Thermal and Structural Performance of 3D Printed Wall Section as a Function of Infill Pattern

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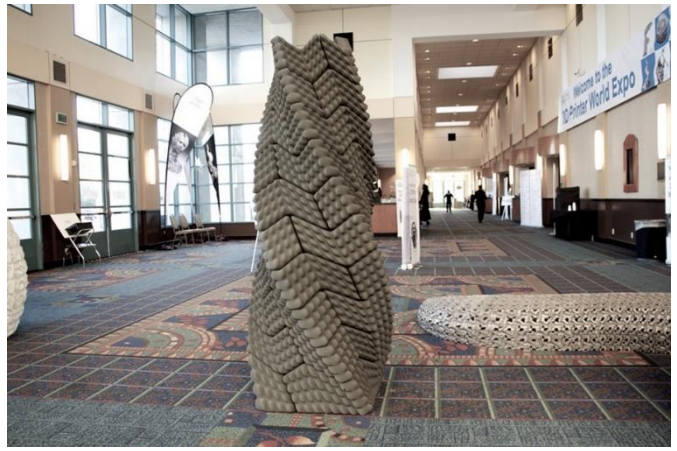
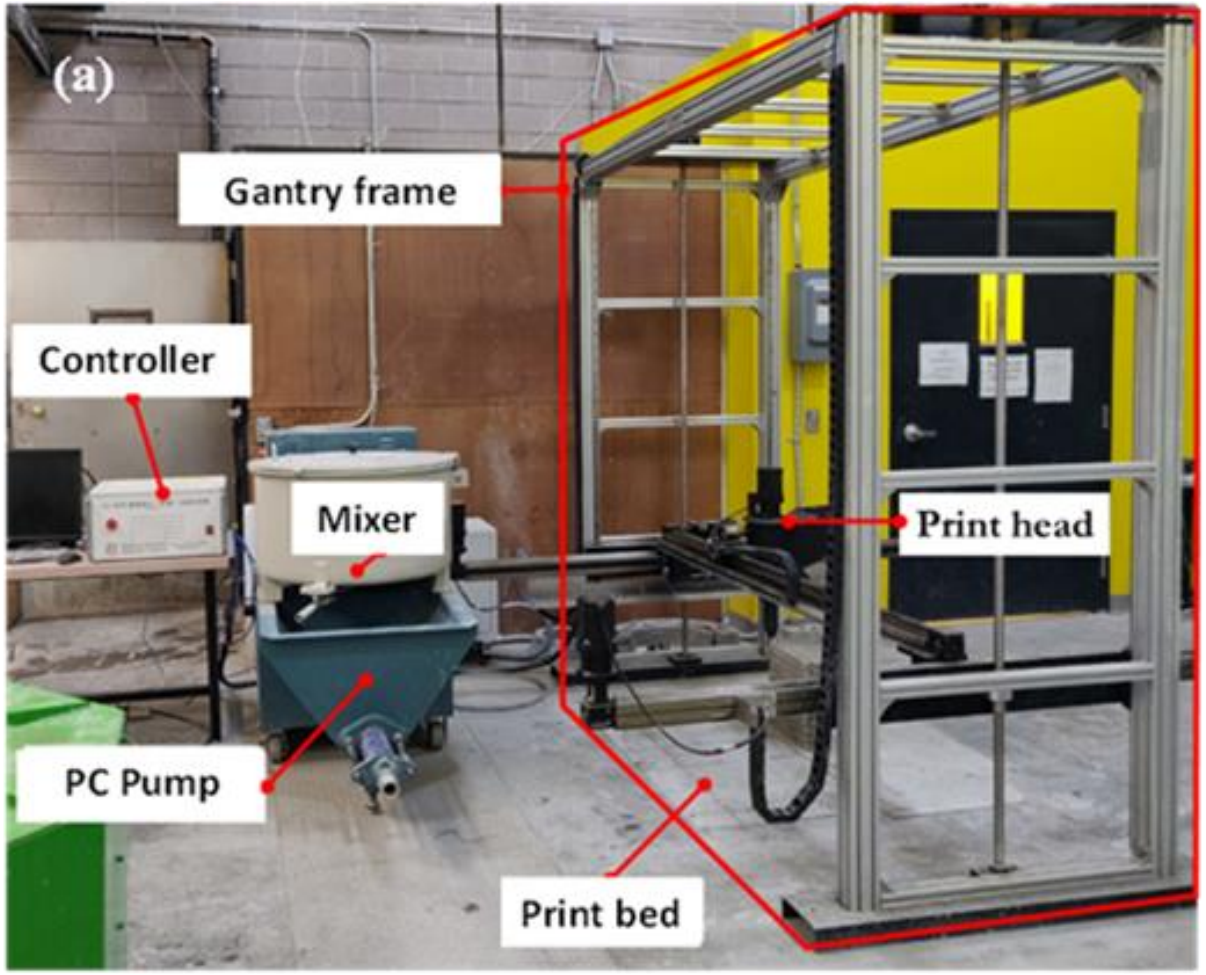
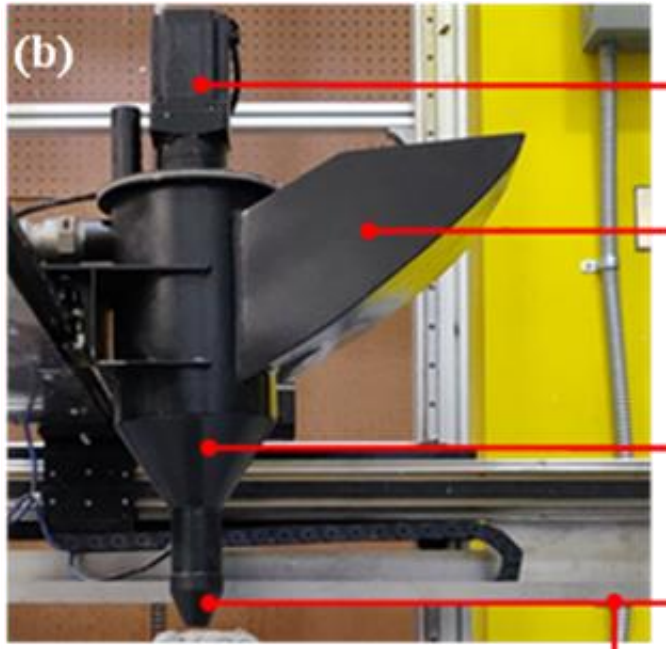
Concrete 3D Printing



