

The effects of slide cohesion on impulse waves generated by landslides

Zhenzhu Meng*, Christophe Ancey*

* Environmental Hydraulics Laboratory, École Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland (zhenzhu.meng@epfl.ch)

When gravity-driven mass flows, such as avalanches and landslides, enter bodies of water, they can generate large impulse waves whose effects can be devastating. Experimental studies of impulse wave formation have mostly used rigid blocks or granular materials to mimic landslides at the laboratory scale. These studies have deduced that material deformability plays a key part in wave formation: the more rigid the sliding mass, the higher the impulse wave. It is, however, still unclear whether higher wave amplitudes arise solely from lower deformability. Indeed, blocks are not only rigid, but they are also cohesive, whereas granular media are deformable and cohesionless. To shed light on this issue, we ran experiments using two deformable materials of equal density, one exhibiting no cohesion (soft 15-mm diameter balls) and the other exhibiting cohesion (a viscoplastic polymeric gel called Carbopol Ultrez 10). A finite volume of material was released at the top of a chute, penetrated a body of water and generated impulse waves. We monitored how the mass slid and interacted with the water volume. Using high-speed cameras, we measured maximum wave heights, amplitudes and lengths of the leading wave. We used dimensionless groups to reduce the dimension of the parameter space, making it possible to carry out a regression analysis. Viscoplastic slides generated larger wave amplitudes but shorter wave lengths than granular materials. Surprisingly, the wave features did not depend on the polymer concentration. In other terms, impulse wave features were not found to be dependent on the cohesion of the deformable material landslides causing them, within the range of concentrations tested.

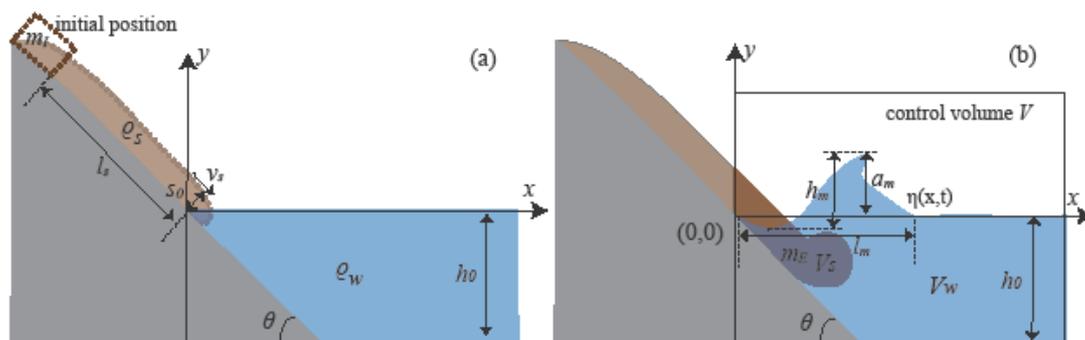


Figure 1. Sketch of the wave generated by releasing slide material into a body of water.

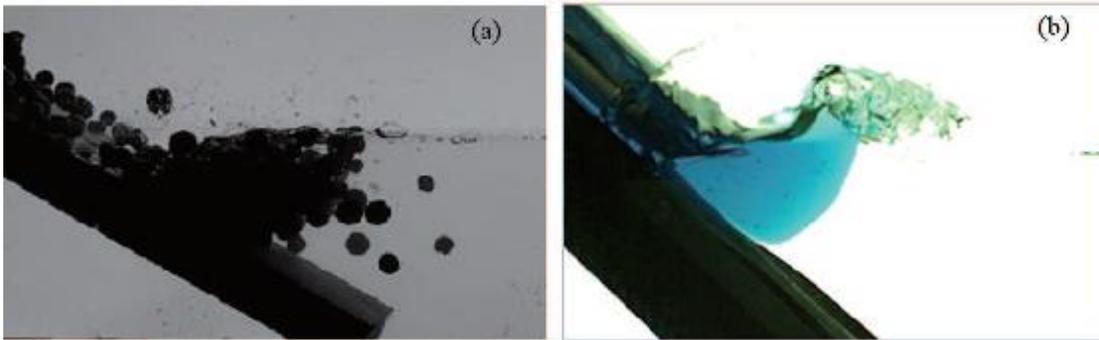


Figure 2. Sketch of the wave generated by releasing slide material into a body of water.

REFERENCES

- 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.
- Meng, Z., 2018. Experimental study on impulse waves generated by a viscoplastic material at laboratory scale. *Landslides*, 15(6), pp.1173-1182.
- 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.