Sustainable Polymer Modified Concrete for 3D Concrete Printing

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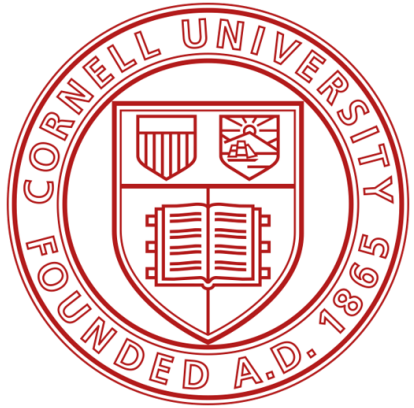
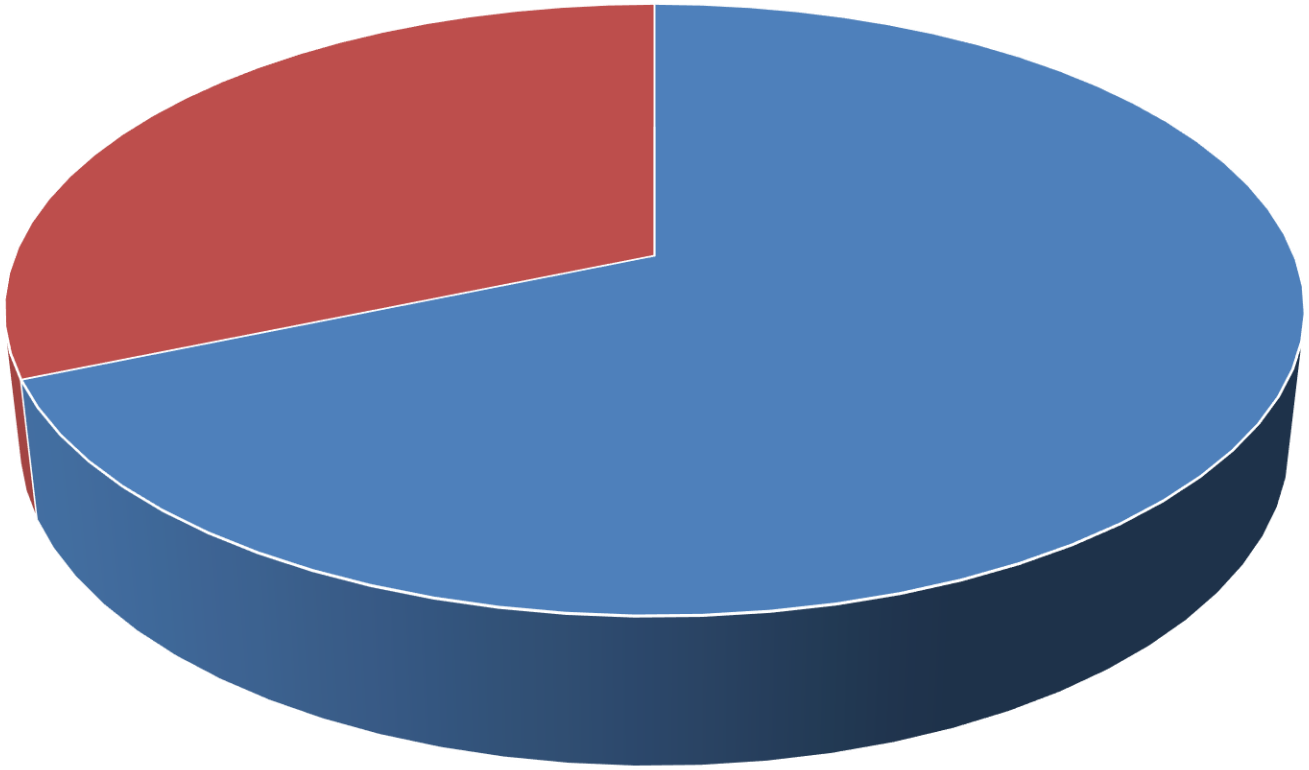


Outline

- Introduction & Background
- Materials & Mix Design
- Mechanical Properties
- Rheological Characterization
- 3D-printed performance
- Challenges and Future Work
- Conclusions

Introduction & Background

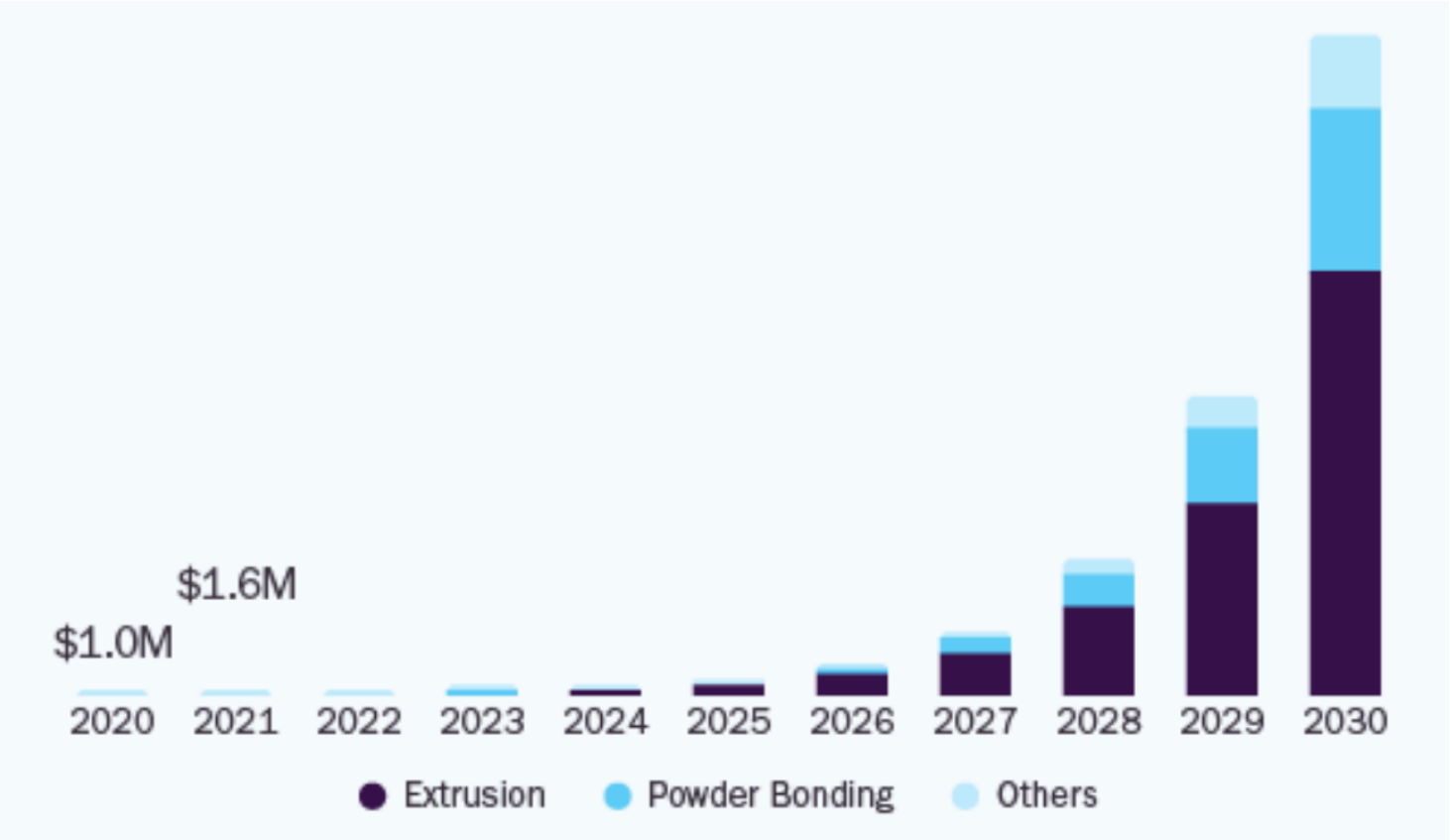
Global 3D-Printing Construction Market in 2021 ($11.3M)