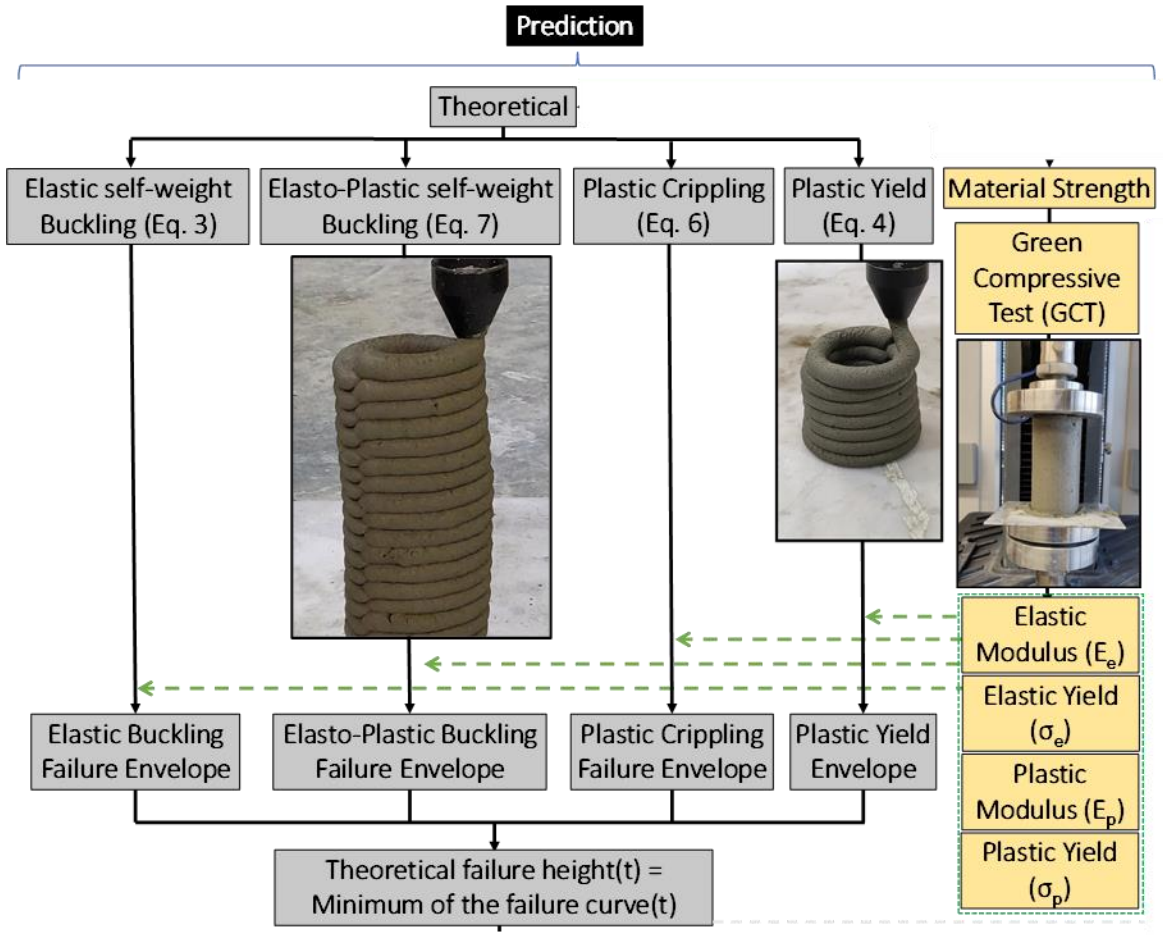
Concrete 3D Printing

Concrete printer





Buildability of Mortars



- Analytical Model developed at ASU used to characterize the buildability.
- Mortar with high buildability required to print larger height sections.
- A normal strength mortar (75 MPa - 28-day strength for casted cubes) with buildability of near 40 cm (wall of 25 mm thickness) after 30 minutes from mixing.
- A HPC mixture (110 MPa - 28-day strength for casted cubes) with a buildability of near 32 cm (wall of 25 mm thickness) after 15 minutes from mixing.

