Interaction between breaking-induced vortices and nearbed structures: experimental and numerical investigation

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During the breaking process, vorticity is generated near the air-water interface, and surface vortices move downward, typically as an effect of either spilling or plunging breakers in a 2D or 3D fashion. Further, sharp discontinuities in the seabed promote flow separation and generation of nearbed vortices, as in correspondence of submerged sandy bars or man-made defense structures. The interaction between surface (breaking-induced) vortices and nearbed structures is an important link between upper and lower boundaries of the wave body, especially in terms of mass and momentum transfer, sediment stirring, air-water mixing (Nadaoka *et al.*, 1989). Such vortex interaction has been experimentally and numerically studied on a vertical breakwater that forced a backward-type breaker (Wu *et al.*, 2012; Wang *et al.*, 2018), although the authors used a solitary wave impacting an artificial structure, which generated a fairly small vortex interaction.

Laboratory tests are currently ongoing at the Università Politecnica delle Marche (Italy) within the FUNBREAK project framework. A 50m-long wave flume hosts a 2D physical model made of contiguous sloping platforms, where regular waves travel and break over a discontinuity. Wave gauges record the surface level along the flume, while optical measurements are obtained using two high-speed cameras and a 10 W green-light laser (Fig.1a). The particle tracking showed relevant interactions between surface and nearbed vortices (Fig.1b).

Furthermore, numerical simulations are run using the in-house code Xdolphin3D (Xie *et al*., 2020). The N-S equations are discretized using the finite volume method in a Cartesian grid and the VOF method is employed to capture the air-water interface together with a Cartesian cut-cell method to deal with the complex topography. The motion of the wavemaker was input directly into the solver to generate different waves using the moving body method. 2D RANS simulations have been run to check the interaction between surface and nearbed vortices after the discontinuity, while detailed 3D LES are being undertaken to elucidate the insight for the complex 3D vortical structures, which is difficult to measure in laboratory experiments (Fig.1c).

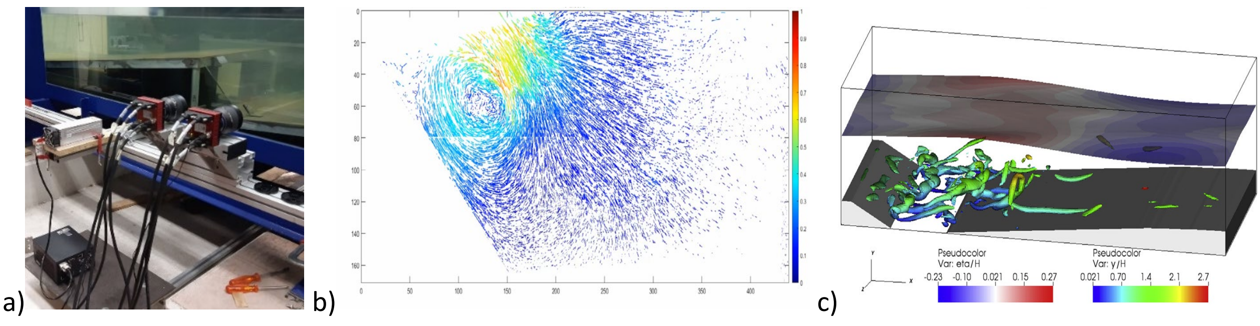

Figure 1. Experimental setup (a). Preliminary results from particle tracking (b) and numerical test (c).

References

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