3D Printing Construction Market Size, Share & Trends Analysis Report https://www.grandviewresearch.com/industry-analysis/3d-printing-constructions-market

US 3D-Printing Construction Market Prediction

- Annual growth rate ~ 100%
- Expected to reach ~ $1B by 2030



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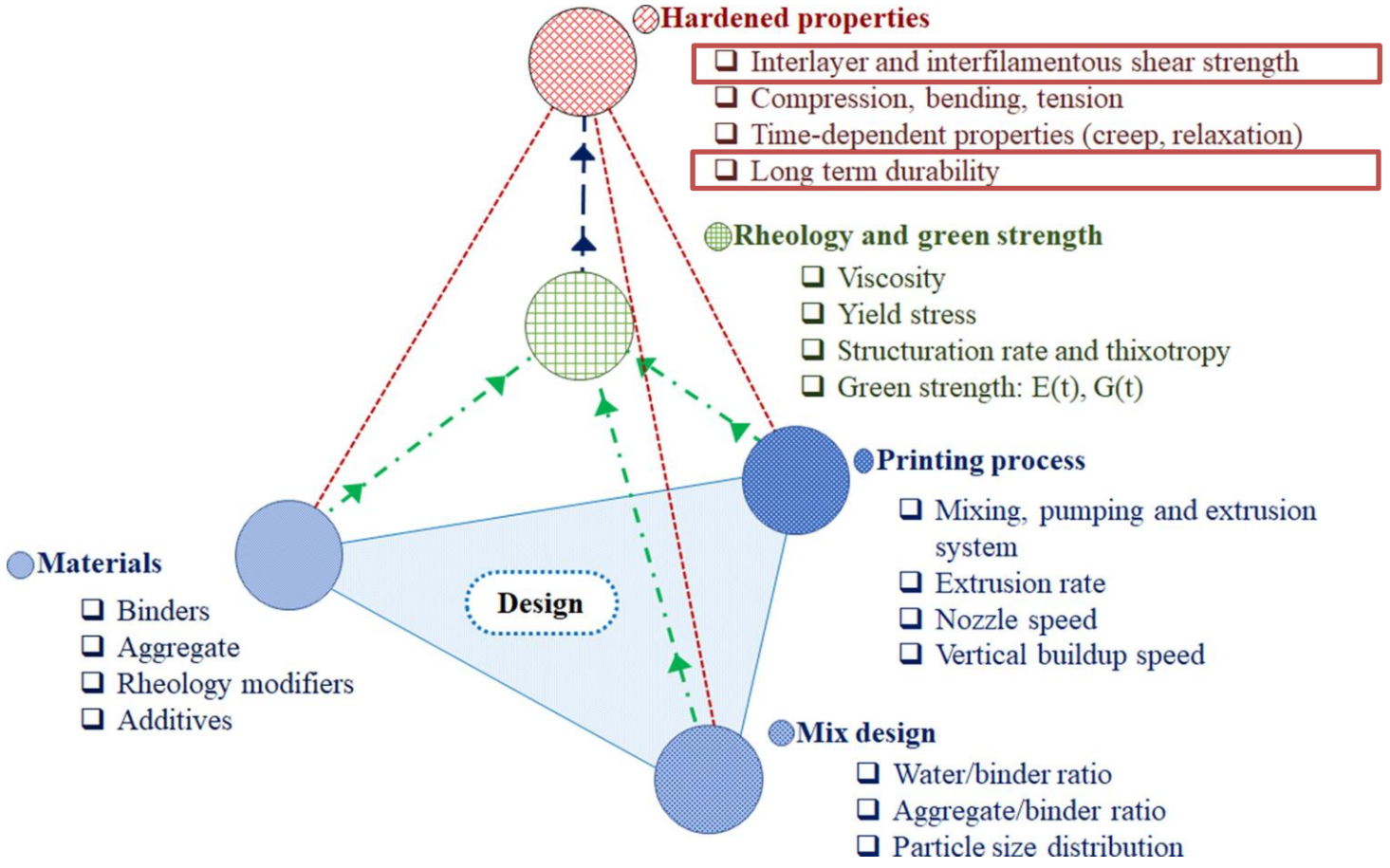
Tetrahedral model of 3D printed concrete



Murcia, D. H., Genedy, M., & Taha, M. R. (2020). Examining the significance of infill printing pattern on the anisotropy of 3D printed concrete. Construction and Building Materials, 262, 120559.

