TU Delft

Offshore & Dredging Engineering

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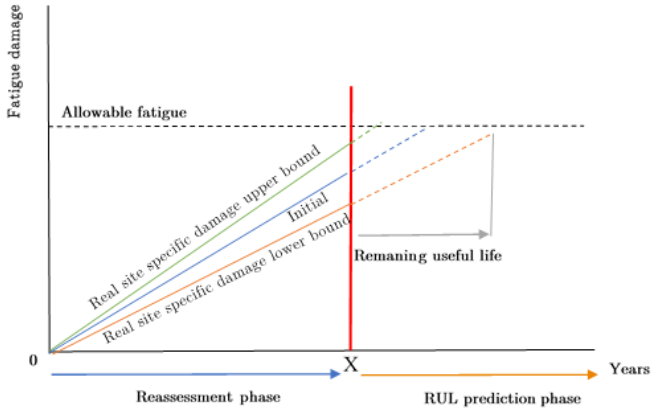
Fatigue assessment of existing offshore wind turbine support structure for lifetime extention

Wind energy has become an important topic nowadays and has made a remarkable growth during the last decades, especially in Europe. Offshore wind turbines (OWTs), together with their support structures, are designed for an operational period of 20 years. The first generation of these offshore wind turbines has already reached or is approaching their designed lifetime of 20 years. Depending on the legislation and the governmental subsidies, a decision needs to be made about their future. One option is to keep the OWTs in operation after exceeding the design lifetime while the safety levels are not compromised. Operating after the design life, which is called lifetime extension has become more and more interesting in the current market conditions. To find out whether the safety levels, which are determined by the design standards are not compromised when the lifetime is extended, the OWT support structures should be reassessed when the end of design life is insight. Reassessing the support structure can take out the uncertainties of the parameters that are monitored and can make lifetime extension possible.

The objective of this study is to propose a framework for reassessing existing OWT support structures for lifetime extension since there is not a clear detailed methodology describing the assessment and extension which can be applied for OWT support structures. Because of the complexity of the problem and the limited time, only the governing limit state is studied which is the fatigue limit state. The proposed framework consists of two phases. The first phase is the reassessment phase in which the available documentation and measurements of the (operational) history are taken into account to determine the fatigue damage with more certainty from the installation of the OWT till the point when the reassessment takes place. The second phase is the remaining useful lifetime (RUL) prediction phase, which aims at determining the remaining operational lifetime of an OWT without exceeding the safety limits. For both phases, different methods can be used that can be classified in deterministic methods and probabilistic methods. An overview of the proposed framework is presented in the figure below.

Finally, the suggested framework is demonstrated in a simplified case study. First, the fatigue lifetime of the simplified structure is calculated with wave conditions of the Gemini wind farm; This calculated lifetime resembles the initial design lifetime and serves as a comparative measure for the following reassessment and RUL prediction phases. Then the simplified structure is reassessed with updated data, using a deterministic method. Subsequently, the RUL is predicted by using probabilistic fatigue calculations whereby different uncertainty distributions are taken into account. From this case study, it can be concluded that the proposed framework is applicable for different amounts and types of measurement data as well as assessment methods. The deterministic reassessment shows different outcomes of fatigue life of the structure even with a small change in the input parameters. The probabilistic fatigue calculations used for the RUL are computational more complicated but very promising since site-specific uncertainty distributions replace the generalized partial safety factors. The suggestion is, therefore, to use probabilistic models to achieve a longer lifetime for the OWT support structure without compromising the safety levels.



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