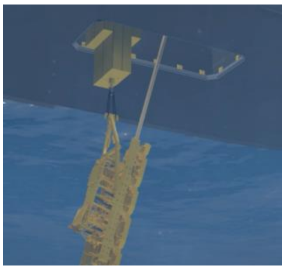
Offshore & Dredging Engineering

Technische Universiteit Delft

Motion behaviour analysis of 18" ILT structures



220 miles offshore the West-Australian coast lies the Ichthys Field. In 2013 Heerema Marine Contractors (HMC) was contracted to install the umbilicals, risers and flowlines for the Ichthys Project, including the installation of several in-line structures such as in-line tees (ILT) and flow-line end terminations (FLET). The ship assigned to these installations was HMC's deep water construction vessel Aegir. Environmental loads, such as waves and currents, as well as vessel motions induce significant loads on the submerged structures and pipeline. These loads could impose high risks and damage to people and equipment when not completely controlled. Therefore, each installation step is thoroughly analysed. The main software package for these analyses is Flexcom, FEM software specialised on pipeline calculations.

The installation analysis of the 18" ILT-structure installations involved in the Ichthys project shows high compression in the upper- and upper-counter stem, the connection between the ILT and the pipe. Although Flexcom shows that buckling limits are exceeded, offshore load measurements of previous installations show hardly any compression.

By means of a sensitivity study, the Flexcom model has been investigated to determine the driving mechanism for compression. Varying several parameters, it was found that the compression in Flexcom was closely related to the wave kinematics, and thus to the hydrodynamic loads on any of the submerged structures (pipeline, ILT & weight-compensation buoy). Finally, the compression could be related to the hydrodynamic loading of the weight-compensation buoy. The reason for the discrepancy between the Flexcom calculations and offshore load measurements is the fact that the weight-compensation buoy is hanging in a moonpool. Flexcom does not account for the flow characteristics of the water in the moonpool and is, by taking the incident waves for hydrodynamic loads calculations, over-predicting the loads on the buoy. In operational conditions, water in the moonpool moves in a so-called piston mode, a purely vertical motion, and moves periodically with its resonance period.

In order to predict the water motions in the moonpool for future installations, 1,5 year of offshore motion measurements of the water in the moonpool have been compared to the incident wave field. Using this data, RAO's for water motions in the moonpool have been developed for each wave heading. From these RAO's it was found that the response of the moonpool is wave heading dependent; beam waves tend to excite water in the moonpool to a larger extend than waves reaching the bow or the stern. This relation is also observed in moonpool response calculations with diffraction software (WAMIT). Knowing the moonpool is excited by pressure fluctuations at the inlet of the moonpool, the pressure distribution around barge models of varying lengths has been studied. It was found that the distance between the hull side and the moonpool is a governing parameter for the response of the moonpool, but in case the moonpool is located close to the side, pressure interference patterns along the hull could both in- or decrease the excitation. This interference occurs at hull lengths of a multiple of the incoming wave length.

Using the acquired knowledge from both literature and measurements, two new analysis procedure are proposed for structure installations through a moonpool. The first procedure uses incident waves for the vessel motion calculation, but uses a separately defined moonpool motion spectrum for the calculation of hydrodynamic loads on the buoy. However, due to the assumption of empty-moonpool conditions and the exponential decrease of wave kinematics over depth, this procedure yields some inaccuracies. The second procedure comprises the application of a user-defined load time-trace on the submerged structure, which is generated from non-empty moonpool measurements or CFD-results. Although the second procedure is more accurate, both procedures have shown to well approximate the loads measured offshore.

Further research should be done on object-specific water motion characteristics of the moonpool.

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