Mix Proportions [kg/m^3]

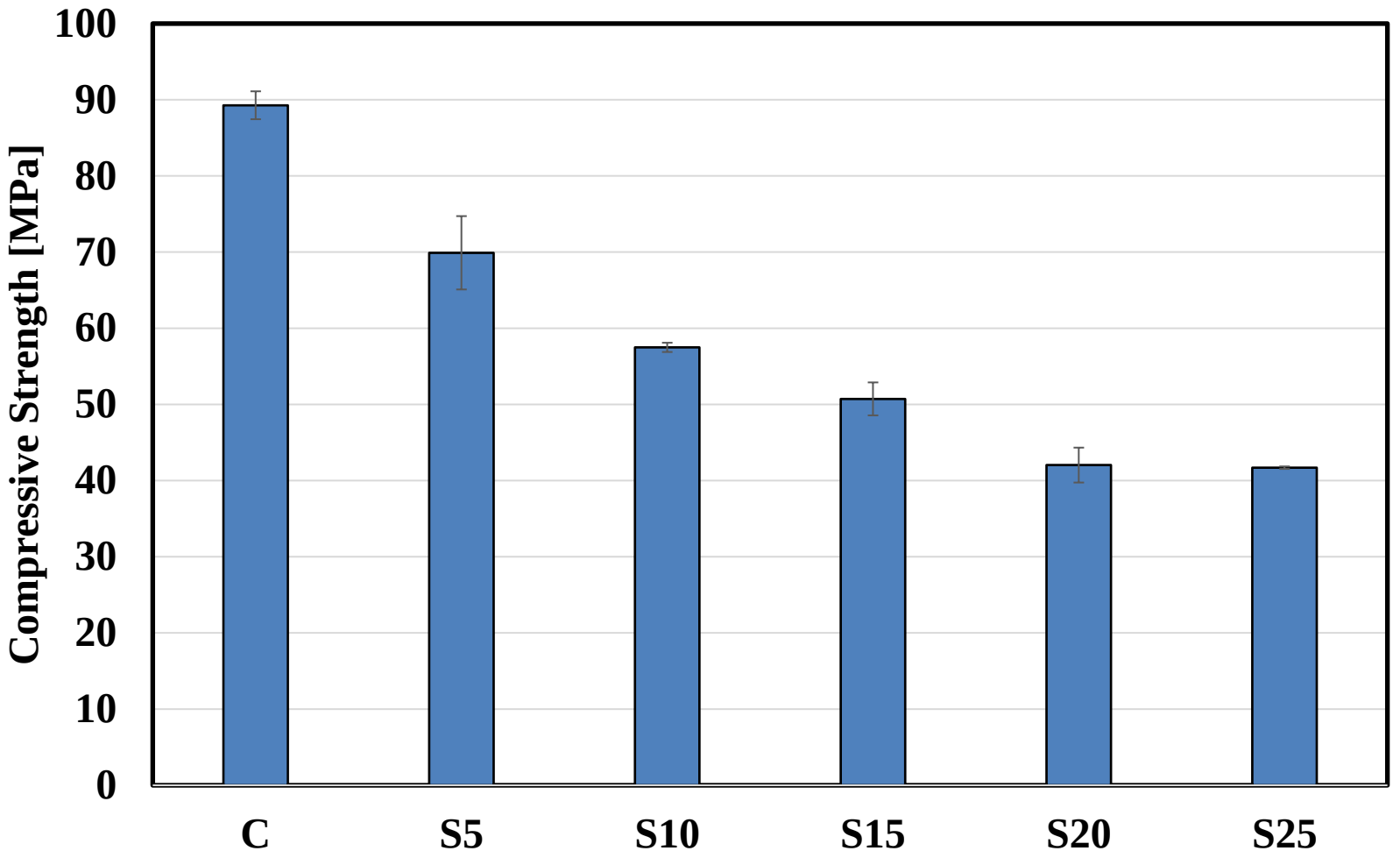
Mix	Cement	Fly Ash	Silica Fume	Sand	Water	SBR	HRWR
C	780.6	133.8	200.7	943.2	223.0	0	23.9
S5	741.5	127.1	190.7	896.0	211.8	50	22.7
S10	702.5	120.4	180.7	848.9	200.7	100	20.4
S15	663.5	113.7	170.6	801.7	189.5	150	17.4
S20	624.4	107.0	160.6	754.5	178.4	200	13.9
S25	585.4	100.3	150.6	707.4	167.2	250	10.4

- W/Cm = 0.2
- Aggregate maximum nominal size = 2mm

SBR: Styrene-Butadiene Rubber
C: Control Mix, S5: Mix with 5% SBR, S10: Mix with 10% SBR, etc.

