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Inertial effects in just-saturated axisymmetric column collapses

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Introduction and Background

Debris flows are a subset of gravity-driven slope hazards comprising a mixture of grains (rocks, soils) and water that represent a significant geophysical hazard across the world [1]. Undertaking research to understand the physical mechanisms controlling their motion is crucial to the improved modelling of their behaviour and mitigation of their destructive potential.

Figure 1: Aerial view of debris flow aftermath in Caraballeda, Venezuela [2]

Aims and Objectives

Aim: To establish which flow processes are governed by larger particle sizes whose behaviour are predominantly controlled by their inertia.

Objectives:

- Develop an experimental setup capable of performing high-g column collapse tests.
- Use dimensional analysis to understand what parameters are likely to play the most significant roles on collapse dynamics.
- Evaluate how runout behaviour varies with collapse scale.

Research Gap

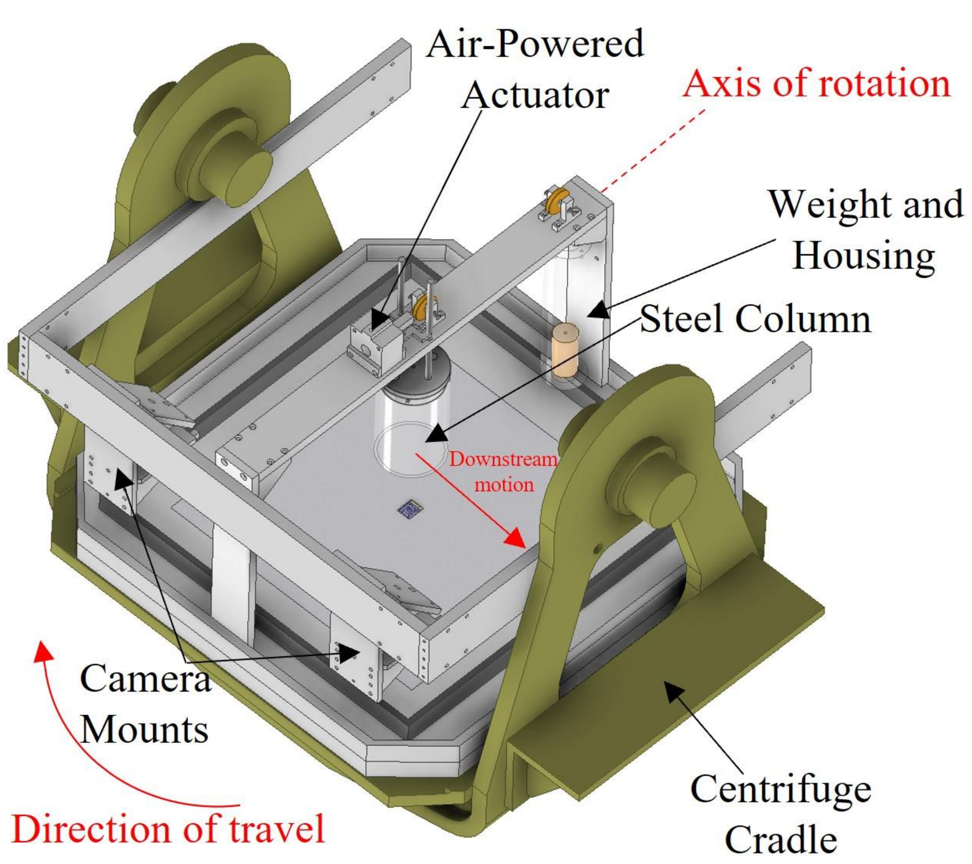


Figure 2: Schematic of experimental setup on centrifuge cradle

The current study is one of the first to utilise a geotechnical centrifuge to conduct laboratory-scale debris flow experiments where some aspects of geophysical flow behaviour, like the domination that inertial forces have on collapse dynamics, can be replicated by the elevated gravitational acceleration.

Methodology

- A series of **axisymmetric just-saturated granular column collapse** tests were conducted where grain diameter, fluid viscosity and gravitational acceleration were systematically varied.

