3D PRINTING OF LUNAR REGOLITH

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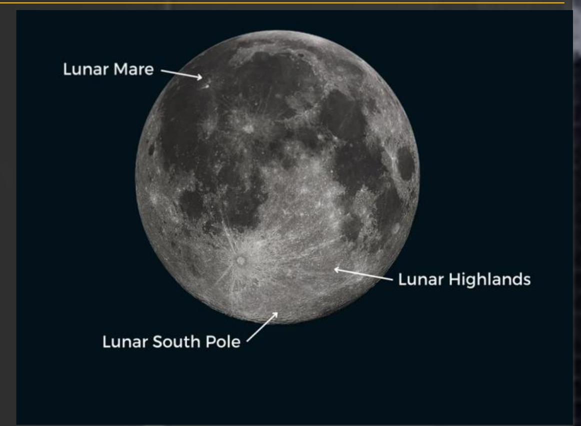
Background



Challenges:
- High Transportation Cost: 100,000 $/kg to space
- Reduces the cost by using the recourse on the moon

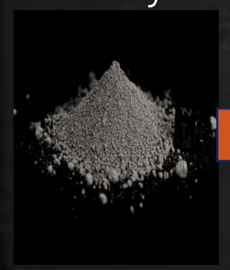
Innovation:
- Using Lunar Regolith and Urine simulant to 3D print
- Sustainable method by minimizing water and material transport

Objectives

Development of Sustainable materials in space aiming for resource efficient construction on the moon
- Develop automated construction methods that are suited to support human life on the Moon.
- Optimization of 3D printing processes by determining best printing parameters for strength and stability
- Able to withstand extreme environmental conditions

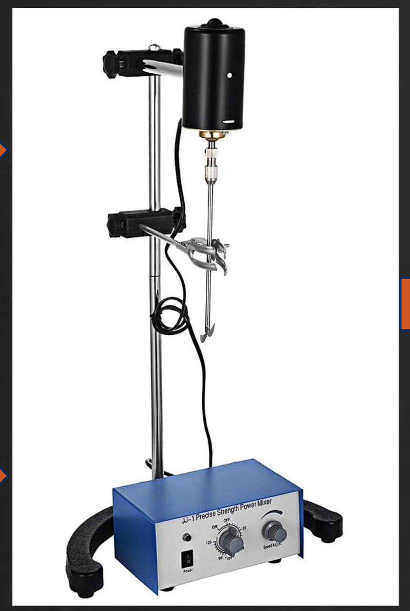
Methods/ Process


Clay


Lunar

7% H20

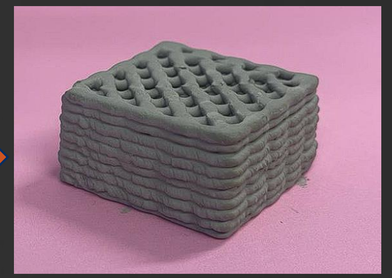
33% Urine


Power Mixer


Viscometer


Moore 2 Pro


Clay


Lunar

Results

Controlled Parameters:
- Layer Height
- Line width
- Flow
- Infill Density Precent

