Wind INduced Dynamics of Floating OffshoRe solar

Publieke samenvatting / Public summary

As Offshore Floating PhotoVoltaics (OFPV) is a relatively new industry, there is a knowledge gap in the wind induced dynamic behaviour of floating solar plants. Without an in-depth understanding, OFPV designers need to take large margins into account for wind induced dynamics, leading to (too) costly constructions. Offshore Wind Turbines are successful in the North Sea thanks to the availability of an abundant resource. This same resource poses a threat for OFPV systems. Not only on the North Sea but also for the worldwide export of Dutch OFPV it is important to withstand windspeeds in hurricane prone areas where correct assessment methodologies are essential.

As a starting point, literature on wind induced vibrations of high-rise buildings, suspension cables and airplane wings was studied. Wind induced vibration can either be triggered by vortex shedding (VIV), or by lift and drag instabilities of a lifting surface. The latter is referred to as galloping and flutter. This mechanism is expected to play a role in OFPV, as the deck can function as a large lifting surface. From literature studies it becomes apparent that there are two phenomena which play a role in galloping; 1) the wind has a destabilizing effect, proportional to the translational and/or rotational offset of the object, and 2) the wind has a damping effect, proportional to the translational and/rotational speed of the object. The ratio between the destabilizing and damping effect depends on the wind speed. It is found that the position of the aerodynamic centre is a crucial parameter in the stability/damping assessment.

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Model scale tests on a single triangular platform have been performed in a combination of wind and waves in MARIN's offshore basin. The main objective of these tests were to obtain validation material for the numerical methods used in this project. The model is a simplified and schematized representation of the SolarDuck platform at scale 1:13. A set of 6 different waves have been tested with and without wind. Two different wind speeds have been tested that represent North Sea extreme wind conditions. Especially the pitch response is influenced by the wind. The wind introduces a mean pitch angle, but more importantly, the presence of the wind decreases the wave induced pitch oscillations of the platform. For the tested conditions, the dampening effect of the wind has the overhand over the destabilizing effect.

In order to increase the understanding of this phenomena, and to be able to generalize the findings of the model tests to conditions which have not been tested, numerical methods as CFD and Morison based time domain solvers have been applied. The CFD shows similar trends in the results, the wind introduces a mean pitch angle but reduces the wave frequent pitch oscillations. Although this behaviour is qualitatively consistent with the model tests, quantitatively there are differences between the model tests and the CFD results. These differences are not fully understood due to the complexity of the physics. The consistent trends between tests and CFD give confidence in the general behaviour of the platform, but the quantitative validation needs further work. CFD has been applied to a multi-body (multi-platform) configuration as well within this project. This demonstrated the capability of the numerical tool, i.e. it is possible to perform these simulations, however as the differences in the single body are not fully understood, the interpretation of the multi-body simulation is difficult.

A Morison based time domain model using wind coefficients has been developed from the test and CFD results, and has shown that the wind coefficients can improve the prediction of the

platform motion. Even though it is not perfect, the estimated motions are typically more accurate than without wind coefficients. Qualitatively showing a good trend with the test results. An important next step will be to see to if the coefficient model can be applied for more complex multibody wind interactions. This can be done with the same methodology and scripts developed in this project.

Overall it can be concluded that a large step has been made towards a better understanding of the complex interaction of wind, waves and the platform. It should also be concluded that more steps need to be taken before the complex physics is fully understood.

De data in deze applicatie is afkomstig van de Rijksdienst voor Ondernemend Nederland (RVO) en wordt in samenwerking met de Topsector Energie ontsloten.
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