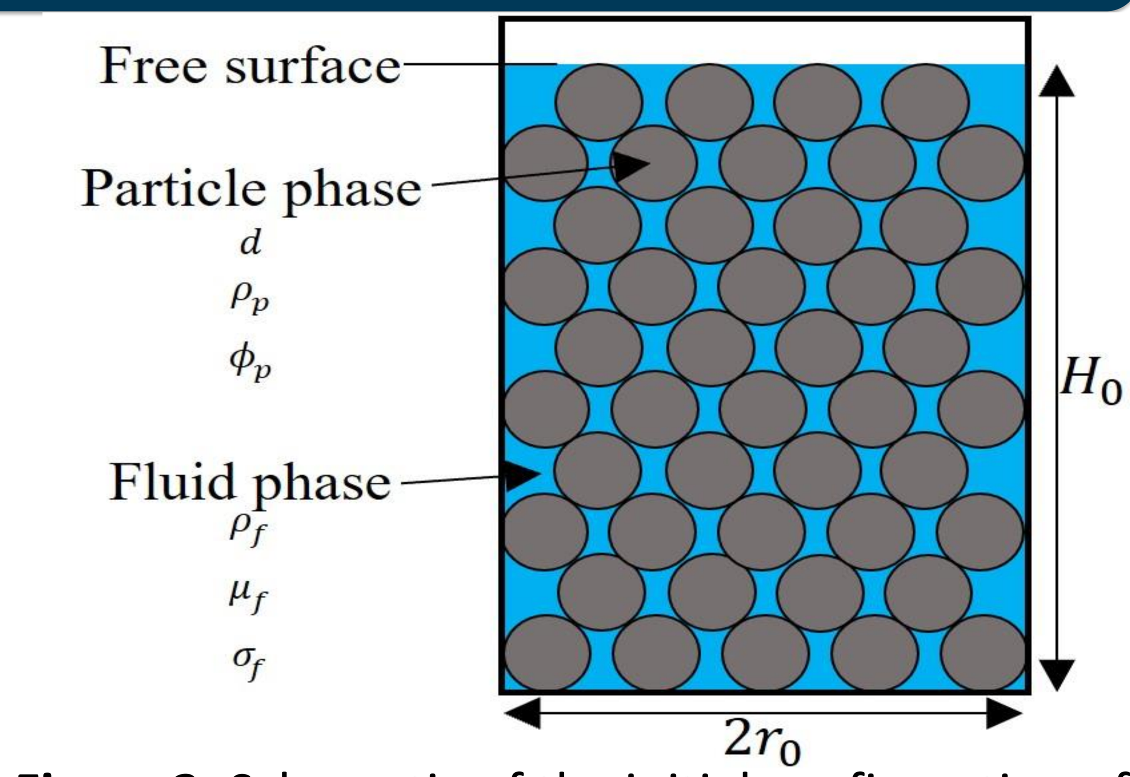
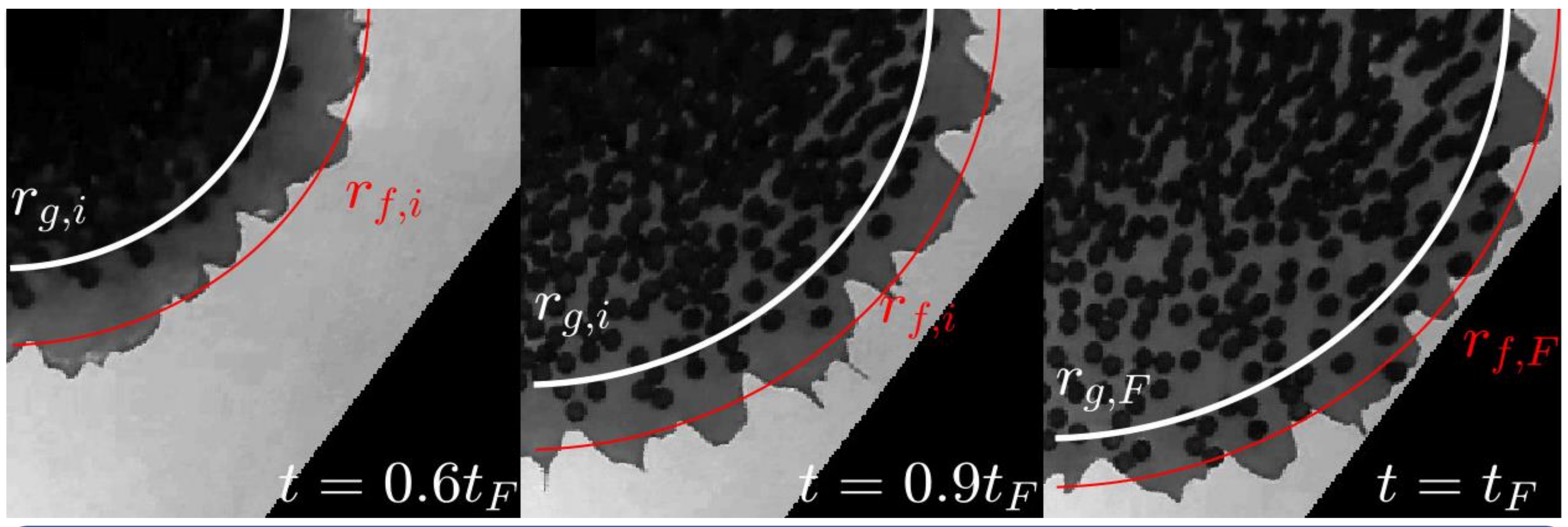


Figure 3: Schematic of the initial configuration of a just saturated granular column collapse

- Evolution of the fluid and granular fronts were tracked using a Digital image correlation scheme.



