Offshore & Dredging Engineering

Technische Universiteit Delft

Numerical validation of experimental modal analysis of slip-joint connection in offshore wind turbine

To fulfil the increase in global demand of clean energy, the dimensions of offshore wind turbines are expected to increase with greater capacities and move further offshore in deep waters. For these conditions, the diameter of the monopile will have to increase beyond current manufacturing capacities. The slip joint connection can provide a means to construct monopiles out of smaller segments, thereby removing the limitations to its application.

A slip-joint consists of two inverted conical sections made of steel plates, placed one over the other. the upper conical section is connected to the transition piece and the lower conical section is connected to the monopile. It was found in preceding research related to the vibration assisted installation of the slip-joint, that the frequency of the vibratory force is the key to the successful installation of a slip-joint. The applied vibrations of specific resonance frequencies were found to be effective in the settlement of the slip-joint. A finite element (FE) model created in his work, failed to predict the exact resonance frequencies as observed in experimental modal analysis.

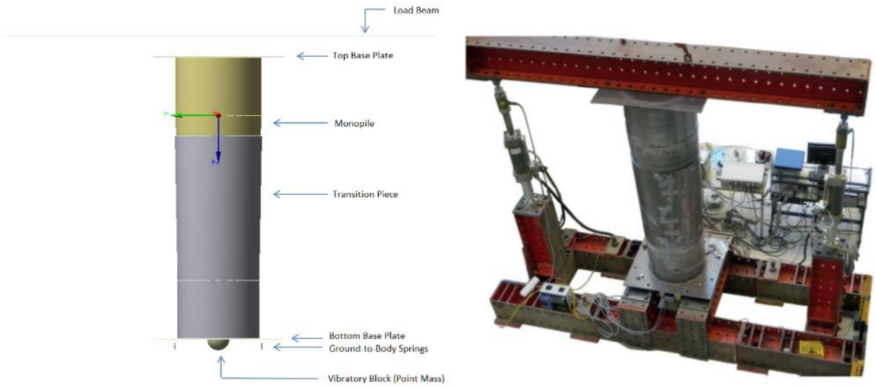

Figure 1: The FE model created (left) including components from experimental setup (right)

The main objective of this thesis was to replicate the results obtained by experimental modal analysis during dedicated lab experiments at TU Delft, by including the components from experimental setup in a FE model. These components include the top and the bottom baseplates which are connected to the monopile and transition piece respectively, the load beam on which the external static load is applied, and machine mounts connected to bottom base plate as shown in Figure 1. Further in this thesis, the FE model is modified in various ways to investigate the difference between the predicted and the observed natural frequencies of the setup. Factors like wall thickness of the cones, elasticity of the steel and stiffness of the machine mount which affect the global stiffness of the combined system are studied. As observed in the experiments that the monopile and the transition piece are not in perfect contact with each other due to the geometrical shape of the monopile, it has been tried to incorporate this observation in the FE model and see the impact of imperfect contact on the results of modal analysis. After investigating the effects of the above mentioned factors and modifications, the FE model was able to replicate the order of the modal shapes, but not the natural frequencies obtained by experimental modal analysis. Additionally, the stiffness near the contact region between upper and lower cone was found to be a key factor affecting the natural frequencies.

Student
Sawan Thakor
January 14th, 2019

Sponsor
Delft Technical University

Thesis committee
Prof.dr. A. Metrikine
Dr.ir. H. Hendrikse
Dr. F. Pisanó
Dr.ir. M.L.A. Segeren