Influence of lateral confinement on granular flows: comparison between shear-driven and gravity-driven flows

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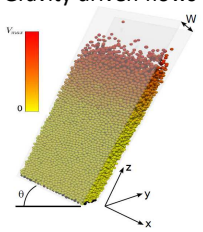
Introduction

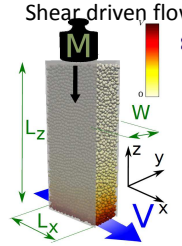
- Confined granular flows are complex systems: confinement (e.g. top, bottom or sidewalls) ⇒ correlations and non-local effects
- Also, they are likely to develop zones without shear ⇒ erosion and accretion
- Good systems to test theories dealing with “solid” and a “fluid” phases (and the corresp. phase transition)
- Full 3D rheological model capturing the behavior of granular flows? ⇒ boundary conditions at sidewalls (velocity, gran. temperature. . .)?
- We study the properties of confined granular flows in two geometries. Common features? Differences?

Soft Sphere Discrete Element Method

Gravity driven flows

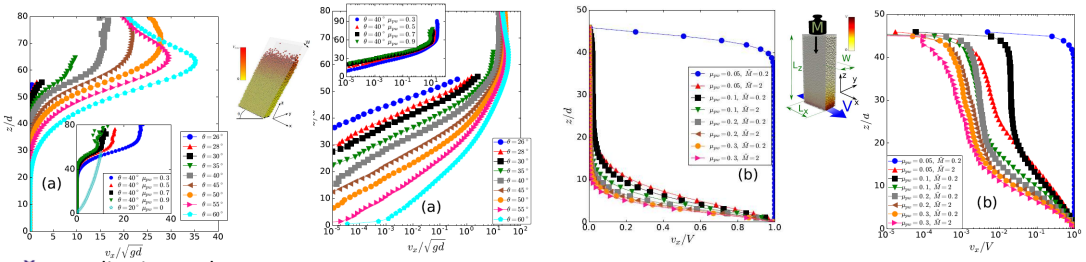


Shear driven flows

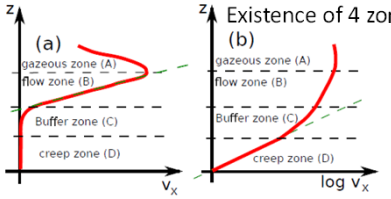


- Two geometries:
  - gravity driven flows topped with a free surface and over a base
  - shear-driven flows with a constant pressure applied at their top and a bumpy bottom moving at constant velocity.
- Flat but frictional sidewalls (gap: W) grains-sidewall friction coefficient μ_{pw}
- Steady and fully developed

Shear localization

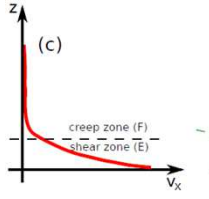


- Localization at the top
- Shear rate increases with flow angle
- Frictionless sidewalls ⇒ shear over the whole depth

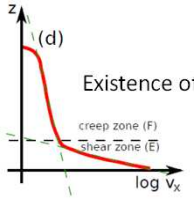


Existence of 4 zones

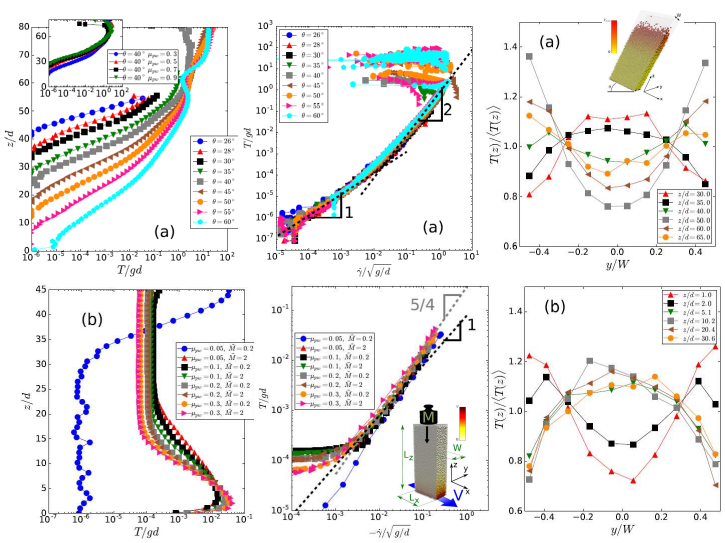
- Localization depends on sidewall friction
- Weak friction localization at the top otherwise at the bottom



Existence of 2 zones

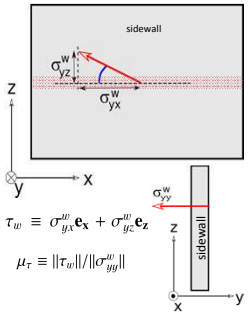


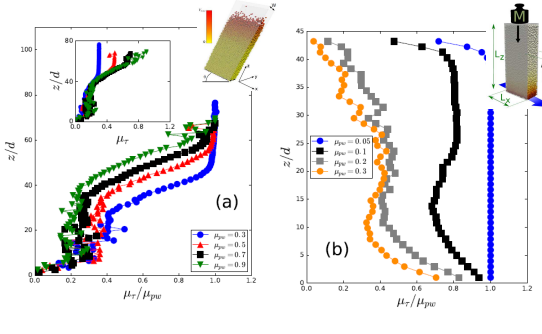
Granular Temperature



- Gravity driven flows
  - the temperature profiles continuously ↗ from the bottom to the end of the flow zone.
- $T \propto \dot{\gamma}^{\kappa}$ with $\kappa \approx 1$ in dense and slow flows and $\kappa \approx 2$ for rapid and dilute flows

Friction Weakening





- For both systems, the effective friction weakens in the creep zone
- Number of stick-slip events become more and more probable when approaching the creep zone

Conclusion

- Lateral confinement is of great importance
- Shear localization in both system but different properties
- Sidewall : either a granular heat source or sink ⇒ no (obvious) simple boundary conditions
- $T \propto \dot{\gamma}^{\kappa}$ is valid or both geometries
- Sidewall effective friction weakens with depth

Bibliography

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