EXPERIMENTAL WAKE DYNAMICS OF PILES WITH ARTIFICIAL BIOFOULING IN WAVES

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MOTIVATION

Offshore structures become colonized by marine organisms after a short period of time, whose common benthic communities depend among others on geographic location, water depth, water temperature, food supply, salinity and oxygen content of the water (Kröncke and Bergfeld, 2003; Shi et al., 2012). While biofouling can be categorized in biological terms as bivalves, kelp, algae, barnacles, tubeworms and other species (van der Stap et al., 2016; Wilhelmsson and Malm, 2008), engineers mostly distinguish between hard and soft marine growth based on the strength of their outer shell alone (Shi et al., 2012; Skaugset and Baarholm, 2008). Due to an increasing demand for sustainable energy, the offshore renewables industry experiences significant growth. However, many uncertainties persist in the consideration of biofouling, specifically when calculating loads according to the Morison concept, the influence of marine fouling on fatigue reassessment, on the flow velocities around cylinders and the vortex formation under waves. **For the first time, the flow around cylinders with different artificial marine biofouling was recorded and analyzed in an extensive experimental study using a comprehensive 4D particle tracking velocimetry (PTV) system.**

EXPERIMENTAL INVESTIGATION

The experimental study on the fluid dynamics around piles in wave motion was conducted in a medium-sized wave flume of 90 m × 2 m × 1.25 m (Figure 1) with a piston-type wave maker. The study distinguished between eight roughness types, either modelled with sandpaper (hard fouling), artificial grass (medium stiff fouling) or carpet (soft fouling) with a relative roughness of *k/D* = 0 - 0.32. All in all, 18 regular wave conditions were generated to cover a wide range of different flow dynamics (cf. Figure 1).

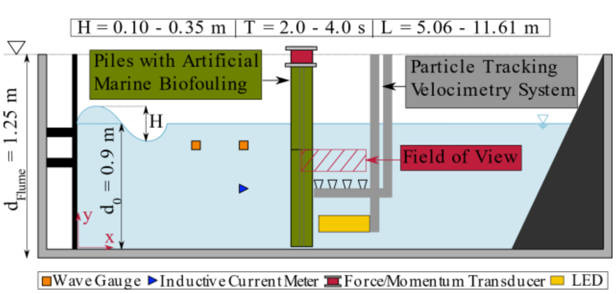

Figure 1 - Experimental setup providing information on the hydraulic laboratory facility and the used instrumentation.

This study lays emphasis on the analysis of data acquired with a novel particle tracking velocimetry system (PTV, LaVision Underwater Minishaker©). Four cameras (896 × 656 pixel @ 500 Hz) detect seeding particles in a measurement volume of 300 mm × 220 mm × 150 mm. The Shake-the-Box (STB)-algorithm (Schanz et al., 2016) is used to robustly detect spatially (*x, y, z*) and temporally (*t*) variable velocity fields and their derivatives.

RESULTS

To reveal coherent turbulent structures in the wake of a pile, the Q-criterion is a widely utilized Eulerian technique. Figure 2 visualizes the *Q*-isosurfaces for $Q = 40\ s^{-2}$ and applies a color map to depict the vorticity in *y*-direction (ω_y). Especially the pile with the highest roughness (green - carpet) contributes to a strongly increased vortex generation. Alternating vortex shedding processes could be observed for all pile configurations.

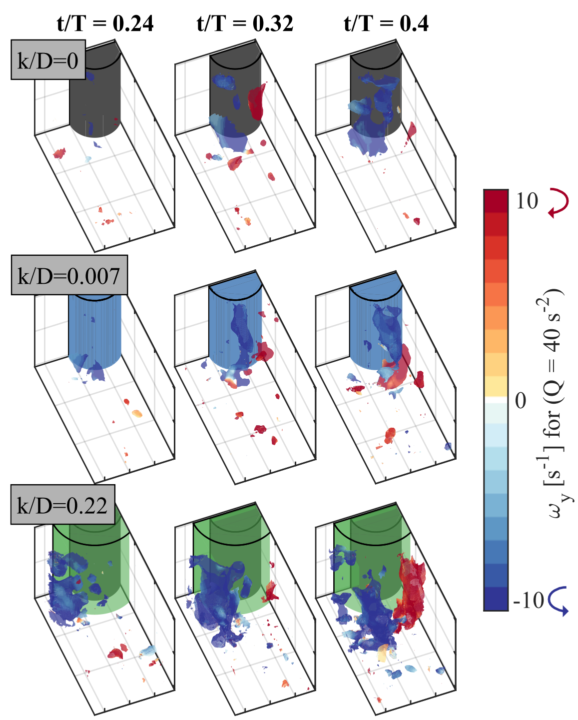

Figure 2 - Visualization of Q-isosurfaces for cylinders with three roughness lengths (rows) and three instants in time (columns) for a wave of *H* = 0.3 m; *T* = 2.5 s. Color coding refers to the vorticity in y-direction (ω_y) for $Q = 40\ s^{-2}$.

CONCLUSIONS

This study substantiates the roughness influence of marine fouling on the flow around upright mounted cylinders. Using the PTV method, the spatial and temporal wake dynamics are mapped at very high resolution, interpreted and quantitatively evaluated in experimental studies to provide more precise insights into the ongoing processes in e.g. offshore wind substructures and wave interaction.

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