Compressive Strength

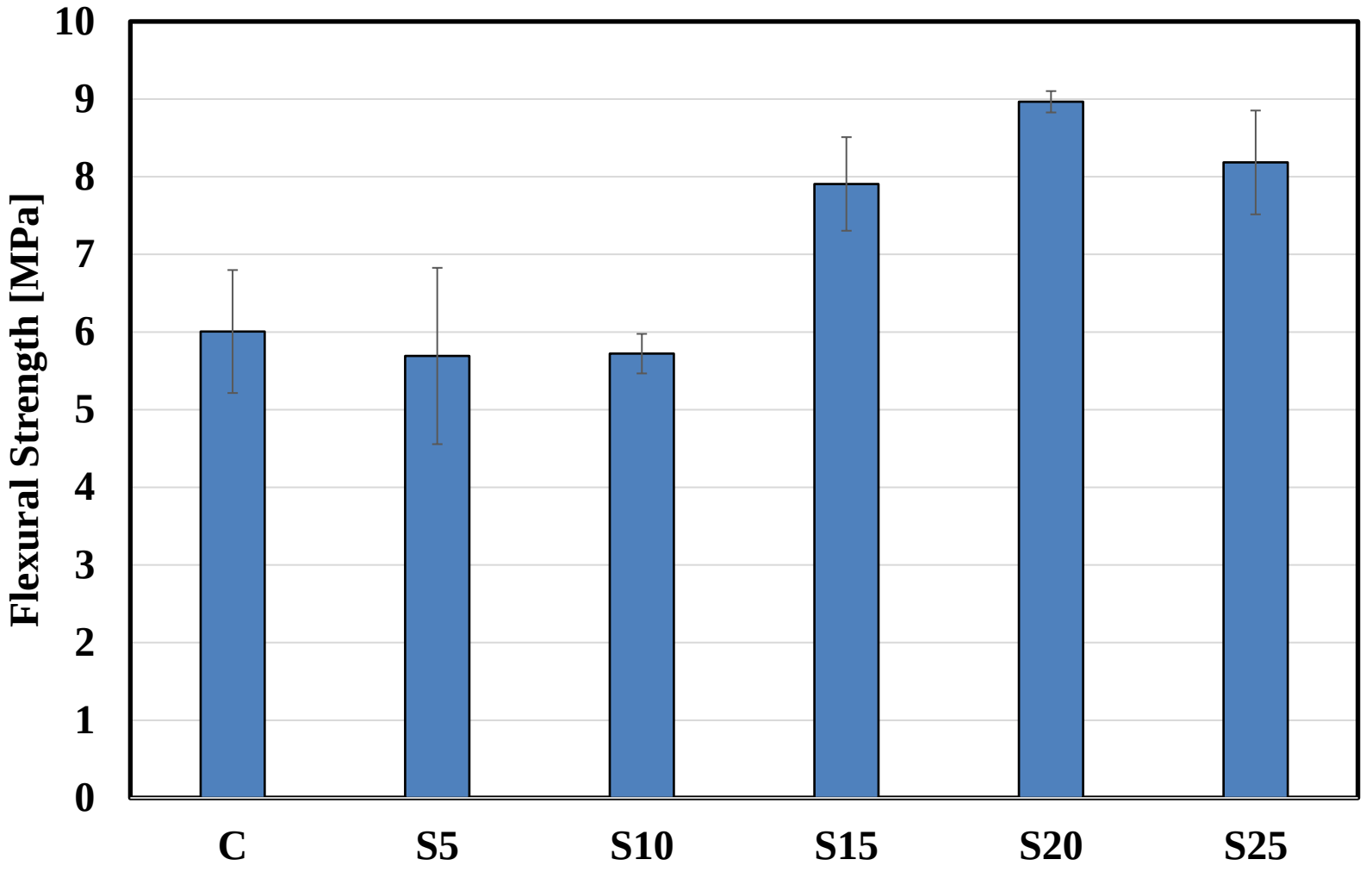
- As expected, increasing SBR content resulted in reduction in compressive strength



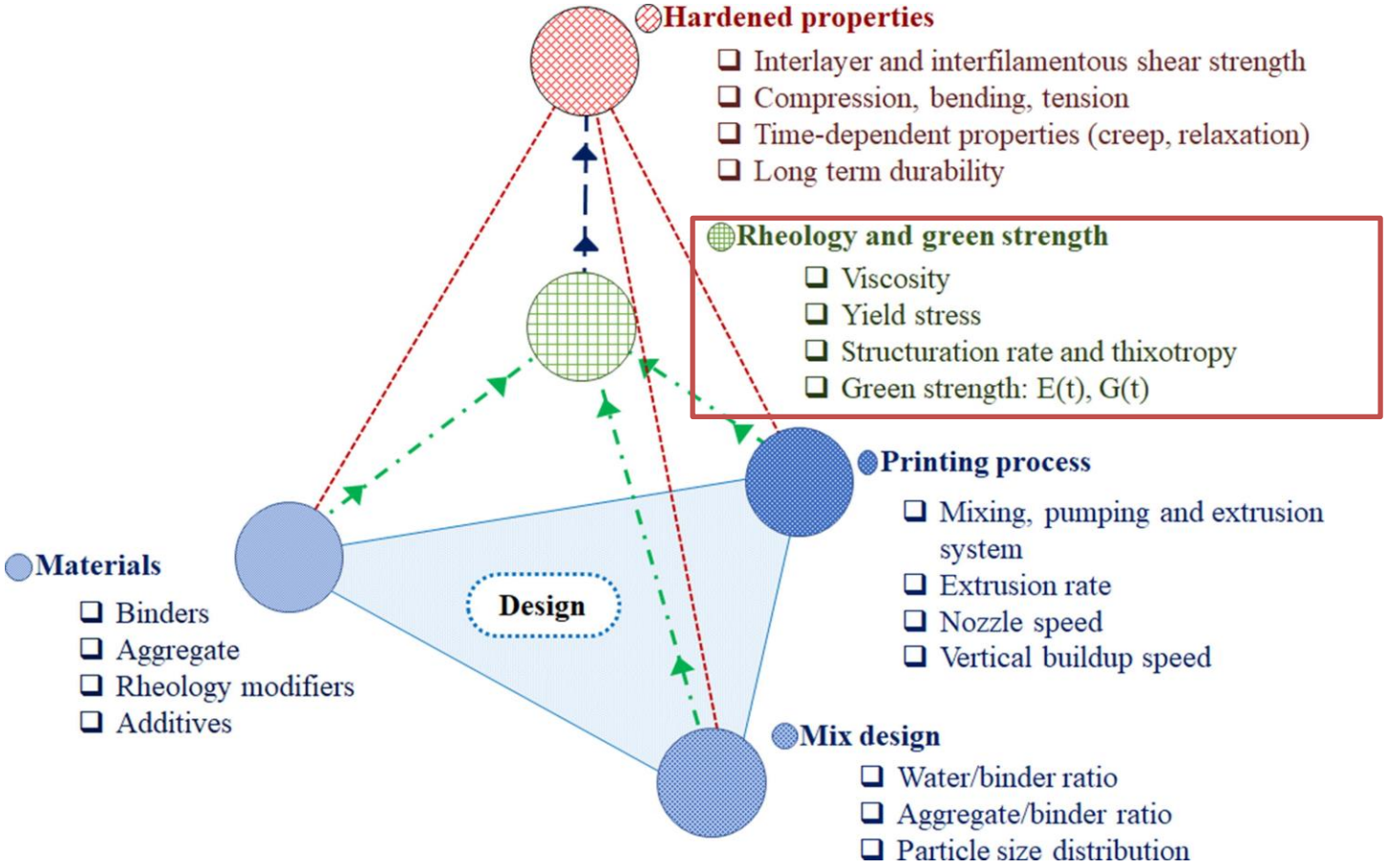
Mechanical Properties

Flexural Strength

- On the other hand, increasing SBR content resulted in increase in flexural strength



