Proposal for a Master 2 intership

Gravitational collapse of a granular column reinforced with fibres

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Introducing a small amount of flexible fibres into a granular medium is known to significantly increase the mechanical strength of the material (Fig. 1a). 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. For these reasons, numerous works have focused on the effect of fibers on the yield stress of granular materials. However, little is known about the flowing behaviour of grain/fibre mixtures above the yield stress. A simple and widely used configuration for testing the properties of complex fluids such as granular materials or particle suspensions is the gravitational collapse of a column of such material and the extension of the resulting deposit.
The aim of this internship is to study the effect of the addition of fibres on the flow behaviour of a granular column collapsing under the effect of gravity (Fig. 1b). To do this, we will realize small-scale experiments using calibrated grains and synthetic fibres with different aspect ratios and flexibility. The first step will be to study the different flow regimes as a function of the volume fraction of the fibres added to the grain and their properties. Preliminary experiments have identified three regimes: one in which the fibres flow with the grains, one in which they separate and one in which the fibres stabilise the granular column (Fig. 1c). In the flow regime, we will quantify the collapse dynamics of the column and the final shape of the deposit as a function of the volume fraction of the fibres, their aspect ratio and their flexibility. Based on these observations, we will propose empirical relationships to rationalise the influence of fibres on collapse dynamics and deposit geometry. We would also like to explore whether these data allow us to deduce an effective rheology law for mixtures/fibres. Finally, these results will provide a better understanding of the effect of fibres added to a granular material and provide a physical basis for the use of fibre-reinforcement techniques in practical situations.

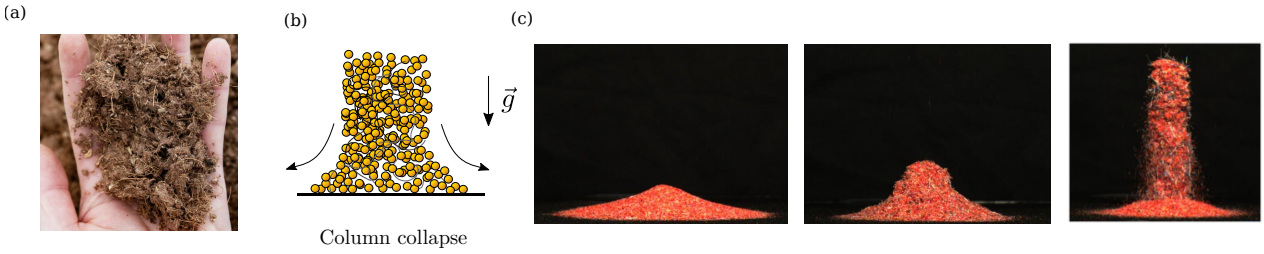

Figure 1: (a) Exemple of granular material (soil) reinforced with fibres. (b) Sketch of a column collapse. (c) Preliminary experiments showing the final deposit for increasing fraction of fibers.

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

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.