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Effect of Capillary Forces on Wet Granular Avalanches

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Abstract : Granular avalanches are ubiquitous in nature and occur in numerous industrial processes associated with particulate systems. When a small amount of liquid is added to a pile of particles, pendular bridges form and the particles are attracted by capillary forces, creating complex structure and flow behavior. We have performed an extensive series of experiments to investigate the effect of capillary force and particle size on wet granular avalanches, and we established a methodology that ensures the control of the granular flow in a rotating drum. The velocity of the free surface and the angle of repose of the particles in the rotating drum are determined using particle tracking method. The capillary force between the particles is significantly reduced by making the glass beads hydrophobic via chemical silanization. We show that the strength of the capillary forces between two adjacent particles can be deliberately manipulated through surface modification of the glass beads, thus, under the right conditions; we demonstrate that the avalanche dynamics can be controlled. The results show that the avalanche amplitude decreases when increasing the capillary force. We also find that liquid-induced cohesion increases the width of the gliding layer and the dynamic angle of repose, however, it decreases the velocity of the free surface.

Keywords : avalanche dynamics, capillary force, granular material, granular flow
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