigue loads is discussed for both applied models.

Keywords: Offshore wind turbines, Jacket support structure, Superelement, Joint flexibility.