Proposal for a Master internship

Avalanches of fibre-reinforced granular materials

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Introducing a small amount of flexible fibres into a granular medium can significantly increase the mechanical strength of the material. This effective and inexpensive technique is used in practice to tune the mechanical resistance of concrete materials, to reinforce soils against erosion or to stabilise fragile slopes against the risk of avalanches (Fig. 1a). Although there is empirical knowledge of these reinforcement techniques, there is no physical framework for predicting the behaviour of fibre-reinforced granular materials.

The aim of this internship is to study the effect of adding flexible fibres on the behavior of granular avalanches to understand how fibres can prevent these phenomena in practice. For this purpose, we will realize small-scale experiments with a model material made of glass beads added with synthetic fibers. The behavior of this material will be studied in a drum rotating at low speed that repeatedly induces avalanches (Fig. 1b). The first part of the internship will be devoted to studying how the presence of fibres modifies the starting and stopping angles of these avalanches. In the second period, we will investigate the effect of the fibres on the stationary flow that develops at the surface of the material when the drum rotates at higher speed. In both cases, we will study the effect of fibre concentration, aspect ratio and bending stiffness on the observed phenomenon. In addition to macroscopic observations, we will also carry out visualisations on a smaller scale in order to observe the interactions between the grains and the fibres. Based on these observations, we will develop a theoretical model to rationalise the influence of flexible fibres on granular avalanches. These results will permit to identify the optimum fibre properties (concentration, aspect ratio, bending stiffness) for reinforcing a granular slope against the risk of avalanches triggered by external events.

This internship will take place in the team *Granular and Suspension* at FAST, which studies the behavior of granular materials and suspensions of particles from an experimental point of view. It will benefit from the local expertise concerning granular avalanches [1], the rheology of granular materials [2] and the mechanics of fibre assemblies [3].

Figure 1: (a) Examples of fibre-reinforced soil and concrete. (b) Experimental configuration studied in this project.

References

[1] B. Darbois Texier, Y. Bertho, and P. Gondret. Downslope granular flow through a forest of obstacles. *Physical Review Fluids*, 8(3):034303, 2023.

[2] J. Lalieu, A. Seguin, and G. Gauthier. Rheology of a 2d granular film. *Soft Matter*, 19(35):6838–6843, 2023.

[3] A Seguin and J Crassous. Twist-controlled force amplification and spinning tension transition in yarn. *Physical Review Letters*, 128(7):078002, 2022.