Results

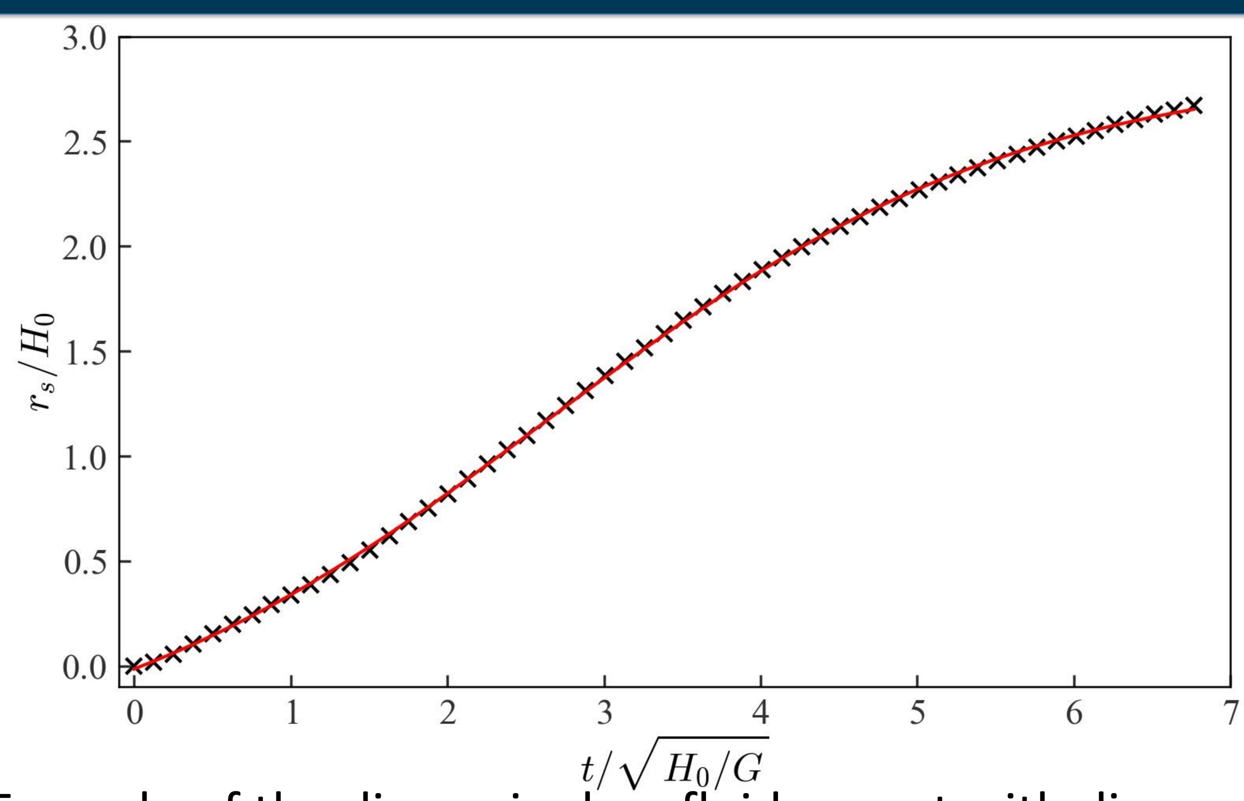


Figure 5: Example of the dimensionless fluid runout with dimensionless time (black) fitted to a sigmoid curve (red)

Characteristic velocities, time durations and dilatancy-related pressure drops of the acceleration phase and the general shape of the runout time series **scale independently of grain-scale surface tension effects. This suggests that the runout behaviour of inertially dominant grains in geophysical debris flows is not affected by grain-scale surface tension effects so can be well modelled in the laboratory and numerically.**

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References

[1] Forterre Y and Pouliquen O (2008) Flows of dense granular media. Annual Review of Fluid Mechanics 40:1–24.
[2] USGS (2019). USGS.gov. Science for a changing world. [online] Usgs.gov. Available at: https://www.usgs.gov/.

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