Infill Patterns

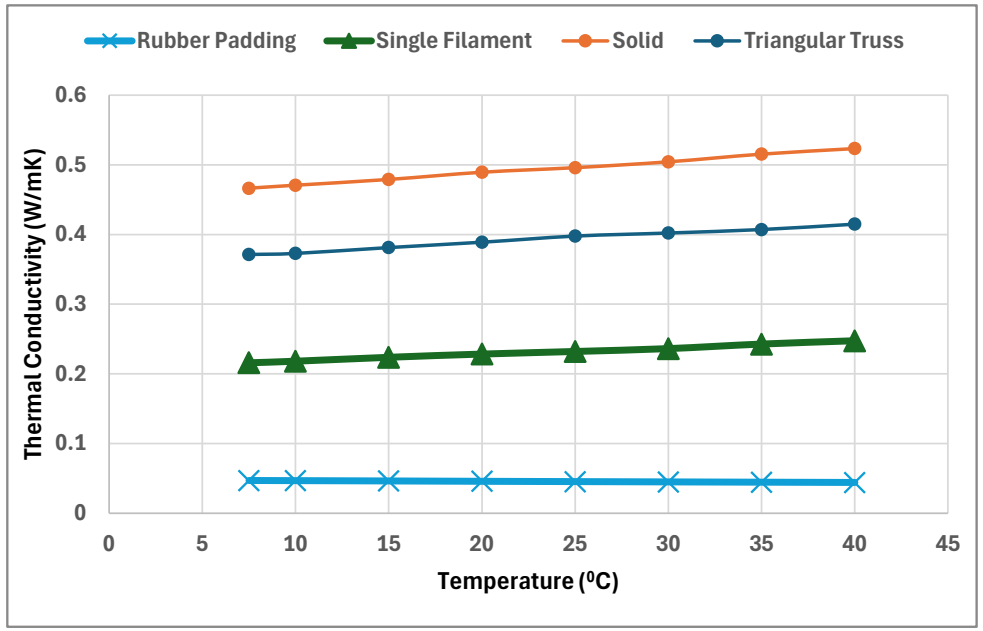
Single Layer

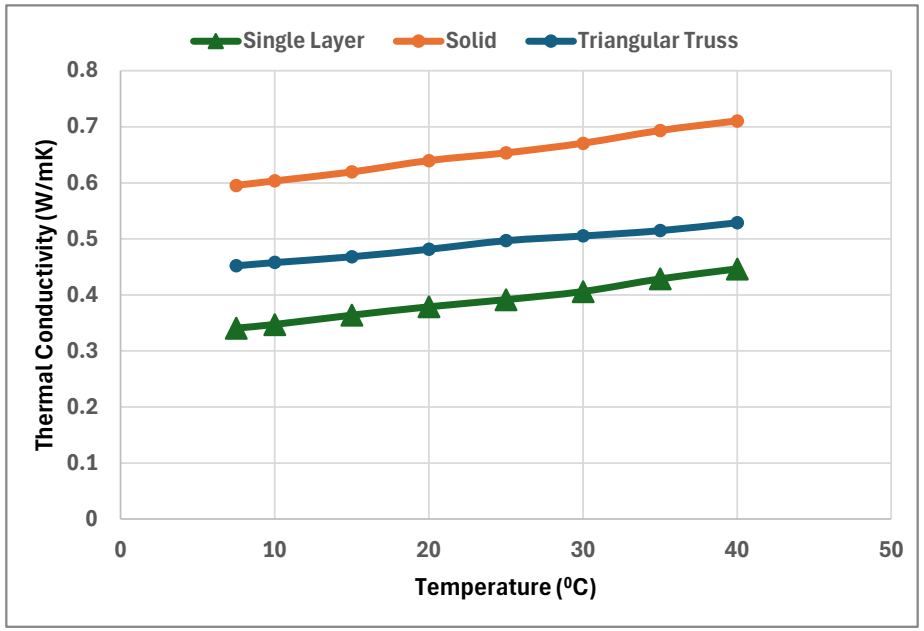
Complete Infill (Solid)

