Technische Universiteit Delft

Offshore & Dredging Engineering

Coupled Dynamics of a dual lift operation

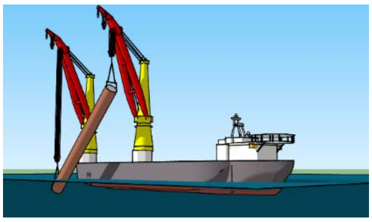
Offshore wind farms are moving to deeper waters, implying that larger substructures will need to be installed. The monopile is the leading substructure nowadays and this structure could be promising for use in deeper waters as well. Generally, jack-up vessels are used for the installation of the substructures and turbines. However, the jacking up and down of these vessels is time-consuming and limiting with regard to the water depth. A solution to tackle these two drawbacks, is to conduct the installation with a floating vessel. However, this brings along other challenges due to the hydrodynamics of the floating vessel. Therefore, this thesis focuses on the installation of XXL Monopiles with a monohull vessel. An XXL Monopile is a monopile with approximately a length of 120m and a diameter of 10m.

Boskalis is expanding its position on the offshore installation market and has recently added a new heavy lift vessel to its fleet. This vessel is the Bokalift 1 which is a monohull vessel equipped with a crane of 3000 tons lift capacity. To strengthen their position on the installation market, Boskalis is thinking about a new kind of heavy lift vessel which will be an extended version of the Bokalift 1: a Bokalift 2. This vessel will be a monohull vessel as well but possibly equipped with two cranes. The idea is to use this vessel for the installation of XXL monopiles with the use of both cranes. Boskalis wants to understand the dynamic behavior of the lifted object and vessel during this kind of operation and to know whether the installation with this kind of vessel is feasible or not. This will be assessed by determining the Eigenmodes and corresponding natural frequencies of the system, including the dynamic coupling between the lifted object and the vessel.

The installation of the XXL monopile with a Bokalift 2 is a novel operation. The phase of interest during this installation is the upending of the monopile, which will be executed partly through the splash zone. Using a simplified model, the modes and corresponding natural frequencies are determined for the lifted object in air (no vessel included). This is done with a modal analysis. With a more complete model made in OrcaFlex, these modes and frequencies are verified. The model is expended by including the vessel and subsequently a modal analysis is done. Since the submerged part of the monopile during the upending cannot be seen as a slender structure, the Morison equation is not applicable. To run the time domain simulations with the correct hydrodynamics included, the model is improved using a diffraction software AQWA. With this improved model, the dynamic coupling between the monopile and vessel is determined and it can be concluded that there is a strong coupling between the monopile's yaw motion and the vessel's roll motion.

Since an XXL monopile is being considered, it was decided to take a look at the piston mode. This is a phenomenon where the water inside the monopile moves up and down. The water column in the monopile will be excited by the waves and this results in a harmonic moving water plug inside the monopile. Since the monopiles are becoming bigger, the water volume is becoming bigger as well and might be of great concern. In previous studies this piston mode has been investigated, but never been applied in a complete model. In this preliminary study, this phenomenon is modeled in OrcaFlex and implemented into the monopile installation model. From the comparison between a model with and without the piston mode it is concluded that, generally, the piston mode will result in larger responses. However, the approximation of the piston mode phenomena is done by making several assumptions. The coupling between the water in and outside is not considered for example and, therefore, further research is required to gain more knowledge on the effects of the piston mode.

The current thesis provides more insight into the behavior of the lift and vessel dynamics. Based on these results, it is known to which motions attention need to be paid. Also, the coupling between the monopile and vessel is established and could be reduced by the use of tugger lines. A novel way of modeling the piston mode is developed and the effect of the piston mode is resolved to be increasing the motions of the system.



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