Rheological Characterization



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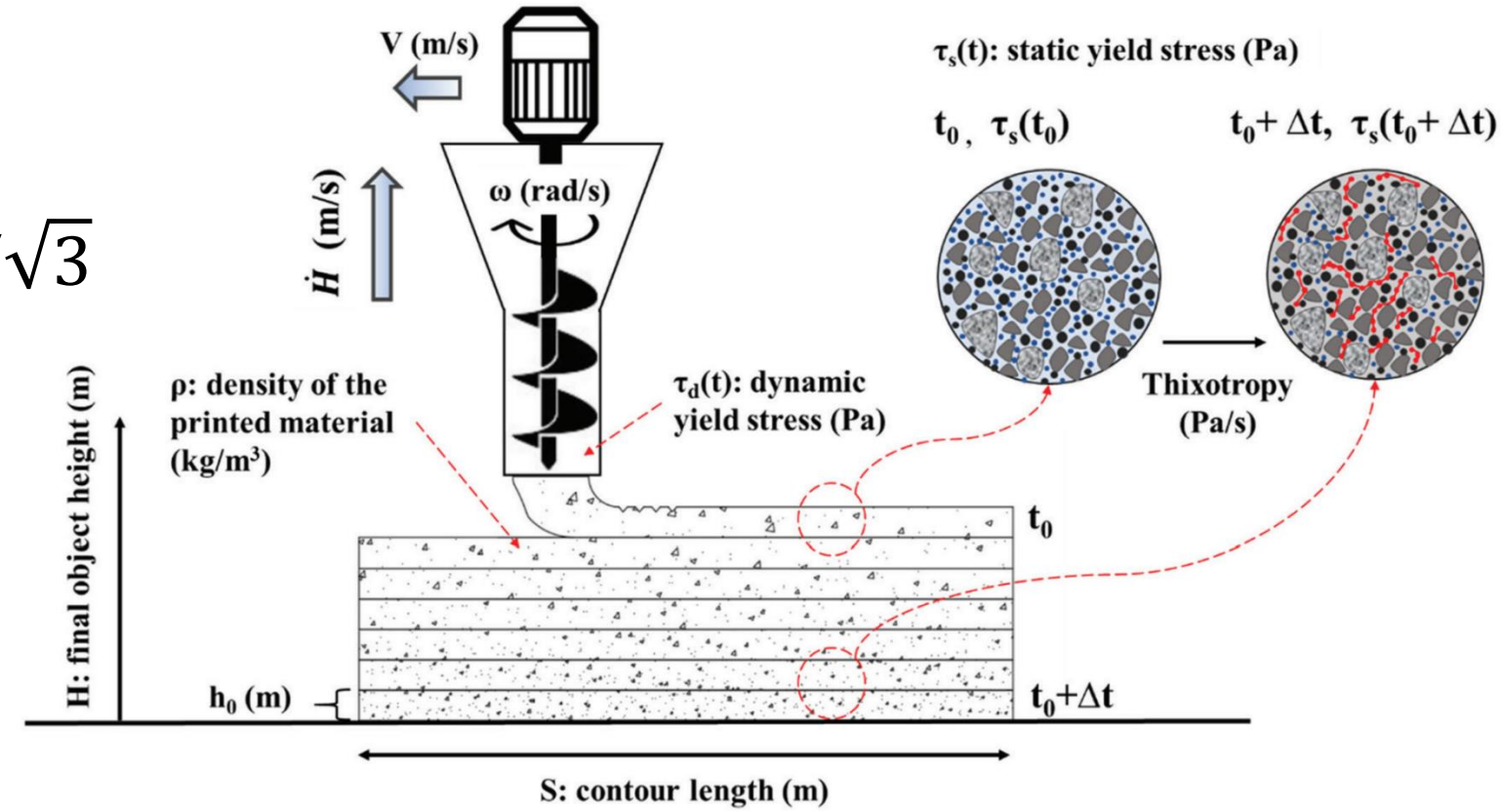
Effect of Rheological Properties

