Effects of hard marine growth, spacing, and incidence on the aerodynamic characteristics of two tandem square prisms with rounded edges in ultra-high Reynolds-number cross-flows

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ABSTRACT

The worldwide increasing demand for clean energy has led to a major growth of existing and new offshore wind farms. The dynamic flow behaviour around the submerged circular or prismatic foundation elements - the latter having square cross-sections with sharp or rounded edges - of (semi-submersed) floating wind turbines is a fundamental hydrodynamic bluff-body problem that is highly complex and very challenging at the same time. Many parameters, like the current direction and velocity, the cross-sectional shape of the submerged elements, their increasing coverage by marine fouling following their placement in the ocean, as well as the spacing between foundation elements in case of multi-column structures, must be taken into account, as each one of them can have a large impact on the amount of susceptibility of these floating structures to VIV. Typical Reynolds numbers can be as high as 10^7, for which to date hardly any numerical or experimental studies are available yet.

In the last couple of years many experimental studies have been performed in the High-Pressure Wind Tunnel of the DLR in Göttingen to investigate the unsteady flow around single stationary circular cylinders and square-section prisms up to Reynolds numbers of 10 million [1-4]. Influencing parameters like the surface roughness height, edge roundness, and incidence angle were varied, and their decoupled and combined effects on the aerostatics were recorded. As a follow-up, the current systematic wind tunnel test focuses on the flow interference of two "infinite" smooth and slightly rough prisms with square cross sections (side width D) and rounded edges of r/D = 0.16 at Reynolds numbers in the range of 70,000 up to 10 million. Both prisms are arranged inline at three different distances S/D = 2.8, 4.0, and 5.6, and at each spacing the two "symmetric" incidence angles, α = 0° and 45°, are studied. Results on both the distributions of the mean and fluctuating surface pressures at the mid-span cross sections and the mean 2D aerodynamic force and pitch moment coefficients of the two prisms, as well as results on the mean and fluctuating 3D, i.e. spanwise-integrated, lift and drag forces, the power spectral densities (PSD) of the unsteady lift and drag forces, and the Strouhal numbers - based on the main vortex shedding frequencies in the PSDs - of the downstream prism are presented and compared to published data of their single counterparts. It is shown that for both angles of incidence a variation in spacing and/or Reynolds number induces drastic changes in the aerostatics, in particular for the prism located downstream. An increase in simulated hard marine growth leads to a shift of the various Reynolds-number flow regimes towards lower Reynolds numbers, as well as a reduced dependency of the aerostatics on the Reynolds number.

REFERENCES

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