Tensile Behavior of Entangled Non-Convex Granular Particles

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Outline

- Motivation
- Beginning the Project
- Particle Design
- Performed Tests
- Ongoing Work
Motivation

Why should I care about granular materials?

https://www.cam.ac.uk/research/news/study-reveals-mysterious-equality-with-which-grains-pack-it-in


Keller & Jaeger, 2016

Dierichs, Wood, Correa, & Menges, 2017
Practical Beginnings

Zinc-plated steel S hooks

Standard staples

Load vs. Displacement

One piece cylinder

Jade Leong

Zoom on Right Slope

Zoom on Left Slope

Katheryn Wang
Particle Design
Aspect Ratio

**Staple**
- Width: 5.5 cm
- Max Height: 18.2 cm
- Aspect Ratio: ~1:3.30

**S**
- Width: 5.5 cm
- Max Height: 18.4 cm
- Aspect Ratio: ~1:3.35
Packing Density

Staple:

\[ 2.30 \quad 946.5 \text{ cm}^3_{\text{avg}} / 3120_{\text{Np}} * \]
\[ .038647 \text{ cm}^3_{\text{y}} \]

S:

\[ 5.14 \quad 617 \text{ cm}^3_{\text{avg}} / 3104_{\text{Np}} * \]
\[ .131796 \text{ cm}^3_{\text{y}} \]
Angle of Repose

Staple AOR

- Average = 43.2
- Min = 30.1
- Standard Deviation = 4.343
- (mean) Max = 54.5

S AOR

- Average = 64.4
- Min = 49.9
- Standard Deviation = 5.706
- (mean) Max = 76.5

Friction?
Interlocking Capabilities

![Graph: Width vs Length with R² = 0.0078]

![Images of interlocking materials and measurement tools]
Continued

Convergence?
Interlocking Strength

4-5 N applied, warping instead of breakage
Ongoing Work

- Use the LS-DEM code to simulate these real life experiments
- Shake table testing with 3D printed particles
- 1D compression testing of 3D printed particles
- Design different shaped particles
- Print more particles

Fixed Funnel Method
400 S-hook particles
H = 7.5 cm

Animesh Rastogi and Jade Leong
Thank you!

Professor José Andrade
Siavash Monfared
Computational Geomechanics group
Summer Students
Student Faculty Programs
Northern California Associates
Questions?