ESTIMATION OF FATIGUE LIFE OF OFFSHORE STEEL STRUCTURES USING NUMERICAL SIMULATIONS AND ARTIFICIAL NEURAL NETWORKS

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ABSTRACT

Offshore Wind Turbines (OWT) are a promising alternative energy source. They have many advantages such as use of cheap state-owned land and proximity to urban centres built on coastlines among others. Nevertheless, OWTs continue to be expensive to design and construct. As research progresses in this field, the behaviour and performance of these structures become more understood. This is expected to bring costs down as designs and processes get more optimised and more economic, making OWTs more competitive.

This research focuses on a particular type of foundations for OWTs, namely steel jacket foundations. This foundation system demonstrates several advantages compared to other systems, especially the monopile system which is the most common in practice. Steel jacket 3D frame arrangement provides high stiffness all while exhibiting resistance to waves and thus reduced loads. Moreover, jacket foundations require minimal preparation of seabed and can reach to great depths below sea level (current record at 85 m below sea). However, a major drawback of jackets is that they are prone to fatigue failures. With many welded joints in the corrosive seawater environment, cyclic wave and wind loading poses great risk of fatigue implying prohibitive costs and preventing the structure from serving for its intended service life. The current work aims to address this issue by producing a model that predicts fatigue life of steel jackets of OWTs with adequate accuracy and small computational cost.

The proposed model is based on FE results and machine learning. A sample OWT model was adopted and then modelled using the FE technique in Python. Various load spectra on the structure due to waves and wind were calculated using both linear and non-linear wave theories and Morison's equations. Numerous analyses were conducted modifying key parameters and variables of the jacket structure and external conditions. The main objective of this parameterization is to identify those having a greater impact or influence on the accumulated fatigue damage. The parameters can in fact be used to build reduced models and as inputs or features for an ANN. The reduced models could be efficiently implemented in optimization loops while the use of ANN could improve the accuracy of the estimation.

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