Triangular Truss

And few more…

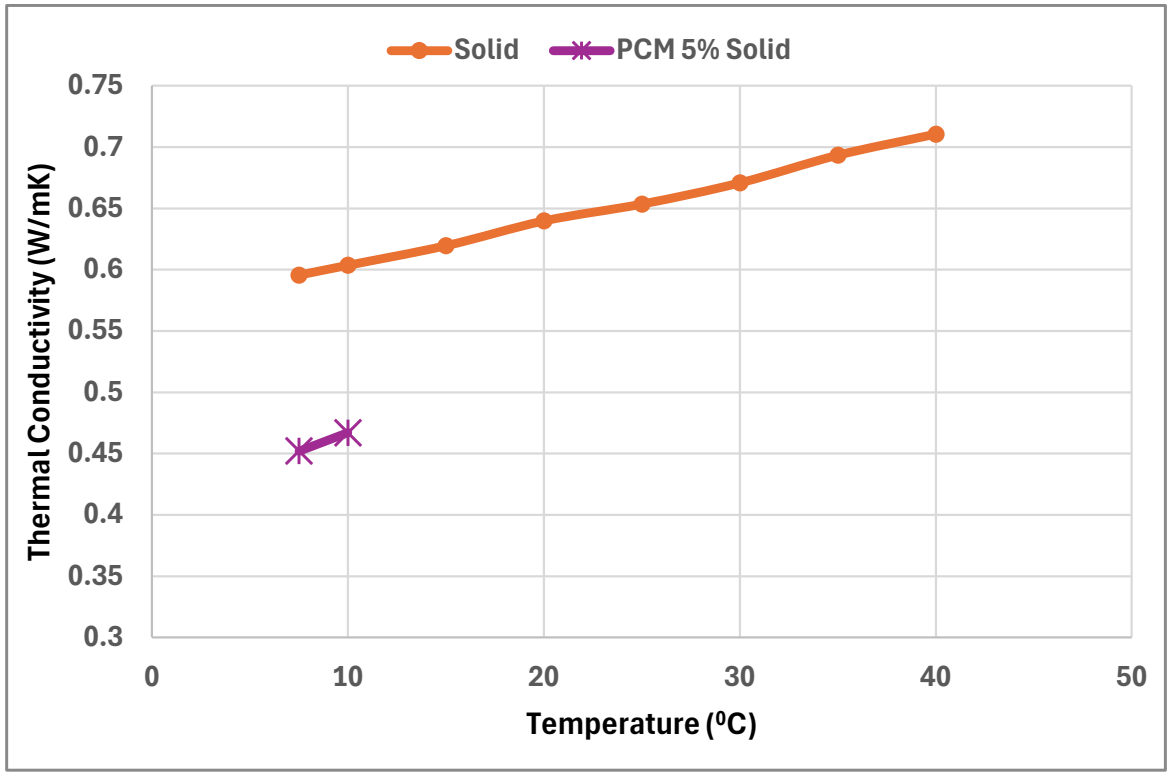
Thermal Conductivity





- Conductivity in the lower spectra for general mortar (typically reported to be in the range of 0.5 to 2.5 W/mK).
- 25% decrease in conductivity (or simply 25% more resistant to transfer of heat through the thickness) with a Triangular Truss infill compared to solid infill.

Effect of Inclusion of PCM in the mixture

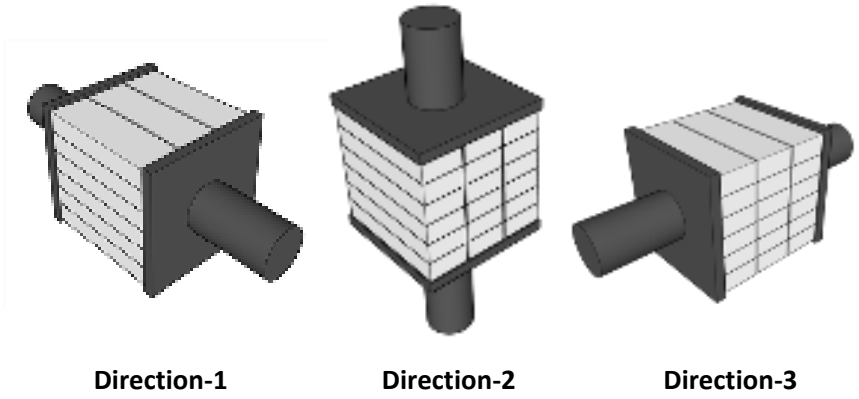


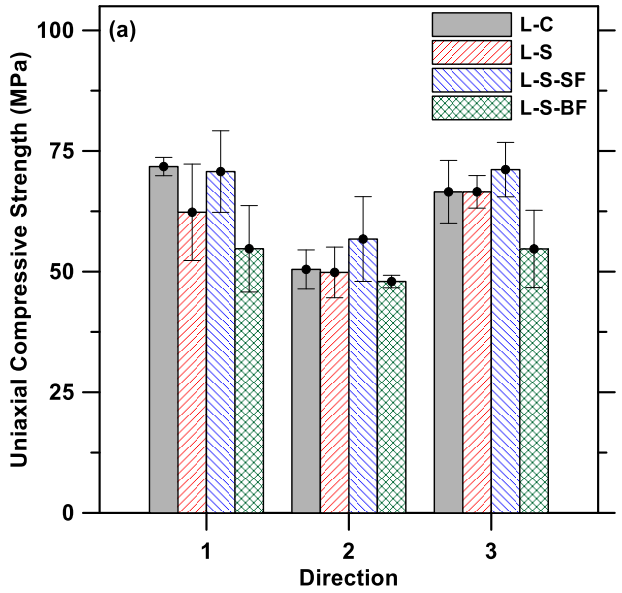
- 5% PCM (Phase change temperature - 25^{0}C) by volume of the mix added to the normal strength mixture and printed (Solid infill).
- At 7.5^{0}C, near 25% decrease in conductivity; 22% decrease at 10^{0}C.
- Conductivity expected to increase more rapidly at higher temperature.

