Scaling Smart Autonomous Construction

Abdul. S. Mohammad, Babajide. Onanuga, Hajar. Taheri and Joseph. J. Biernacki
Department of Chemical Engineering, Tennessee Technological University

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MODELING OF CEMENT PASTE FLOW FOR IDEALIZED GEOMETRIES

❖ **Printability of Cement Paste: Size, Geometry and Material Property Effects.**

➢ **Geometries:**

❑ Size 1:

Shape (2-D)	Dimensions (mm)	Surface Area (mm^2)
Sphere	R = 22.6	6400
Slab	H= 40 and W= 160	6400

❑ Size 2:

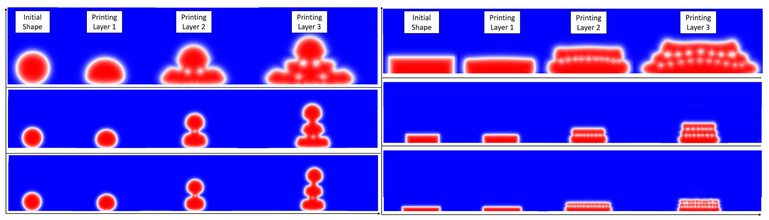
Shape (2-D)	Dimensions (mm)	Surface Area (mm^2)
Sphere	R = 11.3	1600
Slab	H= 20 and W= 80	1600

❑ Size 2:

Shape (2-D)	Dimensions (mm)	Surface Area (mm^2)
Sphere	R = 8.5	900
Slab	H= 10 and W= 90	900

❖**Results – Size and Shape Effects** :

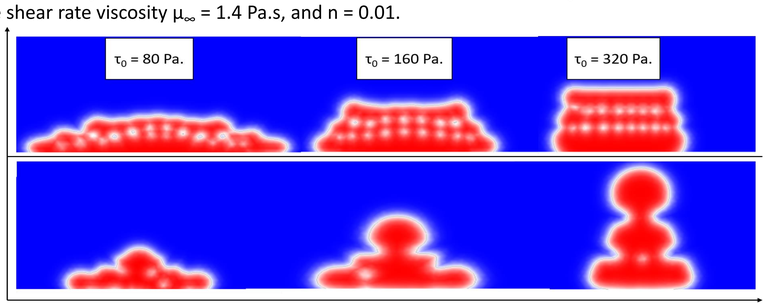
➢ Each shape was simulated for 1 second at zero shear rate viscosity μ_0 = 700 Pa.s, infinite shear rate viscosity μ_∞ = 1.4 Pa.s, yield stress τ_0 = 320 Pa and n = 0.01. Three sizes were used maintaining the superficial surface area constant for each shape (geometry) at a given size.



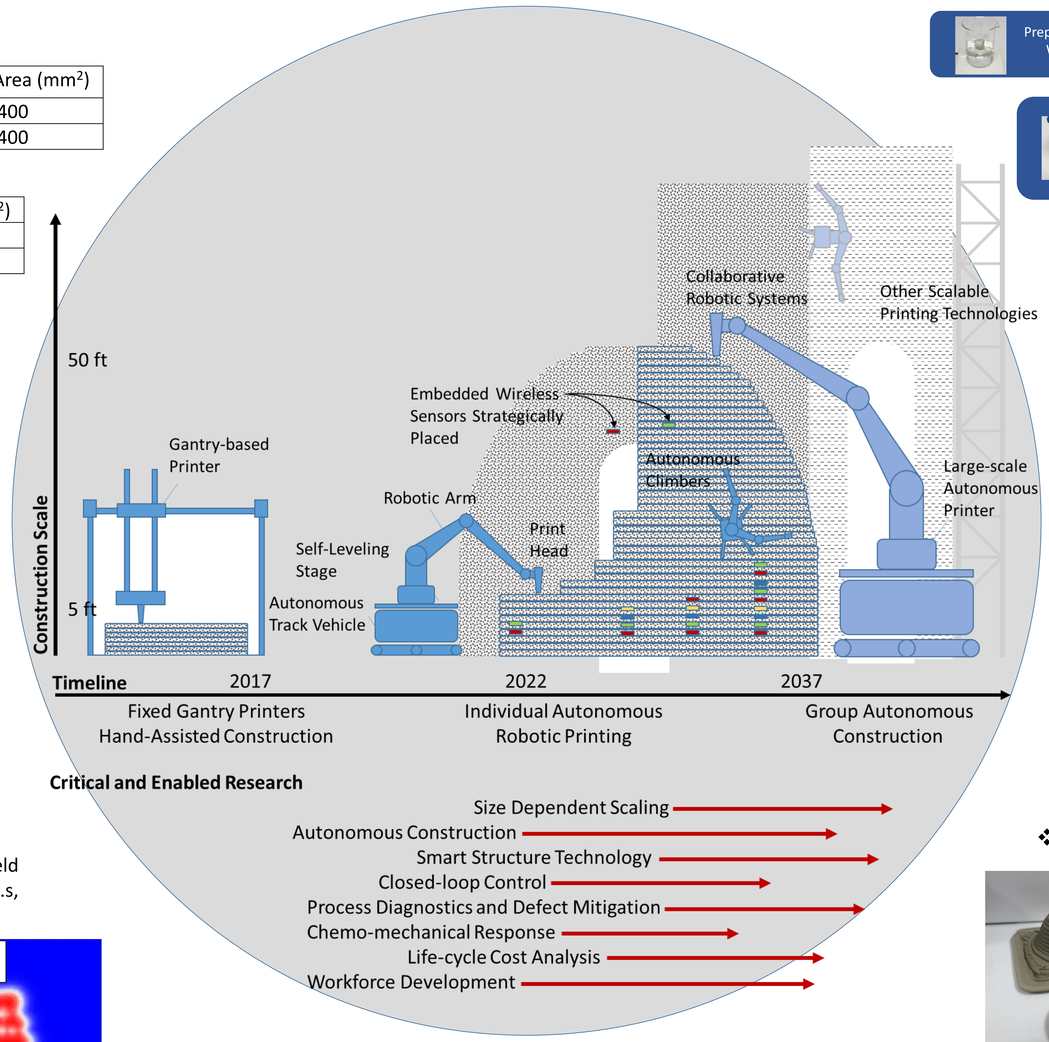
For fixed fluid property, clear size-effects on shape retention is noted, i.e. smaller sizes retain shape better.

