

Viscoplastic fluid impacting a body of water: predicting wave features from the fluid properties

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We investigate viscoplastic fluids (described using a Herschel–Bulkley model) striking a body of water: a fixed volume of a viscoplastic material (a polymeric gel called Carbopol ultrez 10) initially contained in a box is released on a slope and flows down under gravity. When it enters flume filled with water, it generates an impulse wave. The problem is to determine impulse waves' features from the viscoplastic fluid properties.

First, we use momentum and mass conservation in a control volume for modeling the interaction between the viscoplastic flow and water^[1]. To close the resulting equations, we calculate the flow depth and average velocity of the viscoplastic fluid (at the shoreline) using an approximate model (based on lubrication theory and matched asymptotic expansions)^[2]. We then solve the mass and momentum balance equations numerically. The scale analysis of these equations allows us to define 5 dimensionless groups, which are used to correlate wave features and fluid properties.

Second, we compare the theoretical model with experimental data specifically acquired for this purpose. Figure 1 shows the experimental facility. Using PIV techniques, we measure the velocity profile of the viscoplastic fluid near the shoreline and its velocity field after immersion. This makes it possible to determine the water velocity field and the interface between the solid, water, and air phases. Good agreement is found between the measured and predicted wave characteristics (e.g. amplitude and height).

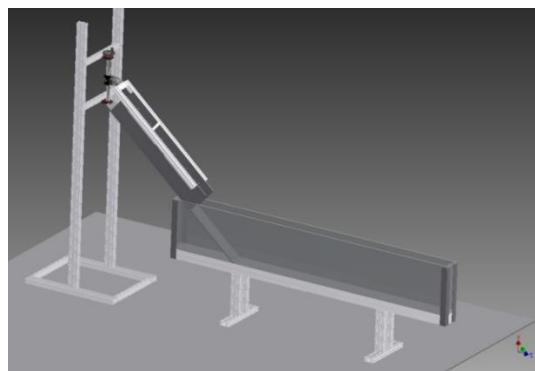


Figure 1: the experimental facility.

Reference:

- [1] Zitti, G., Ancey, C., Postacchini, M. and Brocchini, M., 2016. Impulse waves generated by snow avalanches: Momentum and energy transfer to a water body. *Journal of Geophysical Research: Earth Surface*, 121(12), pp.2399-2423.
- [2] Ancey, C. and Cochard, S., 2009. The dam-break problem for Herschel–Bulkley viscoplastic fluids down steep flumes. *Journal of Non-Newtonian Fluid Mechanics*, 158(1-3), pp.18-35.

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