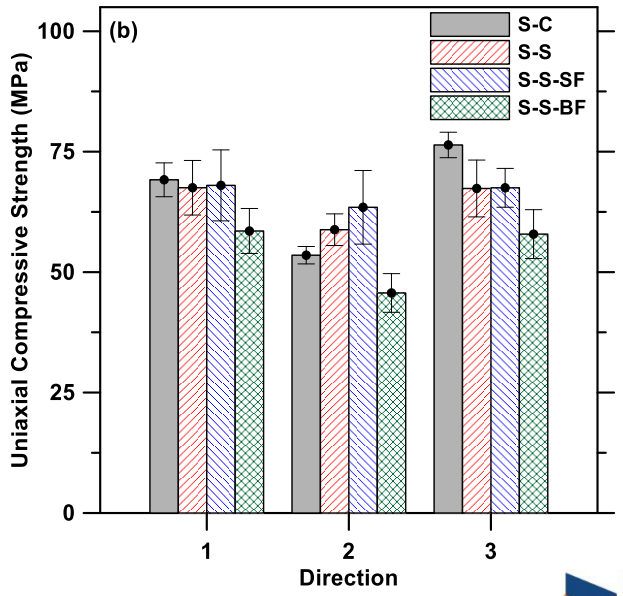
Anisotropic Effect of 3D printing

- Previous work shows weakest when tested in compression in the vertical direction (i.e. compression along the built-up direction).

Direction-1 compression along print direction in the print plane.
Direction-2 compression along the built-up direction.
Direction-3 perpendicular to print direction in the print plane.

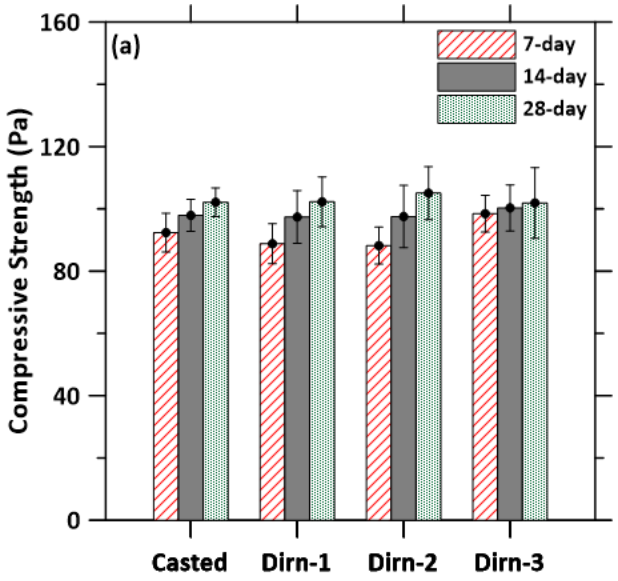




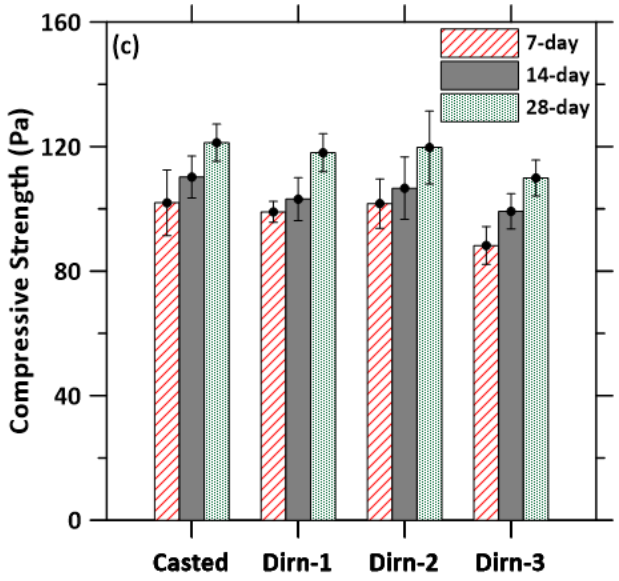


- Walls are subjected to loading along built-up direction.

