Triggering mechanism of wet granular avalanches

Claude EL TANNOURY [1], Luc OGER[1]

Irene IPPOLITO[2], Renaud DELANNAY[1], Yves LE GONIDEC[3]

1. Université Rennes1, Institut de Physique de Rennes, UMR 6251, Milieux Divisés, Rennes, France.
2. Universidad de Buenos Aires, Facultad de Ingenieria, Grupo de Medios Porosos, Buenos Aires, Argentina.
3. Université Rennes1, Géosciences Rennes, UMR 6118, Dynamique, Imagerie et Modélisation des Systèmes Environnementaux, Rennes, France.

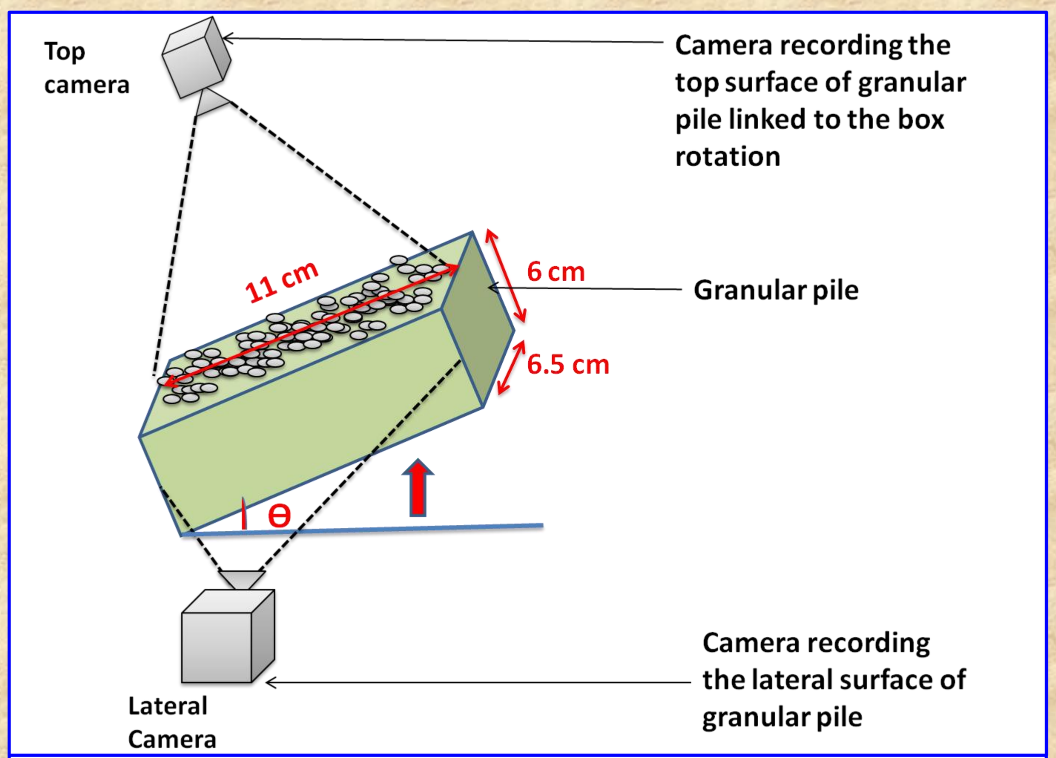
Grupo de Medios Porosos
Departamento de Fisica
Facultad de Ingenieria
UBA

Introduction

We study experimentally the triggering mechanism of granular avalanches. The dynamic of destabilization has **three regimes**[1]: (1) a regime of small independent and localized rearrangements followed by(2) a regime of collective and successive motions of grains, called ‘precursors’, which appear at quasi-periodic-tilting angles then(3) the avalanche which occurs at the maximum stability angle.

We focus on the effect of relative humidity, showing that it strongly affects the avalanche angle and precursors dynamics. We also show a dependency with other parameters, such as grain size and nature, height of the granular bed.

