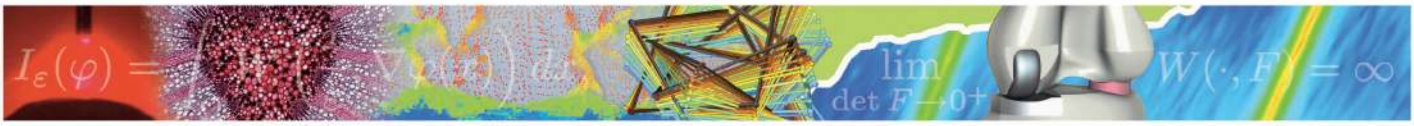

Partially Immersed Granular Collapse: from Grain Mechanics to Tsunami Dynamics

Granular collapses into water, be they natural (submarine landslides, coastal cliff erosion) or man-made (mine slurries, dam breaks), generate waves and turbulent currents that can have major economic and natural consequences, wreaking havoc on coastal communities and industries. Recent experimental and numerical studies have highlighted the coupling mechanisms between the collapse of the granular phase and the generation of far-travelling waves [1, 2], but few have focused on microscopic, grain-scale mechanisms [3]. The influence of micromechanical parameters such as grain friction, lubrication, capillarity, and fluid percolation is yet to be thoroughly explored.

Objectives

This thesis aims at understanding the momentum transfer between the granular phase and the fluid phase at a macroscopic scale based on complex micromechanical interactions. More precisely, the investigation will focus on the effect of grain-scale parameters, such as polydispersity, contact physics (lubrication, friction and capillarity), and porosity, on the momentul transfer. Then, the momentum transfer will be linked both qualitatively and quantitatively to the dynamics of the generated waves. This would enable the assessment and prevention of environmental or operational hazards. Finally, the extension and validation of the numerical tool would pave the way to its use in similar contexts.

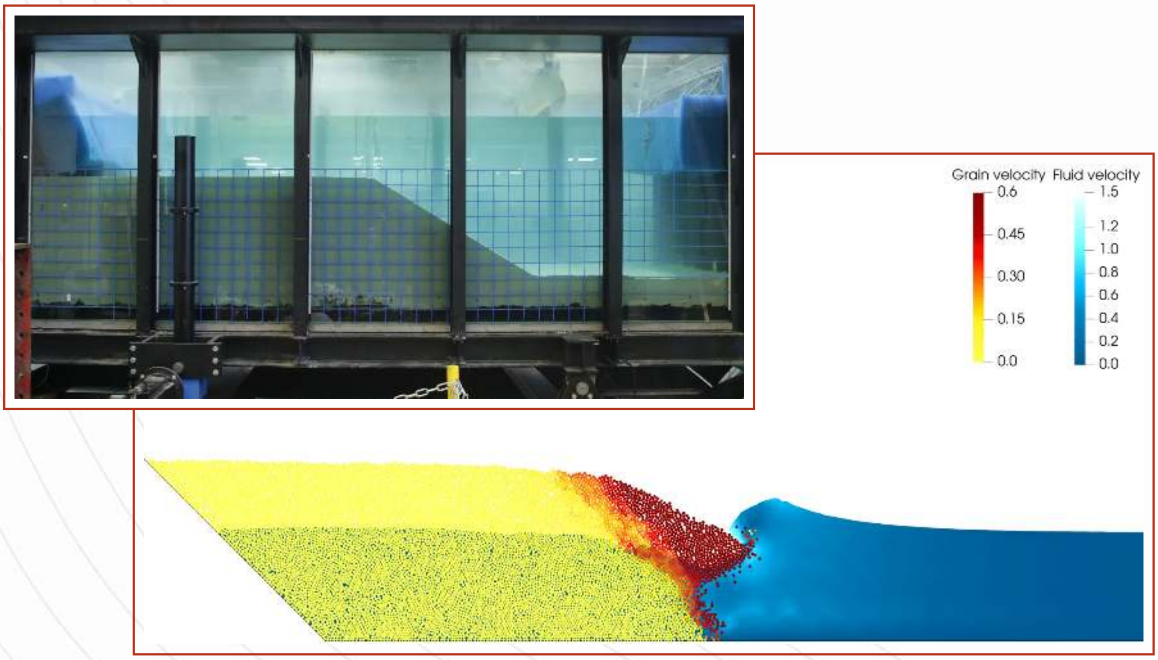

Figure 1: Top left: Experimental static liquefaction tank at TU Delft. Bottom right : Preliminary simulation of a granular mass collapsing into water made with the MigFlow software.

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Numerical part

For this thesis, a recent innovative numerical approach developped in the MigFlow software (Fig. 1 bottom right) will be used [4]. This open-source software combines a Nonsmooth Discrete Elements Method (DEM-NSCD) for the granular phase to a Particle Finite Elements Method (PFEM) for the fluid phase. While the DEM provides insights on the grain-scale physics, the PFEM enables the reliable simulation of a free surface. It will be necessary to extend this model, adding key micromechanical aspects such as contact lubrication or capillarity, with a focus on code optimisation to minimise computational costs.

Experimental part

In order to assert the reliability the numerical results, an important aspect of this work will be the experimental validation in direct collaboration with TU Delft. In that view, a research stay is strongly considered. Their static liquefaction tank (Fig. 1 top left) and physical modeling facilities enable the study of mass movements, measuring quantities such as pressure, velocity and acceleration, notably with Particle Image Velocimetry (PIV).

Candidate profile

Overall, this thesis offers the opportunity to leverage skills in both the numerical and experimental aspects of research focused on immersed granular materials. Therefore, the candidate should have a strong interest in the development and use of numerical methods, as well as an appetite for experimental approaches. Required skills include Python and C++ in terms of coding, as well as a good knowledge of fluid mechanics. Knowledge of granular mechanics is a serious plus, but is not mandatory.

Supervision

This thesis is offered within the framework of the I2S Doctoral School. Its funding depends on the candidate's success in an audition conducted by a jury of the Doctoral School. The PhD is proposed in the "Laboratoire de Mécanique et Génie Civil" (LMGC) under the supervision of:

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References

[1] 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," JGR Oceans, vol. 125, p. e2020JC016465, 2020.

[2] 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," Journal of Fluid Mechanics, vol. 907, p. A11, 2021.

[3] A. Bouguoin, S. Viroulet, L. Lacaze, O. Roche, and R. Paris, "Dry granular collapse into a liquid: Role of viscous dissipation on granular flow regimes and associated waves," Physical Review Fluids, vol. 9, p. 124302, 2024.

[4] T. Leyssens, M. Henry, J. Lambrechts, V. Legat, and J.-F. Remacle, "A coupled pfem-dem model for fluid-granular flows with free-surface dynamics applied to landslides," Journal of Computational Physics, vol. 537, p. 114082, 2025.