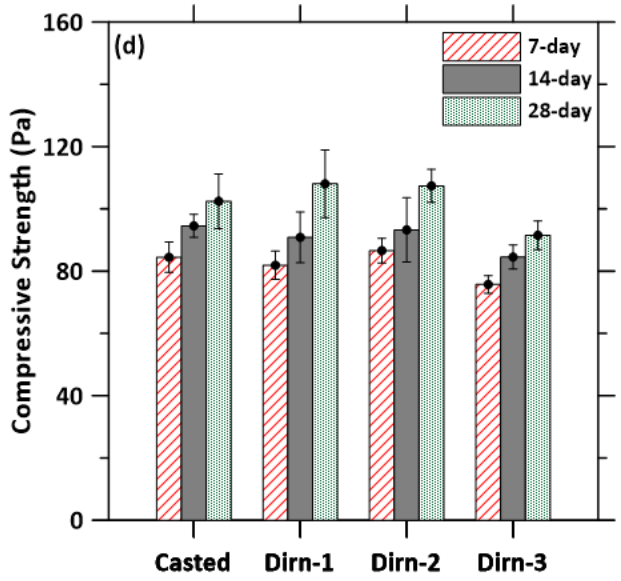
Anisotropic Effect of 3D printing



Non-Fiber



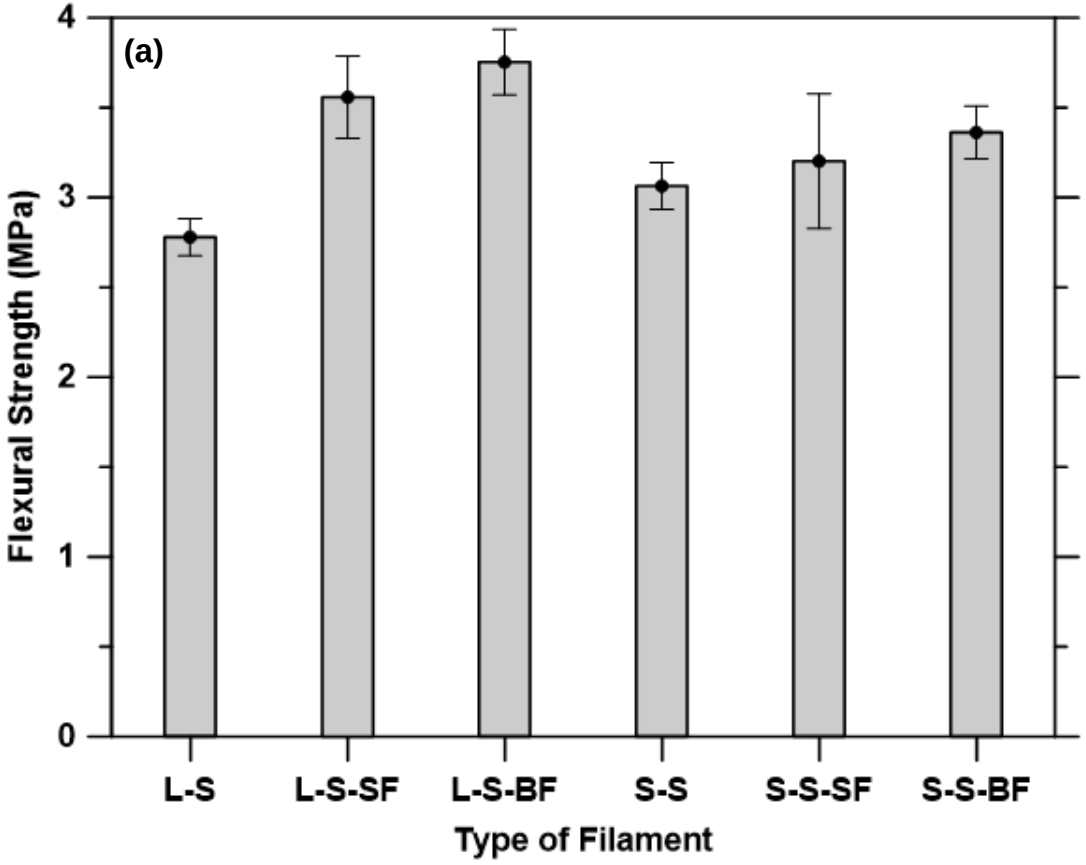
$SF_{1.5\%}$

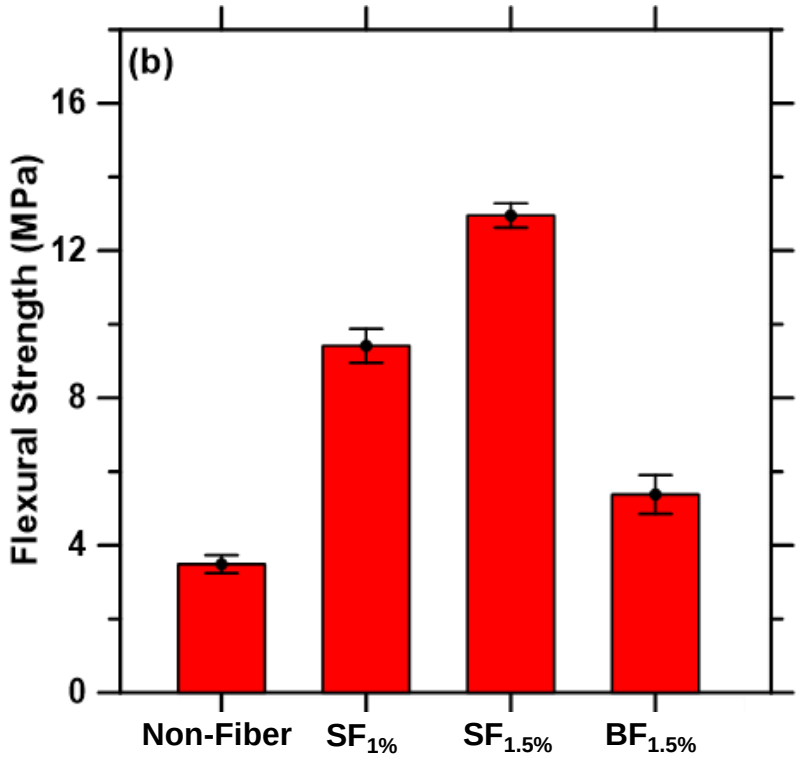


$BF_{1.5\%}$

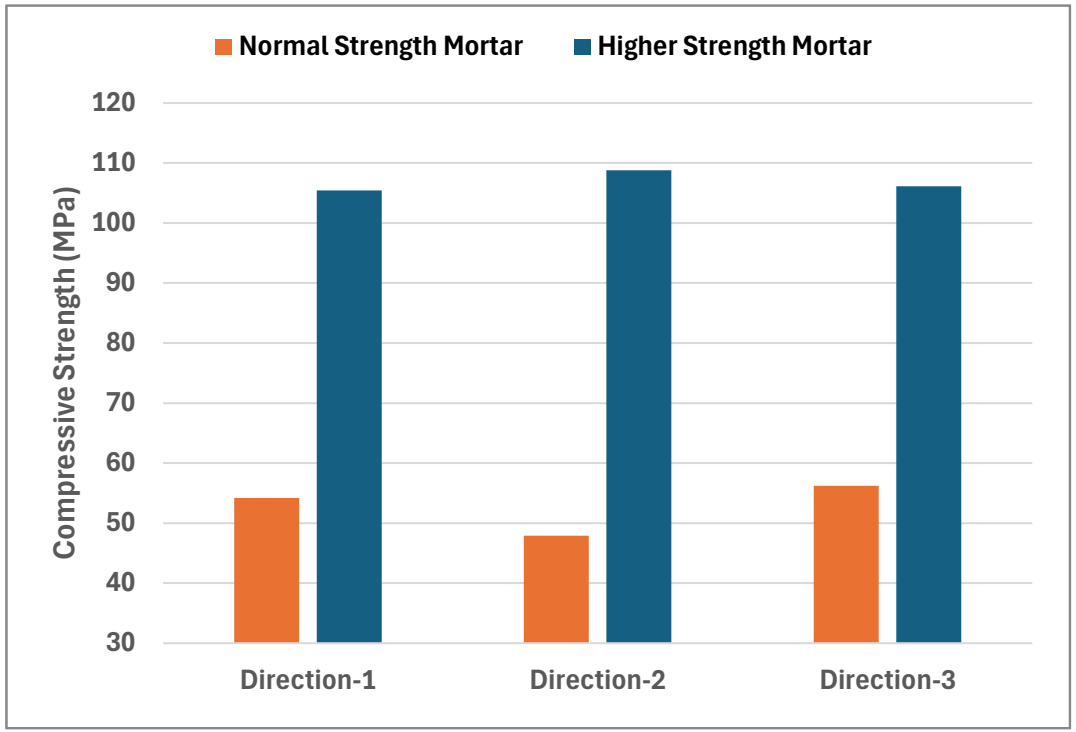
- For low water cement ratio mortars; Direction-2 didn't have deterioration of strength.