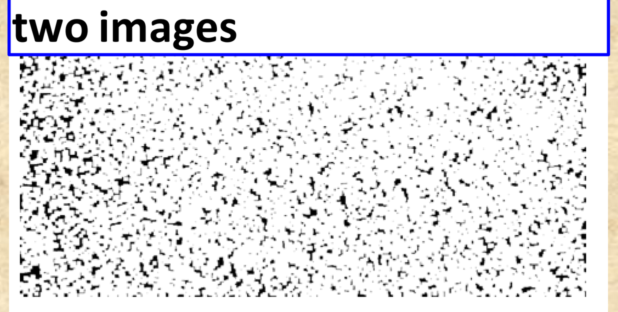
Principles



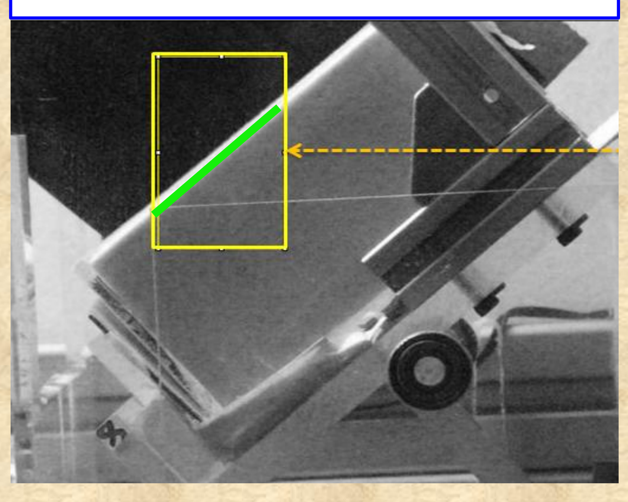
Experimental setup: A box (6.5 x 6 x 11) cm³ containing monodisperse polystyrene or glass beads is slowly tilting by a motor to get the first and the successive avalanches. A lateral camera images the lateral surface of the granular pile. And a top camera images the top surface of the granular pile. The higher wet environment is created by saline solutions on which granular piles are placed for a week .

Surface measurement:

Rearranged surface between two images

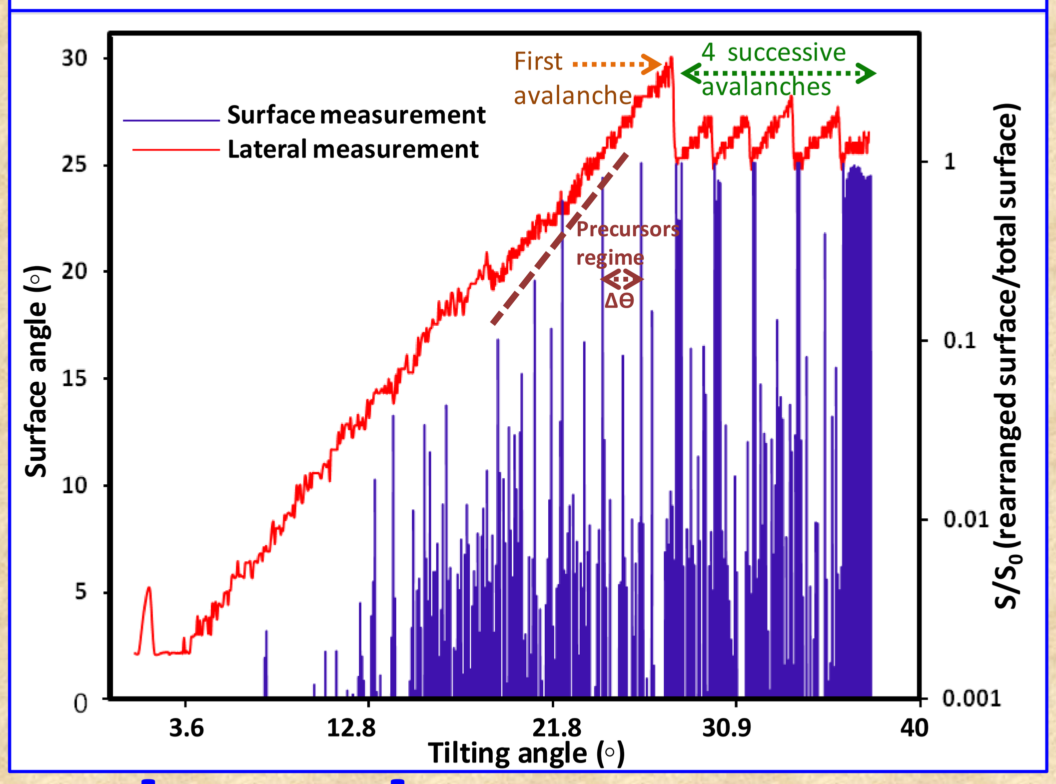


Lateral measurement



➢Correlation of the surface and the lateral measurements

➢Detection of avalanche precursors

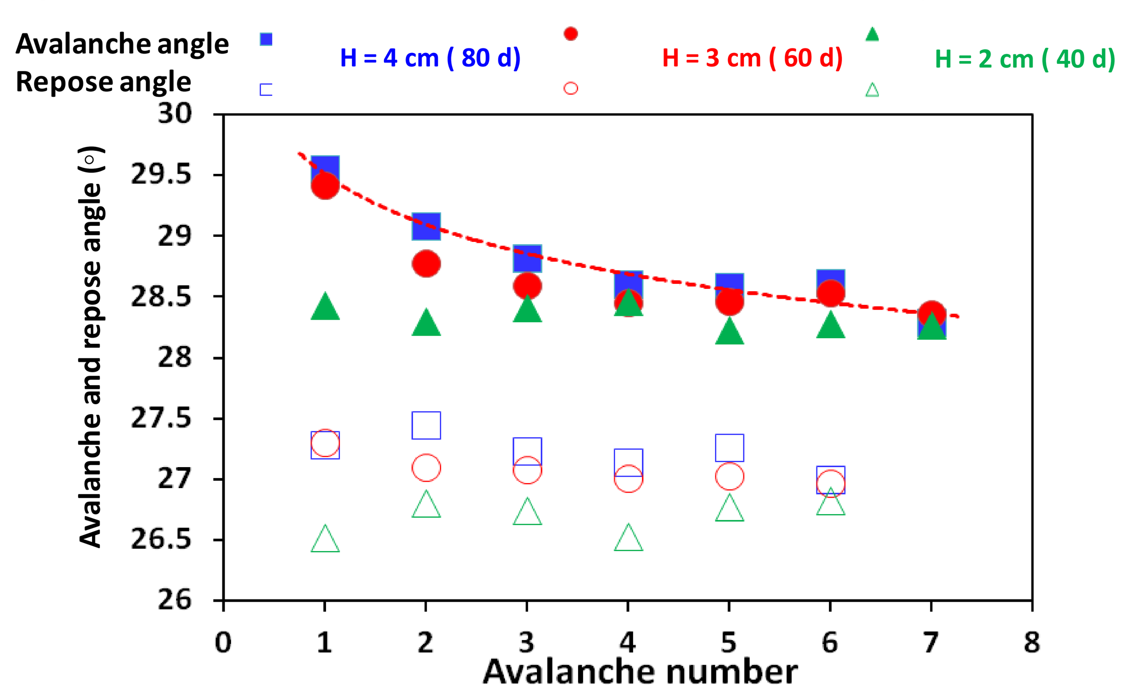


Study parameters:

- ➢ Relative humidity: 44, 55, 68, 75, 84, 94 %;
- ➢ monodisperse glass beads with diameters : 0.2, 0.5, 0.8 mm and monodisperse polystyrene beads with diameters 0.15 mm;
- ➢ tilting velocity: 0.17 ◦/s
- ➢ height of granular pile H = 3, 4.5, 6 cm .

