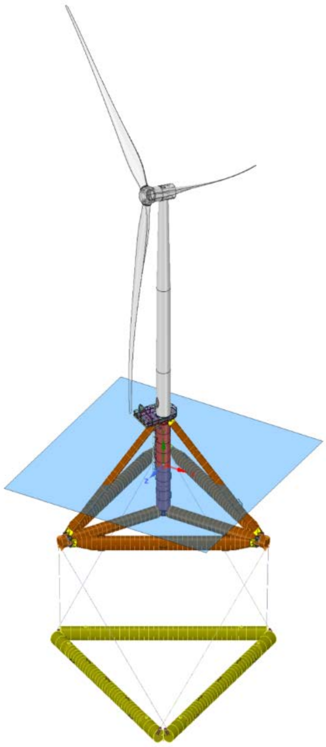
Technische Universiteit Delft

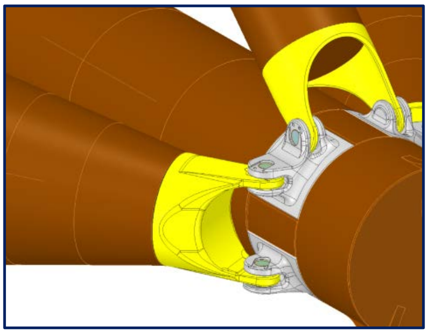
Offshore & Dredging Engineering

**Fatigue strength assessment of the pinned connectiion in the TetraSpar concept**

In a world with an increasing population and level of welfare, there is a large demand for more and cleaner sources of energy. Floating wind turbines have great potential to meet a significant part of this demand. They are however not yet commercially available, because of huge technical and economic challenges. Most of the concepts that are currently developed focus on technical feasibility.



The TetraSpar concept is designed with a focus on both technical and economic challenges. One of the main advantages of the concept is the type of connection, with which the steel tubular members are connected. This connection allows for industrialization of the fabrication and assembly process, which is potentially a huge competitive advantage. However, there are major concerns about the fatigue strength. The variable nature of the environmental loads, and the dynamic behavior of a floating structure result in continuously varying internal forces, which could cause significant fatigue damage.



Hence, the fatigue strength of the pinned connection is assessed in the research project presented in this thesis. The fatigue strength is quantified by an estimated fatigue lifetime, which is the expected time to failure of the most critical point in the connection. The lifetime is estimated based on the yearly accumulated fatigue damage. A computer model of the structure has been constructed, with which time signals of the internal forces in the structure are calculated, based on the environmental loads.

The pinned connection was not included in this model, so internal forces in the steel tubular members have been translated manually to forces in the pinned connection. The connection was decomposed in its basic components and nine potential critical locations have been identified. Stress concentrations are expected at these locations, which make them sensitive to fatigue. The internal forces were combined with the dimensions of the components, so that nominal stresses could be calculated. The hotspot stress at the potential critical locations was estimated with stress concentration factors (SCFs), which are found in literature. Relationships between the internal force and the hotspot stresses are derived in this way, and time signals of the hotspot stresses are obtained. Most of the identified locations could be assessed with hand calculations, except for two locations. They are analyzed with finite element software (ANSYS). The time signals of the hotspot stresses have been used to calculate the expected fatigue damage with the Palmgren-Miner rule. The damage is calculated for all wave directions and based on real wave statistics.

Results have shown that there are five locations in the design that have an expected fatigue life time of less than 100 years. Three of them have an expected lifetime of less than 60 years, which is the absolute minimum according to the standard for floating offshore wind turbines. Although results are expected to be conservative, one of the recommendations is to do a more detailed stress analysis on the critical locations in the pinned connections.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