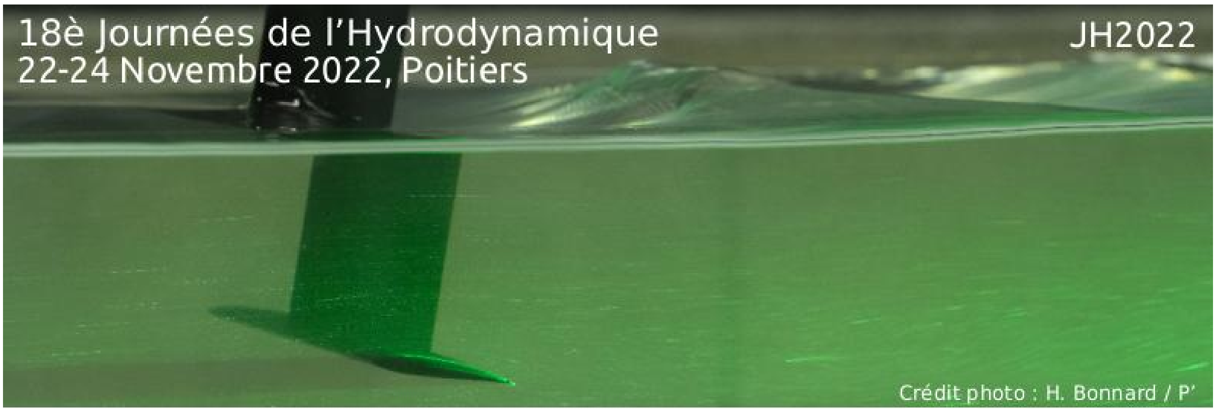

Numerical investigation of breaking focused wave-induced loads on floating offshore wind turbines

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Abstract

Offshore wind turbines and floating offshore wind turbines are growing in popularity, and the design of such devices still carries uncertainties. From the structural point of view, the models employed to predict the hydrodynamic loads are mostly based on the Morison formulas, and these may lead to non-negligible underestimation, especially when energetic steep or breaking waves occur in the vicinity of the structure. These slamming loads have a significant impact in determining the Ultimate Limit State (ULS) of the structure, but the spatially and temporally localised nature of breaking waves makes them difficult to predict and are often overestimated. The present research makes use of a two-phase numerical model with the Volume Of Fluid (VoF) approach implemented in the open-source computational fluid dynamic (CFD) software, code_saturne, to study the validity and range of applicability of existing analytical formulas to estimate these loads such as those initially proposed by Von Karman (1929) [3] or Wagner (1932) [4] and later extended by Goda (1966) [1], Wienke and Oumeraci (2005) [5] and Paulsen (2019) [2], among others. From these references, the present study investigates the ranges of magnitude and validity of the so-called curling factor and the fluid velocities parameters.

The workflow for the present numerical study initially focuses on validating two separate phenomena during a wave slamming situation. On the one hand, a cylinder water entry configuration is used to investigate the stability and accuracy of the modelled loads using code_saturne and promising results have been obtained. In parallel, wave generation and propagation using phase-focused wave is compared with experimental data and good agreements have been observed (see Fig. 1). The wave packets are generated using a JONSWAP spectrum. The results obtained from these two configurations are now being investigated together in a 3D configuration where breaking wave loads are exerted on a rigid vertical cylinder (see Fig. 2). Several wave breaking conditions, as well as different breaking onset distances from the cylinder, are studied as relevant parameters affecting the load history and magnitude. Intermediate and deep water waves conditions are mainly

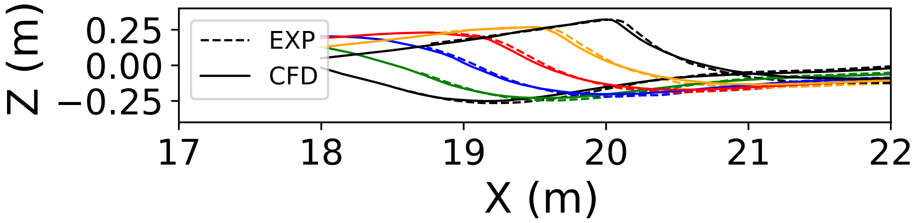

Figure 1: Free surface profile comparison between the CFD results, obtained using code_saturne, and the experimental measurements during a weak-spilling breaking 2D focused packet.

investigated, focusing on characteristic sea-states typical of offshore wind farms. This work is being developed in parallel with experiments and semi-analytical investigations as part of the DIMPACT project, and further comparisons between the CFD and the experimental results will be presented at the conference.

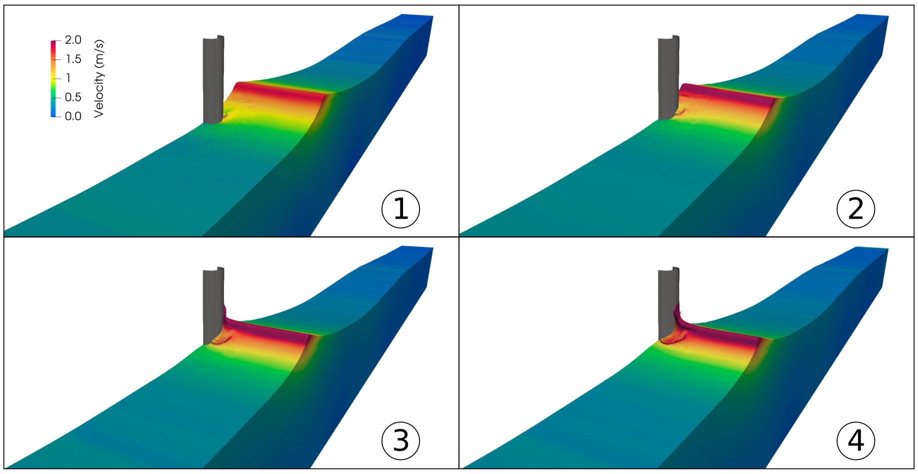

Figure 2: CFD results, using code_saturne, of a weak-spilling 3D slamming on a cylinder. The color range corresponds to the velocity magnitude field (m/s).

References

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