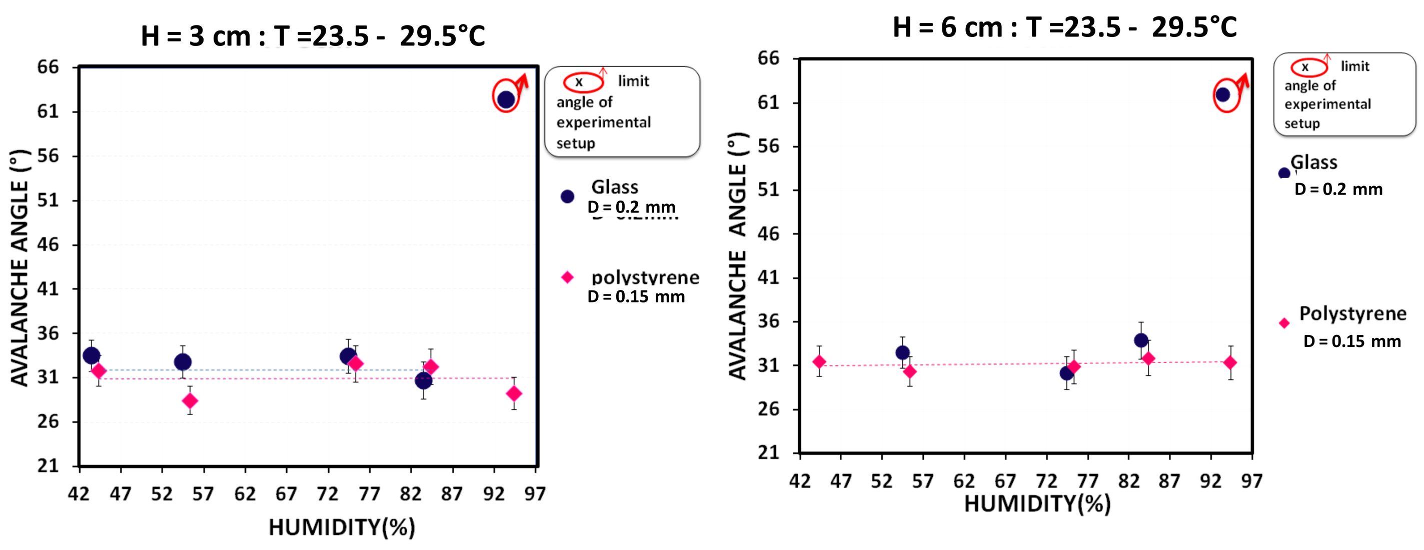
Experimental results

Influence of height pile:



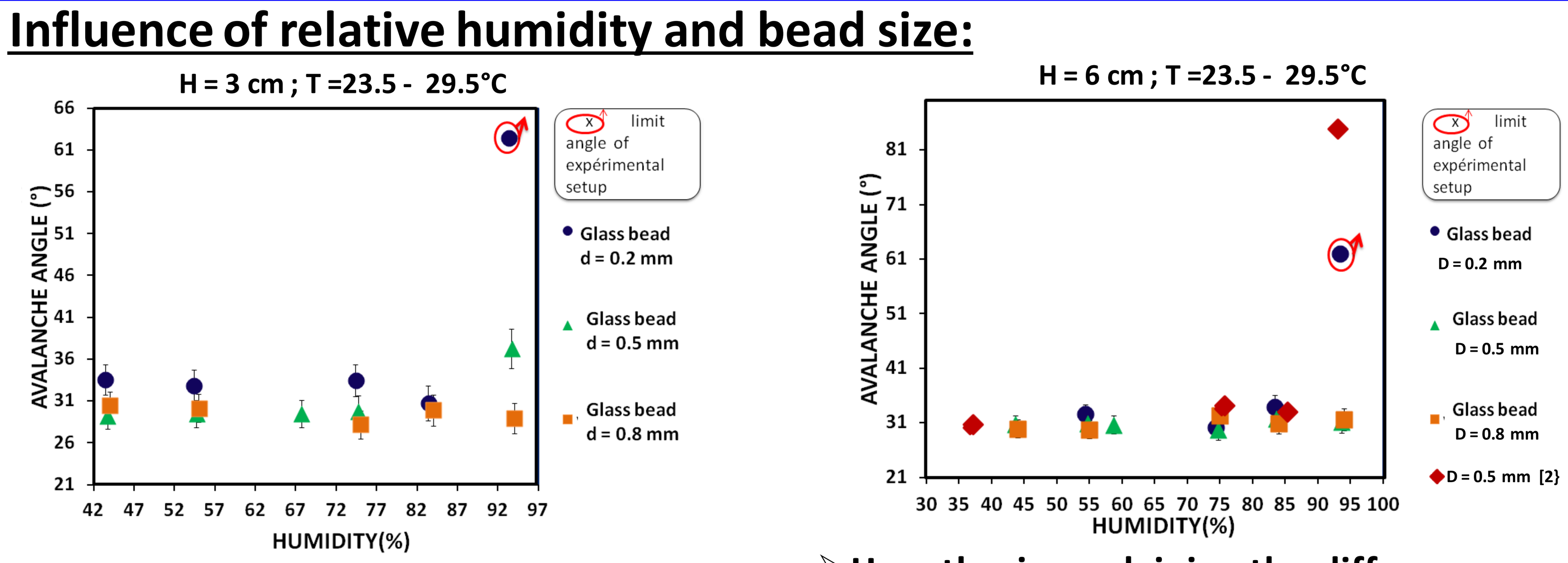
Different behavior for pile height 2 cm (40 layers)
➡ Beads slide over the bottom of the box.

