Generation of water waves by the impulsive motion of a vertical plate

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Recently, the generation of impulse surface waves by the collapse of a rectangular granular column into water was investigated experimentally [1,2,3]. These laboratory experiments aiming at modeling the generation of tsunami waves by subaerial landslides [4] have shown different regimes of waves depending on the Froude number Fr_g based on the velocity of the advancing granular front relative to the linear gravity wave velocity in shallow water [5] : linear Cauchy-Poisson waves at low enough Fr_g, solitary waves at moderate Fr_g, and transient bores leading to breaking waves at large enough Fr_g. For the two last regimes where the grains push the shallow water like a piston, the amplitude of the generated wave can be predicted from the initial characteristic of the granular column [6]. In these gravity-driven flows, the run-out distance of the granular collapse is linked to its time scale and thus to the typical velocity of the granular front [7]. Here, we investigate the more general case of surface gravity waves generated by the impulsive motion of a vertical plate in a rectangular channel partially filled with water. The water surface dynamics is tracked from the images taken by a camera from the side of the channel. By independently varying the stroke L and the velocity V of the piston, as well as the water depth h_0, we observe a large variety of waves including the three wave regimes described before but also other regimes such as a jet splash regime where a tongue of fluid is ejected at high piston acceleration. The different wave regimes are shown to depend on both the relative Stroke L/h_0 and the Froude number $Fr_p = V/(gh_0)^{1/2}$ of the motion of the piston, which have been varied in a large range. Interestingly, all kind of waves exhibit a common transient bore shape during the first stage of formation, suggesting the short-time hydrodynamics belongs to an unsteady shock structure problem.

Références

1. B. Huang, Q. Zhang, J. Wang, C. Luo, X. Chen, and L. Chen, Experimental study on impulse waves generated by gravitational collapse of rectangular granular piles, *Phys. Fluids* **32**, 033301 (2020).
2. M. A. Cabrera, G. Pinzon, W. A. Take, and R. P. Mulligan, Wave generation across a continuum of landslide conditions from the collapse of partially submerged to fully submerged granular columns, *J. Geophys. Res. Oceans* **125**, e2020JC016465 (2020).
3. M. Robbe-Saule, C. Morize, R. Henaff, Y. Bertho, A. Sauret, and P. Gondret, Experimental investigation of tsunami waves generated by granular collapse into water, *J. Fluid Mech.* **907**, A11 (2021)
4. M. Robbe-Saule, C. Morize, Y. Bertho, A. Sauret, A. Hildenbrand, and P. Gondret, From laboratory experiments to geophysical tsunamis generated by subaerial landslides, *Sci. Rep.* **11**, 18437 (2021)
5. W. Sarlin, C. Morize, A. Sauret, and P. Gondret, Nonlinear regimes of tsunami waves generated by a granular collapse, *J. Fluid Mech.* **919**, R6 (2021).
6. W. Sarlin, C. Morize, A. Sauret, and P. Gondret, From granular collapses to shallow water waves : A predictive model for tsunami generation, *Phys. Rev. Fluids* **7**, 094801 (2022)
7. W. Sarlin, C. Morize, A. Sauret, and P. Gondret, Collapse dynamics of dry granular columns : From free-fall to quasistatic flow, *Phys. Rev. E* **104**, 064904 (2021)