Fix Parameters:
- Mixing Raito
- Speed
- Nozzle Size
- Feeding Speed
- Pattens

Increasing the LH and LW will decrease problems of too much material

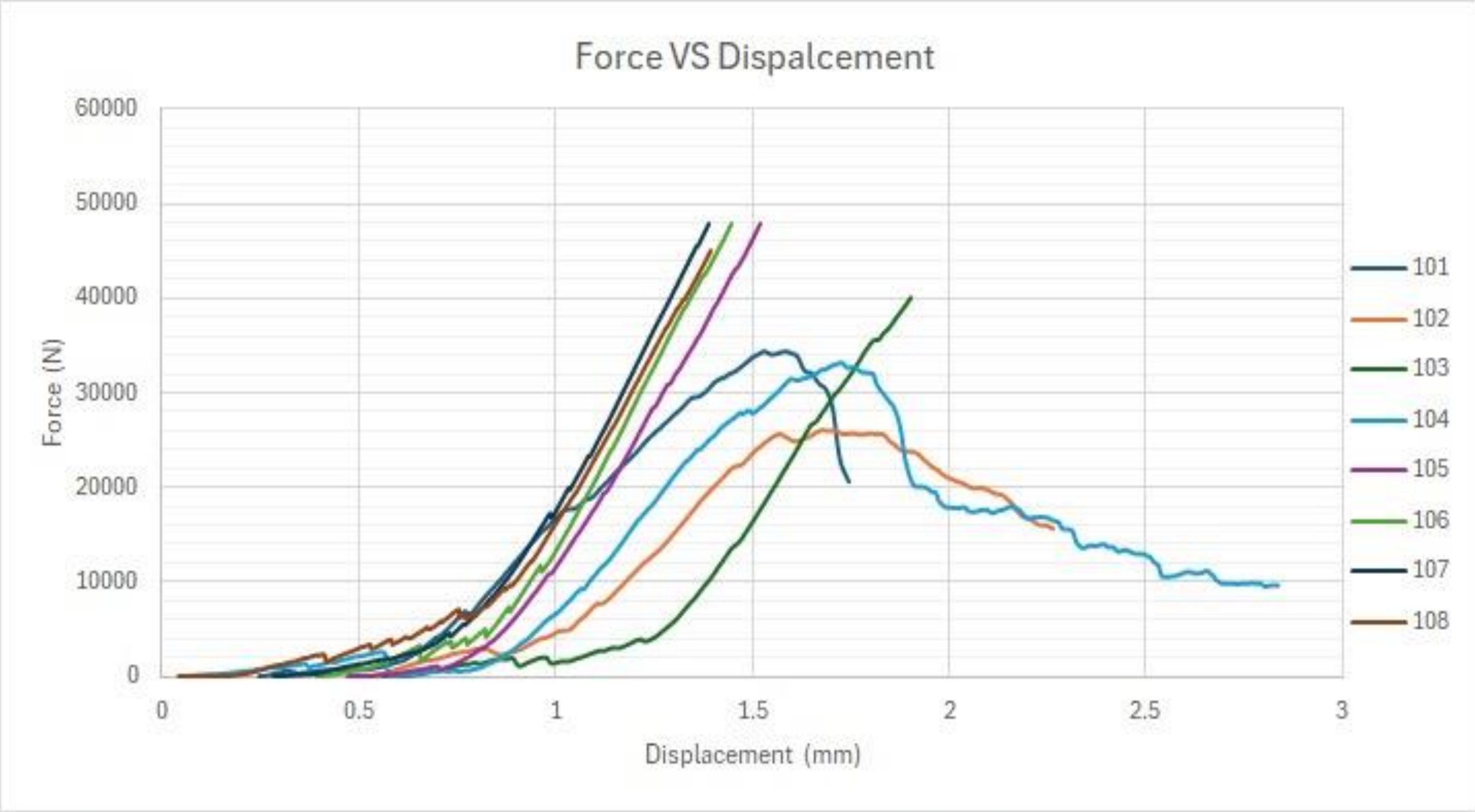
Items	Range	Average
Density (Reduction) (%)	6.40 - 10.35	7.51
X (Shrinkage) (%)	1.47 - 6.18	5.65
Y (Shrinkage) (%)	0.53 - 7.58	5.41
Z (Shrinkage) (%)	1.45 - 7.18	5.38

Post-Sintering

Initial Sintering Plan:
- 3°C/min ramp(16 hours)
- Room temperature to 550°C (Hold one hour)
- Heat to 1100°C (hold one hour)
- Cool

Due to the cracking of samples, new sintering plan is needed

New Sintering plan:
- 0.75°C/min ramp(34 hours)
- The rest of the process is the same as initial sintering plan



Compression Testing

- The Standard C 39 / C 39M-01: "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens"
- Applied force 45 - 48 KN
- Samples were partially broken
- Only the layer height and infill density are different
- Layer height and Infill density affect on the strength of the sample
  - Lower layer height and higher infill equal higher strength

New Design

Set up time
- Average 1 hour 40 minutes decreased to 35 minutes
  - 65% reduction

Material wasted
- On average 58 g of mixed material decreased to 6 g
  - 90% reduction

Ease of use and set up

Conclusions & Recommendations

- Successfully 3D printed with lunar regolith, using the findings from clay experiments.
- Showcased potential for constructing habitats on the Moon.
- Compression tests pending due to the limitation of current equipment.
- Use an anti-drip mechanism for better control of pneumatic printing.
  - G- Code
- More samples for Lunar
  - Lunar & Urine Vs Lunar & Water
  - Lunar & Urine Vs Clay & water

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