Fine Sedimentation Infiltration Underneath Debris Flows: Preliminary Results

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1. Introduction

Debris-flow dewatering and mixing with underneath substratum is essential to understand distance travelled and potential impacts, as formulated by the relation between the surface slope of a deposit and the maximum travelled distance after a slope break, by notably taking into account water expelled at the surface during sedimentation. This work can be further extended by asking the question: what is happening underneath the deposit when the substratum is porous, and fluid escapes underneath? How much of the fine material, as part of the slurry [2] is escaping underneath, contributing to a modification of the C_u and C_* [1]? These questions are essential as fines contribute to waxing the flow [2] and can have ambiguous roles either acting as part of the slurry or as part of the "dry-load" [3].

2. Objectives and Methodology

As the formulation has been generated from impermeable substratum experiments, the present contribution aims to test whether significant results can be obtained from laboratory analysis of infiltration and mixing of material.

To reach this objective, a simple setup was created at Kobe University at the laboratory of sediment hazards and disaster risk, with a 2400 mm long and 100 mm wide ramp connected to a deposition box of 800 mm x 750 mm, 60 mm deep. (Fig. 1). The flow was generated using a water container with 500 ml of water released by a mechanical valve onto the sediment previously placed on the inclined and mixed with water 500 ml +/- 50 ml (extra-water was sprayed to keep the material moist) for it sticks to the ramp that was covered with 0.125 mm sand for bed roughness. The material that composes the

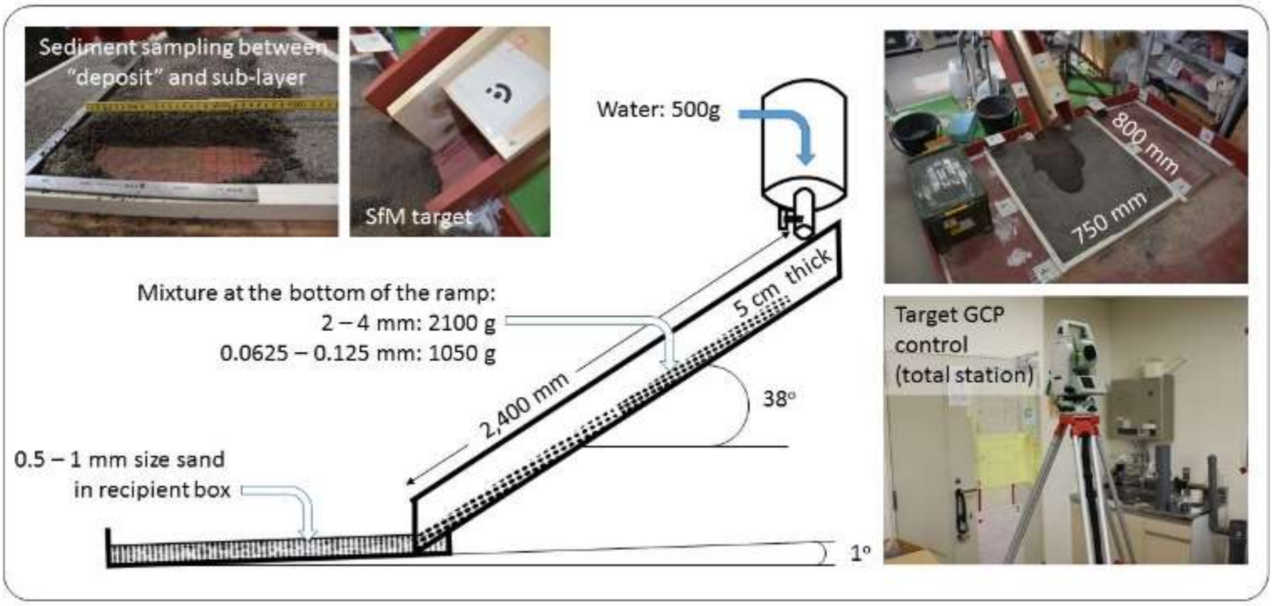

Fig. 1 The experimental setup, showing the ramp and receiving box inclination, the characteristics of the sediments, the sediment sampling process and the topographic data acquisition targets and total station.

simulated debris flow is a mixture of 2-4 mm and 0.0625 – 0.125 mm material with a respective mass-ratio 2/1. The receiving box is made of 0.5 – 1 mm material.