Flexural Strengths (print direction along span of the beam)



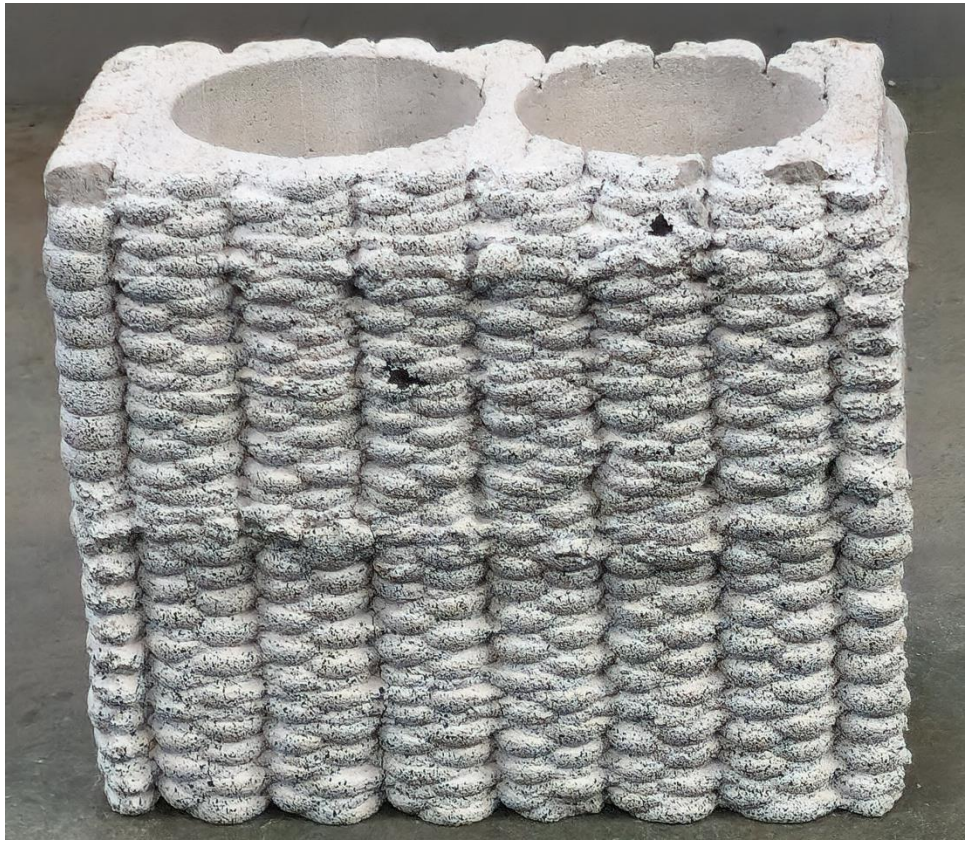


Anisotropic Effect of 3D printing



- Normal strength mortar shows similar effect.
- Higher Strength mortar didn't show significant anisotropy.

