Technische Universiteit Delft

Offshore & Dredging Engineering

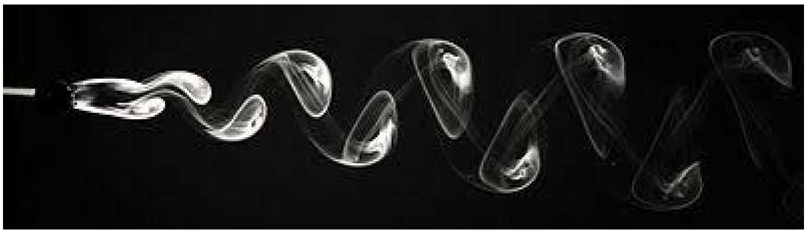
Modelling the vortex induced vibrations of sea fastened wind turbine towers using a wake oscillator model

It is well known that for tall cylindrical structures under wind action, such as wind turbine towers, vortex induced vibrations (VIV) may occur. During the installation of offshore wind turbine towers there are different stages of transport where we might deal with VIV.

The main objective of this thesis is to explore the possibility of modeling the VIV of flexible cylindrical structures by means of an existing wake oscillator model. Sub objectives are to investigate the influence of the deck stiffness and vessel motions on the VIV. And also, the effectiveness of strakes as mitigation for VIV is investigated.

From the literature study it is found that an existing wake-oscillator model with acceleration coupling is a good way to model the VIV of a rigid cylinder that is free to vibrate in water. This wake oscillator model, which was tuned to the experiments in water, is then tuned to an experiment where the rigid cylinder was free to vibrate in air. These free vibration experiments were all done in the sub critical flow regime.
In the next step the model is extended to model the VIV of flexible cylindrical structures. In an attempt to validate, this model is used to simulate the cross-flow amplitude of a in situ chimney on whom measurements were done during VIV. Due to the size of the in situ chimney, the Reynolds number at which VIV occurred suggests that we are in the super critical flow regime. However, the measured Strouhal number had a frequent value of 0.21 which is common for the sub critical flow regime. From the simulations it was found that by making use of the force coefficients from the super critical regime good agreement is found between the simulated and measured crossflow amplitude, while adopting force coefficients from the sub critical regime, the model significantly over predicted the response.

Finally, the model is applied in a case study with a wind turbine tower. A total of four cases are investigated. From this case study it was found that a stiff deck will result in VIV at higher windspeeds, but will also increase the loads. The VIV of the tower is hardly influenced by the vessel motion since the frequencies of the two are far apart. According to the model, covering the top one third of the tower with strakes significantly reduce the VIV, but with a penalty of increased in-line bending load on the deck.



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