$$\tau_s(t_0) + A_{thix}\Delta t = \rho g H/\sqrt{3}$$

$$\Delta t = \frac{H}{\dot{H}}$$



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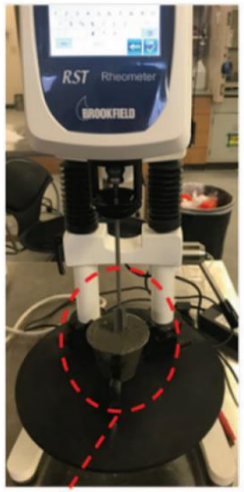
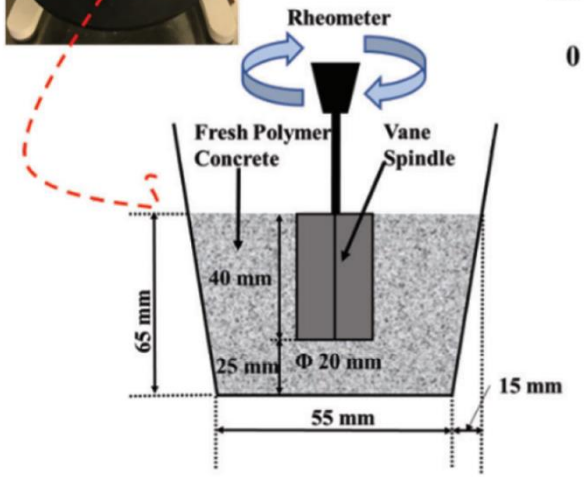
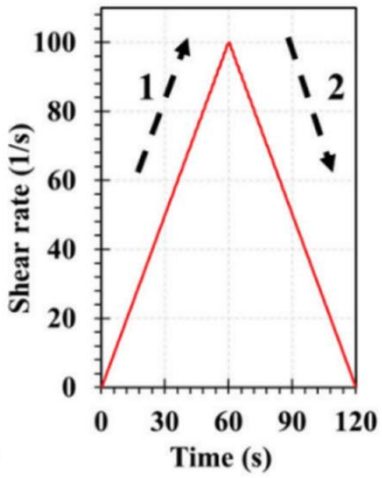
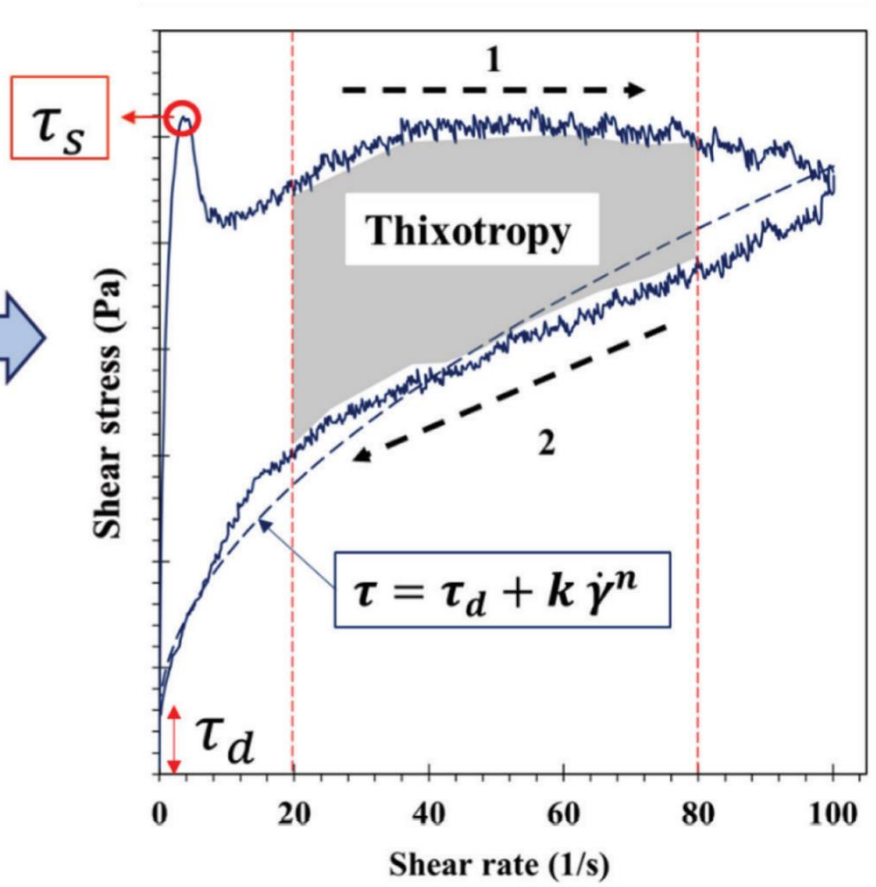
Rheological Testing