The topographic data before-&-after flow were collected using SfM and 11 targets ($RMSE_z$ = 2.3 mm), and the targets' location was measured using a total station positioned 3 m from the tray. The topographic change was calculated using the Difference of DEMs method. The sediments were collected and sieved from a series of slices next to one another with a thickness between 5 cm and 15 cm starting from the snout of the debris-flow deposit and ending near the connection between the receiving box and the ramp. Vertically, the material above the original base topography and underneath were separated to measure any form of mixing and the samples then sieved using dry mechanical sieving.

3. Results

Topographic change shows a typical debris-flow deposit with a snout and levees on the sides (Fig. 2).

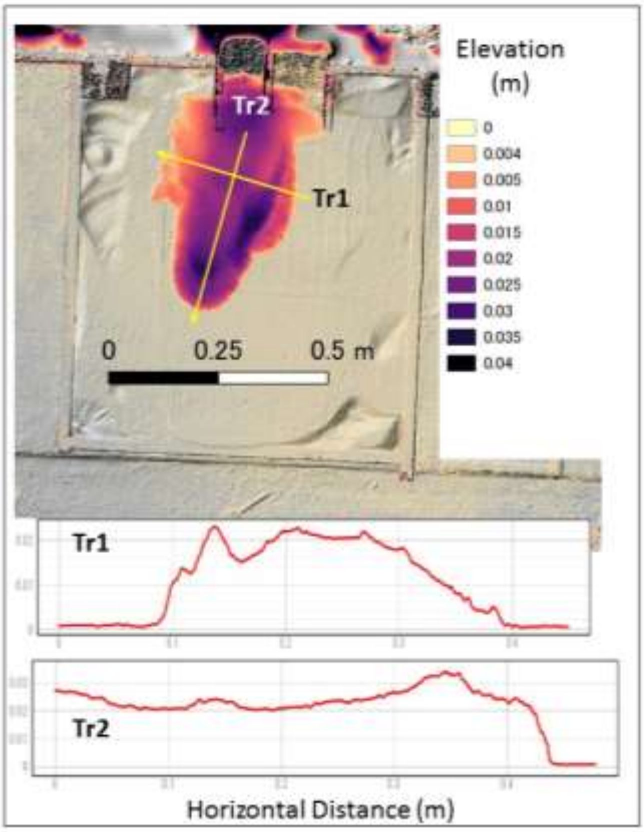

Fig. 2 Topographic change of experiment 2.

The sediment analysis shows that the fine fraction of the material penetrated the subsurface (A on Fig. 3) with majority of the data below 10% of mass incorporated, although in experiment 1 tail flow erosion "replaced" the substratum and generated an artificial 50% of mass sample (B on Fig. 3). Substratum erosion also occurred as the top part of the outcrops also integrated between mass 60% and 80% of the substratum, even in experiment 2 where the flow tail was not consequent.

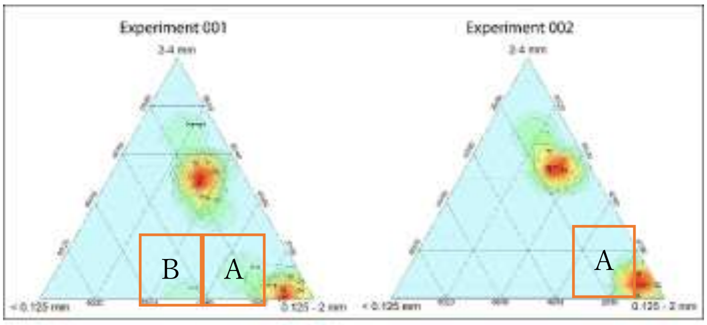

Fig. 3 Ternary diagram of the different grain fractions used in the study, showing levels of mixing by mass.

4. Conclusion

The preliminary experiments show that dewatering is occurring underneath the deposit (the substratum is wetted) and a portion of the sediment accompanies this transfer, with cases of substratum mixing and cases without mixing (pure percolation). A simple infiltration experiment of the slurry in a tube filled with sediment keeping the same grain-size distribution also showed that up to a threshold concentration, material is being transported as part of the fluid in the column, showing that the infiltration head controls the vertical progression of the fines in the substratum.

References

[1] Takahashi. T. 2019. Debris flows, Mechanics, Prediction and Countermeasures 2nd Ed.

[2] Sakai et al. 2019. Journal of Hydraulic Engineering 145-5, 6019004.

[3] Hotta et al. 2013. Journal of Mountain Science 2, 233-238