❖**Results – Material Property Effects:**

➢ Two different shapes were simulated at Size 2 for 0.5 seconds at three different yield stresses values: τ_0 of 80, 160 and 320 Pa, with zero shear rate viscosity μ_0 = 700 Pa.s, infinite shear rate viscosity μ_∞ = 1.4 Pa.s, and n = 0.01.

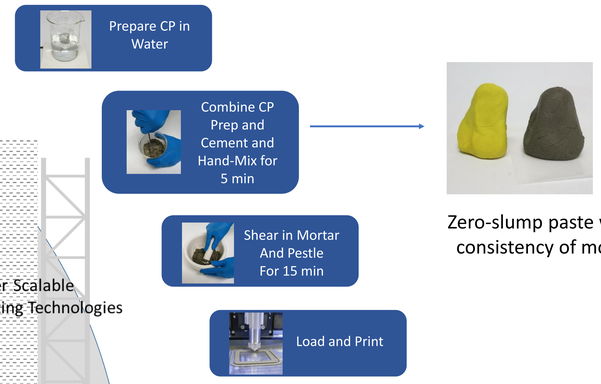


Both yield stress and geometry have effect on shape retention.



3D PRINTABILITY OF CONSTRUCTION MATERIALS

❖ **Mixing protocol for CP containing pastes.**

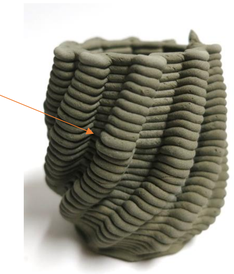


Zero-slump paste with nominal consistency of modeling clay.

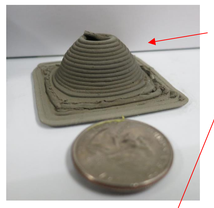
❖**Results – Printable outcomes:**

Twisted Hollow Vases

defects

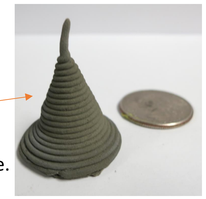


❖**Results – What are we learning?:**



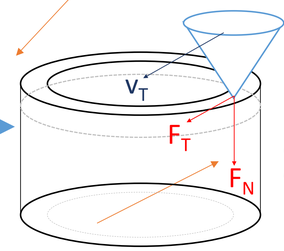
good print layer uniformity, little to no distortion

distortion defects
Caused by transmission of "printing loads" which distort the substructure.



Hollow Cones

Hollow Domes



Printing forces, F_T and F_N, distort (strain) object causing defects.

INFERENCES FOR SCALING OF TECHNOLOGY

Printability is a clear function of both size and rheological properties of the paste. Some printing defects are associated with printing load transmission and resulting gross deformation of the substructure. Such appear to be size and shape dependent.

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