Smaller Scale Testing

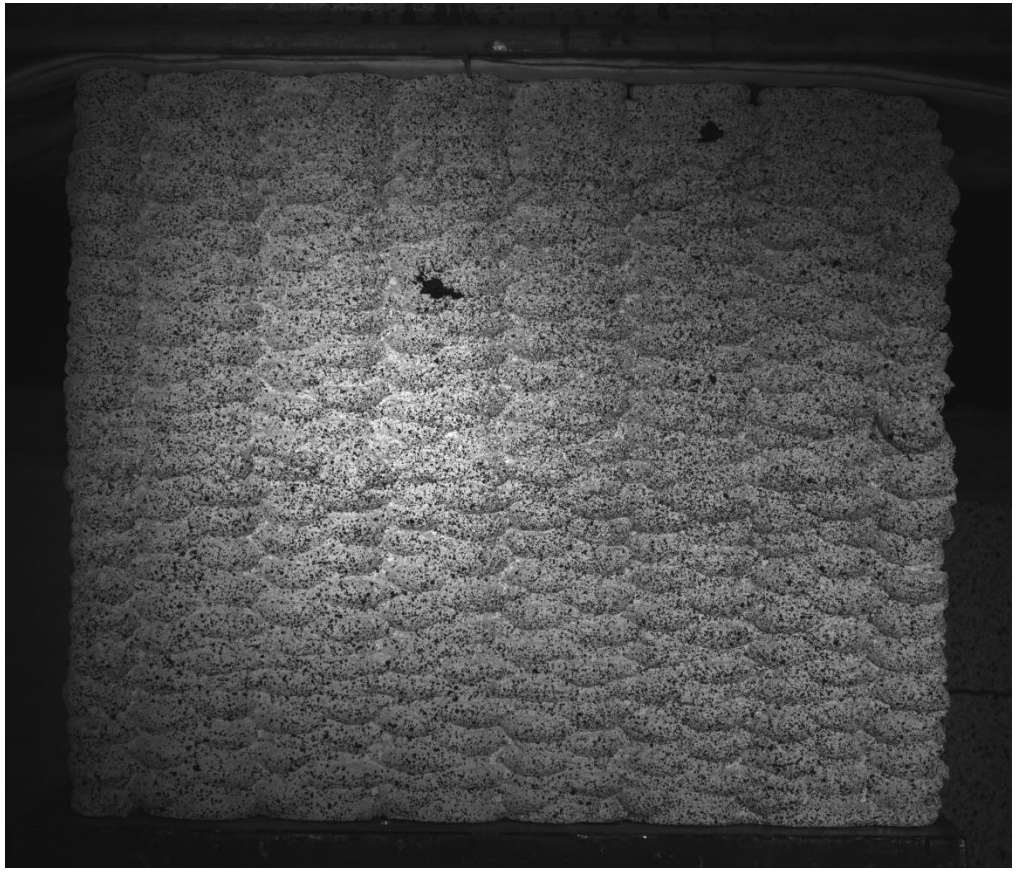


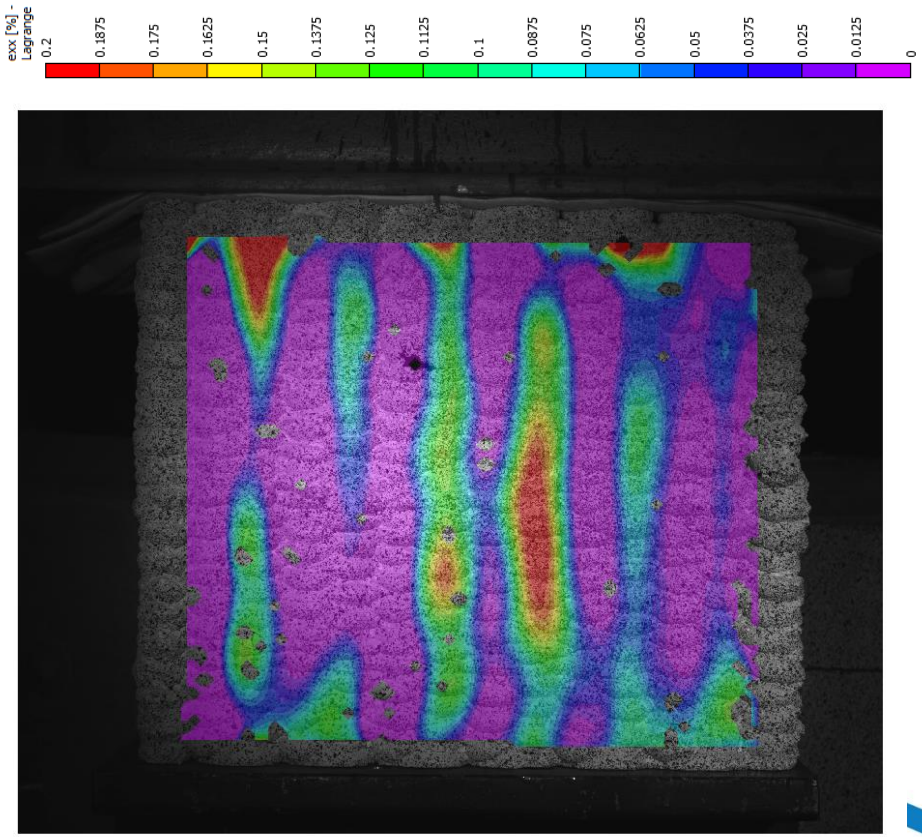
For Normal Strength Mortar; Solid Infill cuboid from which cylinders cored out.

Smaller Scale Testing

- Crack initiation from filament joints, while section still able to take incremental load.
- Cracking in the perpendicular direction followed quickly.

Smaller Scale Testing





Strain along direction-3 from DIC analysis (near 50% loading of crack initiation load).

Large Scale Compression Testing

D. Patel et. al. (2023)

400 kips capacity compression testing machine.

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An NSF AccelNet Collaborative Effort

Arizona State University

QUESTIONS?