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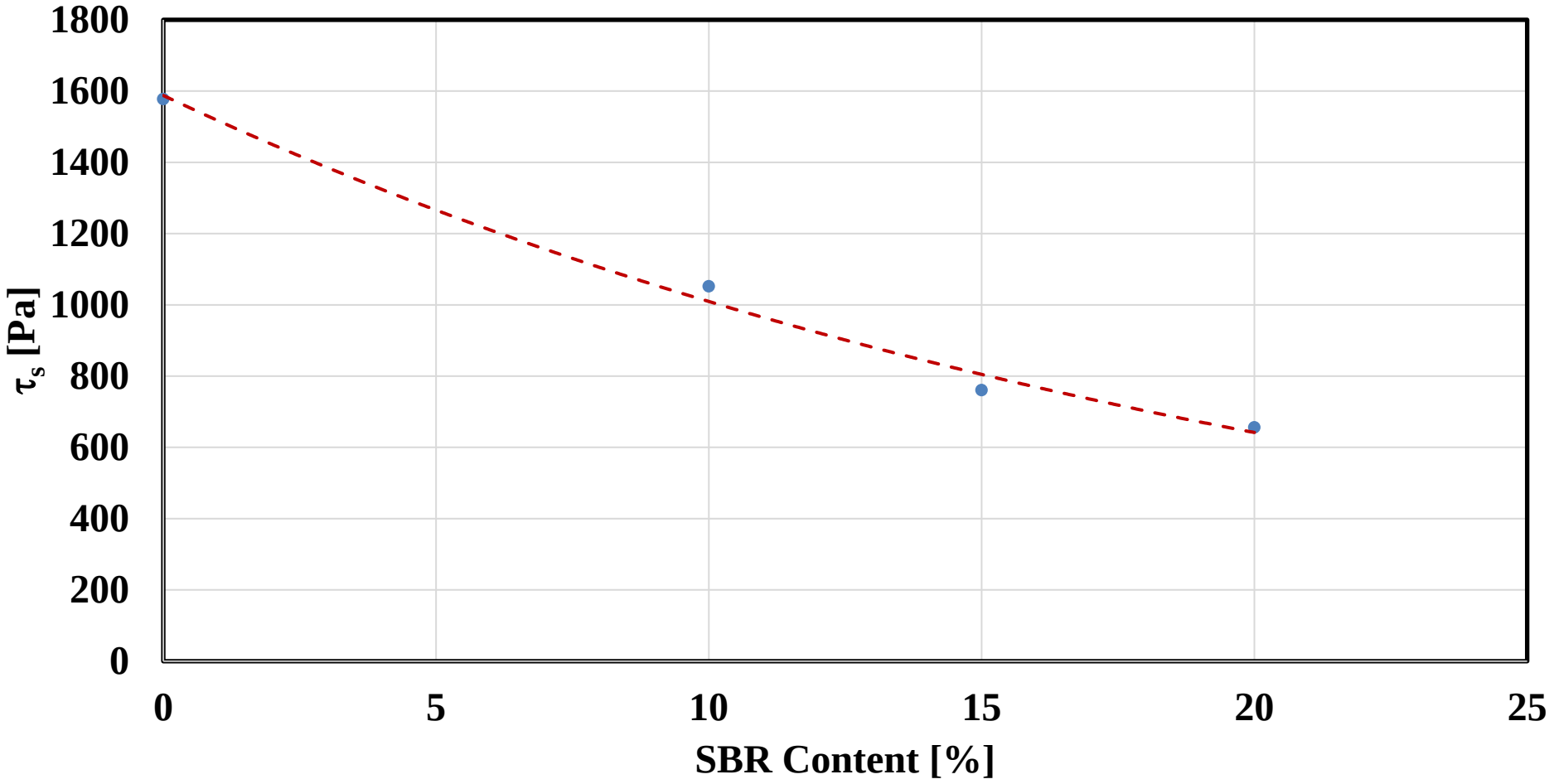
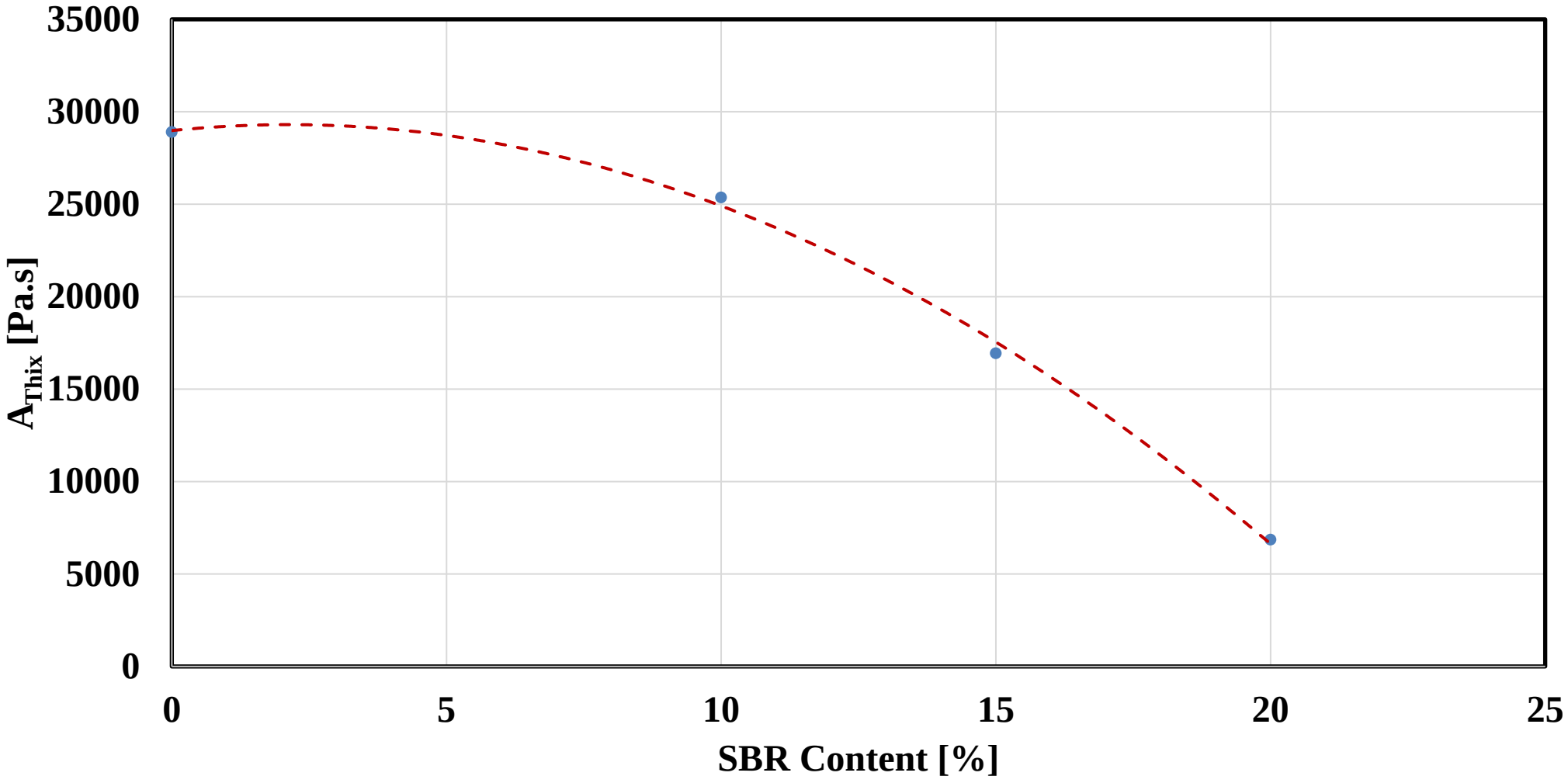
Effect of SBR Content (Yield Stress)

