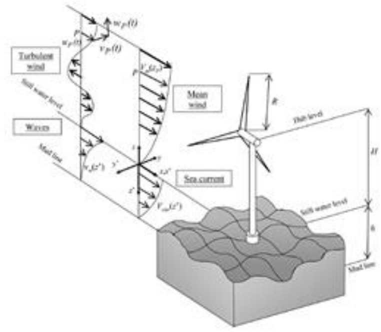
Technische Universiteit Delft

Offshore & Dredging Engineering

Dynamic response of an offshore wind turbine using linear (LIM) and non-linear (NLIM) environmental interaction models.

The present state-of-the-art modelling tools (such as FAST, BLADED) used for modelling an offshore wind turbine (OWT) are too detailed and computationally expensive. These tools are required only at detailed design stages of a project. For the preliminary phase, however, a much simpler (yet reliable) 3D model can improve and speedup the design process.

Therefore, the aim of this thesis was to develop two different finite element models of an offshore wind turbine and compare their dynamic responses. In order to assess the extent of non-linearities in the environmental interactions arising due to structural motions, one model included the non-linear models of soil, hydrodynamic and aerodynamic loads (called **NLIM** henceforth) while the other used linearized expressions for modelling them (called **LIM** henceforth).


Simplified depiction of the environmental interactions of an OWT (Petrini et al)

The soil was modelled as a series of non-linear (and linear) elastic springs using p-y curves. The conventionally used Morison's equation was compared with MacCamy and Fuchs' equation for modelling the hydrodynamic loads on a large diameter pile. It was found that the MacCamy and Fuchs' equation is a better way of modelling the hydrodynamic loads on submerged cylinders than Morison's equation as it takes the wave diffraction effects into account.
Several load cases were defined and the models were subjected to these load cases to check whether they are able to capture the physical behaviour of the OWT. The modal decomposition technique was used for reducing simulation time.

It was found that the model(s) adequately captured the physical behaviour of the OWT till a wind speed of 20 m/s. Its side-side plane physical behaviour needs further investigation for a constant wind speed of 24 m/s. The LIM and the NLIM compared well for most load cases. For the side-side plane responses, however, the LIM developed a phase lag. A strong coupling was found between the motions (rotations) in fore-aft plane and the motions about the yaw axis. The structural velocities were found to be very small to influence hydrodynamic drag terms. Also, the deflections of the pile in the soil were found to be too small suggesting that p-y curves do not capture the non-linear behaviour of soil accurately.

Finally, a damping matrix resulting from the linearized aerodynamic forces was used for calculating the modal damping ratios related to different modes. The results were compared to the literature, with addition of side-side and yaw damping.

Student	Sponsor	Thesis committee
Nischal Sehrawat	TUDelft	Prof.dr. A. Metrikine
July 19th, 2016		Ir. P. van der Male
		Dr.ir. K.N. van Dalen