Technische Universiteit Delft

Offshore & Dredging Engineering

Investigation of the fatigue behaviour of well systems

Subsea wells at water depths larger than 100 metres are usually drilled using Mobile Offshore Drilling Units (MODU). During drilling operations, the MODU is attached to the well system through a marine drilling riser, and their motions cause cyclic loads on the well system, which may lead to fatigue failure. Most of the easily recoverable reservoirs have already been developed, and new explorations take place at more remote locations with challenging conditions (e.g. deeper waters and harsher environments). Moreover, technological advances and the low oil prices enable higher recovery rates of existing wells, leading to a longer connection time between the drilling rig and well system. These two developments result in an increased magnitude and duration of the loads acting on the well system, making it more vulnerable to fatigue failure. The well system is part of the primary barrier that containns reservoir fluids, and therefore a failure could have severe consequences such as an oil spill.

Currently, there are no codes or international standards on how the fatigue calculations of this system should be performed. Companies use different methods for this assessment, and results can vary significantly. The large spread of results makes it is challenging to evaluate which method is or is not reliable. Therefore Shell wants to get a better understanding of how to the fatigue behaviour of the well system can be modelled and what critical parameters affect it.

Two models were developed to analyse the fatigue behaviour of the well system. The first method is a frequency domain model where all nonlinear effects are linearised. This model is very fast and easy to set up. Another advantage of this model is that it can include a soil damping representation that is pointed out as being promising by the literature. However, due to the applied linearisation, it cannot capture important loads acting on the system, such as the time variation of tension. The second method is a finite element time domain model, developed with the USFOS software. It is able to represent nonlinearities and can therefore include more features in a more accurate manner. Its main disadvantages are that simulations are time consuming and more complex to set up

The most important findings are the effects of soil damping and time variation of tension. The soil damping method applied in the frequency domain model showed to increase the modal damping for critical modes to the well fatigue with a factor larger than 5. Including the time varying tension can severely decrease the fatigue lifetime of the well system, by a factor larger than 100. This occurs because it excites critical modes that contribute to the well system fatigue. By actively compensating the heave motions of the MODU, this effect could be mitigated. Increasing the drag diameter of the riser and placing the fatigue sensitive elements, such as connectors, away from fatigue prone areas also significantly improves the fatigue performance of the system.

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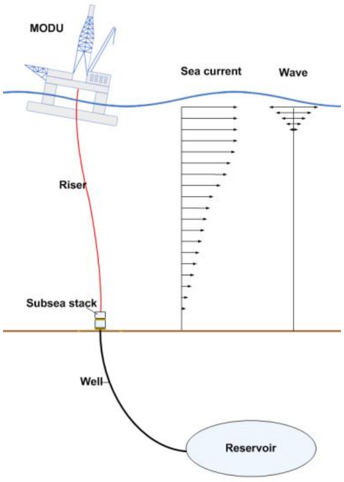

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