Influence of grains nature & relative humidity:



The polystyrene is non-wetting
➡ whatever the height of the granular pile, the moisture has no impact on its avalanche angle (even for the highest moisture content)

Influence of relative humidity and bead size:

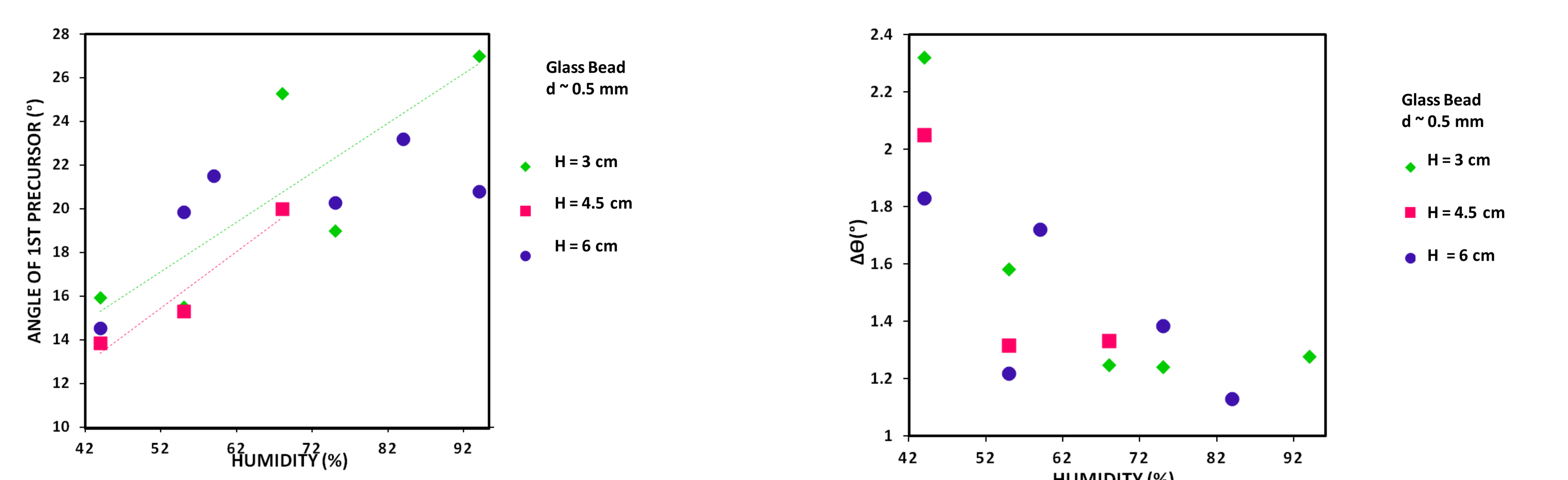


❑Moisture acts strongly on the avalanche angle Θ_M of glass beads D = 0.2 mm. and weakly on the Θ_M of glass beads D = 0.5 mm
→The evolution of the angle as a function of humidity has the same trend as in [2];

❑The Impact of moisture on Θ_M for glass beads D = 0.8 mm isn’t measurable
→ larger bead size therefore larger free space between beads → a longer time is required for the formation of capillary bridges.

➢**Hypothesis explaining the difference between our results and the results of [2] (who get Θ_M (94%) = 85◦) for grains with diameters D = 0.5 mm and H = 6 cm:**
→Different sample preparation times between our experiment (1 week in a humid environment) and the experiment of Gomez (2 weeks)

→ tilting velocity in [2] <<<< our tilting velocity



Increasing of relative humidity leads to:
→ Increase of the angle where the first precursor appears ;
→decrease on the pseudo-period of precursors ΔΘ **?**
ΔΘ is the angular difference between two precursors

Similar study shows that it increases with RH [3]
Is it due to
- variation of temperature ?
- variation of grains size (2 mm)?
(state of surface of beads and its production)
- box size ?

Conclusions

➢Relative humidity plays a very important role in bead cohesion. This cohesion implies the increase of both the avalanche angle and the angle where the first precursor appears.

➢ The effect of moisture on the granular media depends on several parameters: the bead size, the time at which the media is exposed to moisture, the nature of the material constituting the beads, etc.

Perspectives

Make measurements of the same type by using the experimental setup of Rennes which is bigger than the Argentinean experimental setup.

References

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2. I. Gomez-Arriaran, I. Ippolito, R. chertcoff, M. Odriozola-Maritorena and R. De Schant, *‘Characterization of wet granular avalanches in controlled relative humidity conditions’*, Powder technology 279, 24–32 (2015).
3. Mickael Duranteau, *‘Dynamique granulaire à l’qpproche critique’*, PHD thesis, université Rennes 1, 2013.