Dynamic Shear Band Dependence on Particle Size

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Background

• Understanding granular flows will aid industrial preparation and transportation of granular materials
• Granular materials do not flow as a whole, flow is usually confined to a localized shear band
• Shear bands of different sizes are created to study the universal effects of reversing shear direction
Experimental Procedure

- Rotating rough inner cylinder and bottom
- Various filling heights of 1mm, 2mm and mixtures
- “stop start” shearing and “reversal”

Gap = 4.39cm

Rough sides and bottom
Data Analysis

Top View

- Average over each region and time
- Angular velocities are displayed

1mm Beads
8.8 cm Depth
Shear Bands at Various Heights

6.2cm Depth

9.2cm Depth
Angular Velocity vs. Time

- No change observed when shearing started in same direction
- Widening of shear band seen in previous results when direction is reversed, for large height
- Very different behavior for small height
Velocity Profile during Reversal

- Can see a general trend throughout all
- Shear band widens beyond some radius
- Passes through near linear to return to steady state
- Same trend seen in 2D system
Torque Required to Shear

- Takes time for force network to reform
- Shear displacement is proportional to particle diameter
- 1mm beads (blue line) take less force to shear than 3mm beads (red line)
Length Scale for Mixtures

- Exponential fit, $y \sim e^{-x/\tau}$, to region 1 of the velocity graph
- Time to return to steady state depends on particle size
Mixtures

- Segregation was not studied, but occurs when a mixture is sheared
- Larger particles come to the surface in one region, then spread across the surface
Conclusion

• Shear band width and location can be adjusted with filling height

• Different steady state shear bands pass through the same near linear velocity profile upon reversal of shear direction

• Shear strain to return to steady state after reversal scales linearly with particle diameter