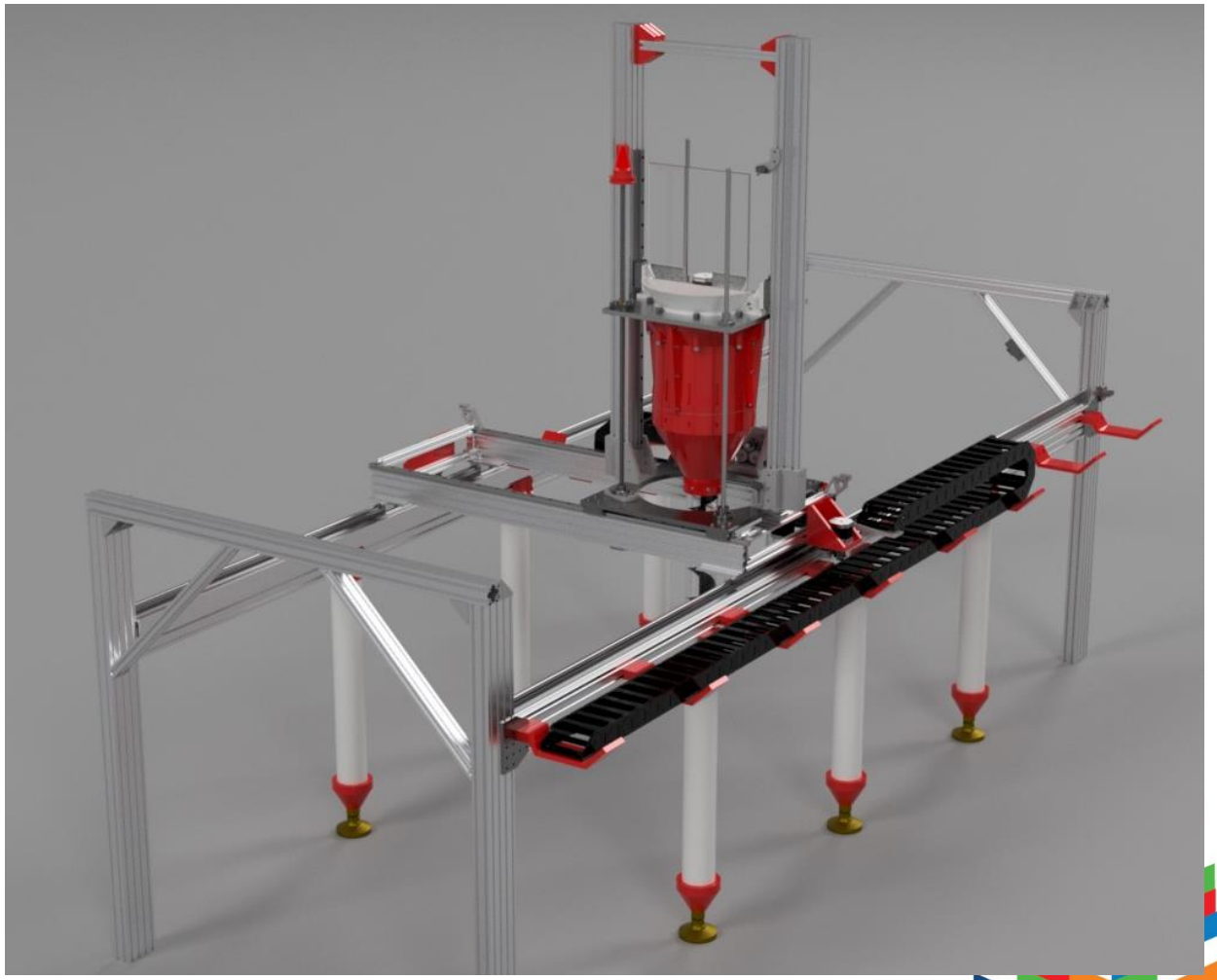


Effect of SBR Content (Thixotropy)



In-house custom-built 3D-Printer

- 2 ft x 2ft x 10 ft printing area
- Augur Extrusion
- Printing Volume: 20 L
- Minimum Volume: 4 L



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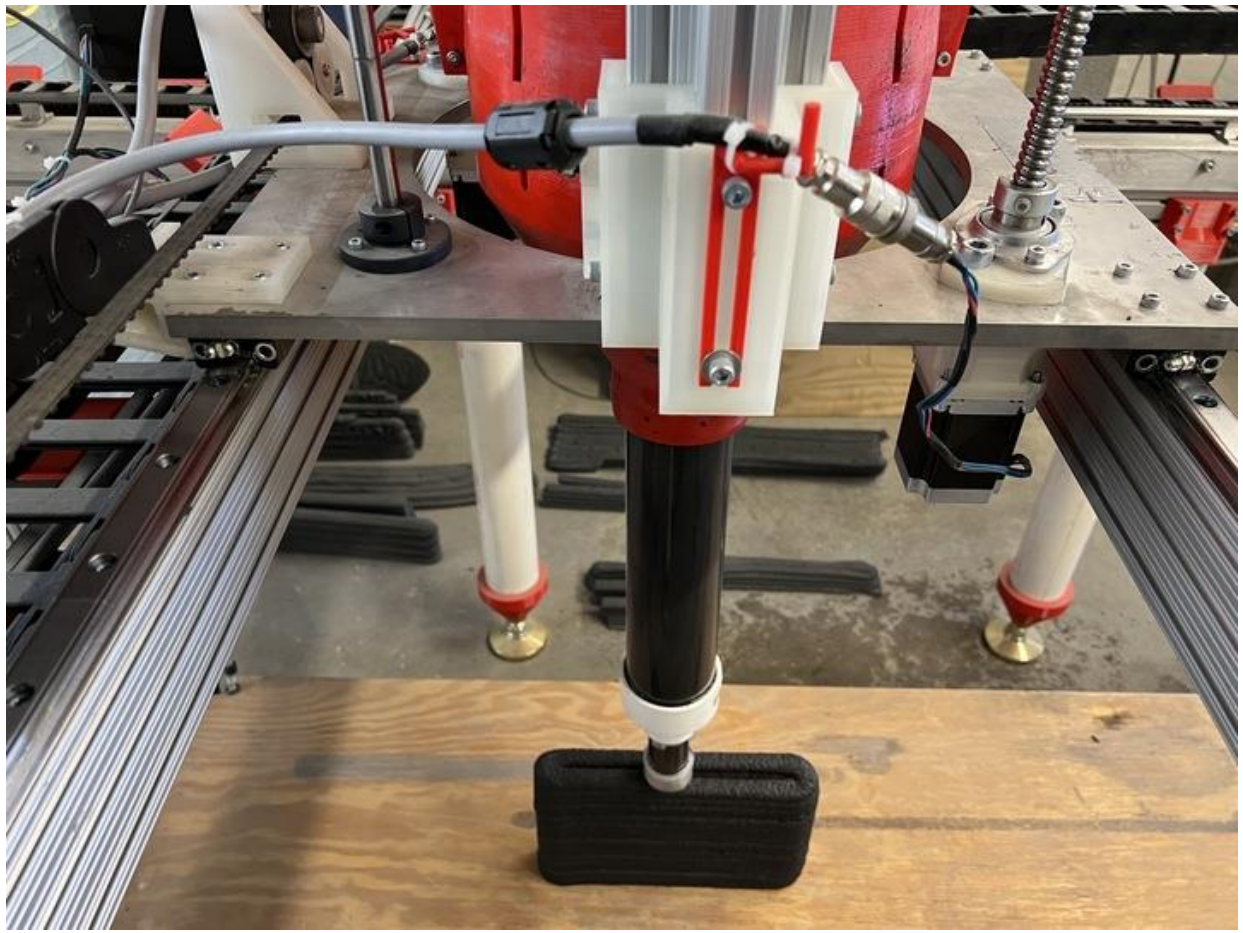
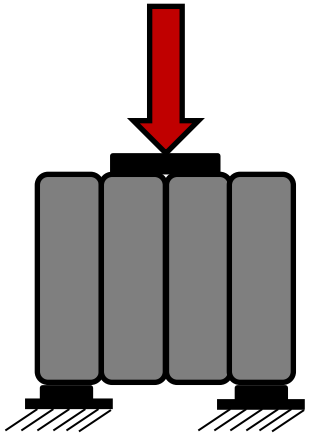


3D-printed performance

Layer-to-Layer bond strength



- S15 showed 42% Higher Shear Strength

3D-printed performance

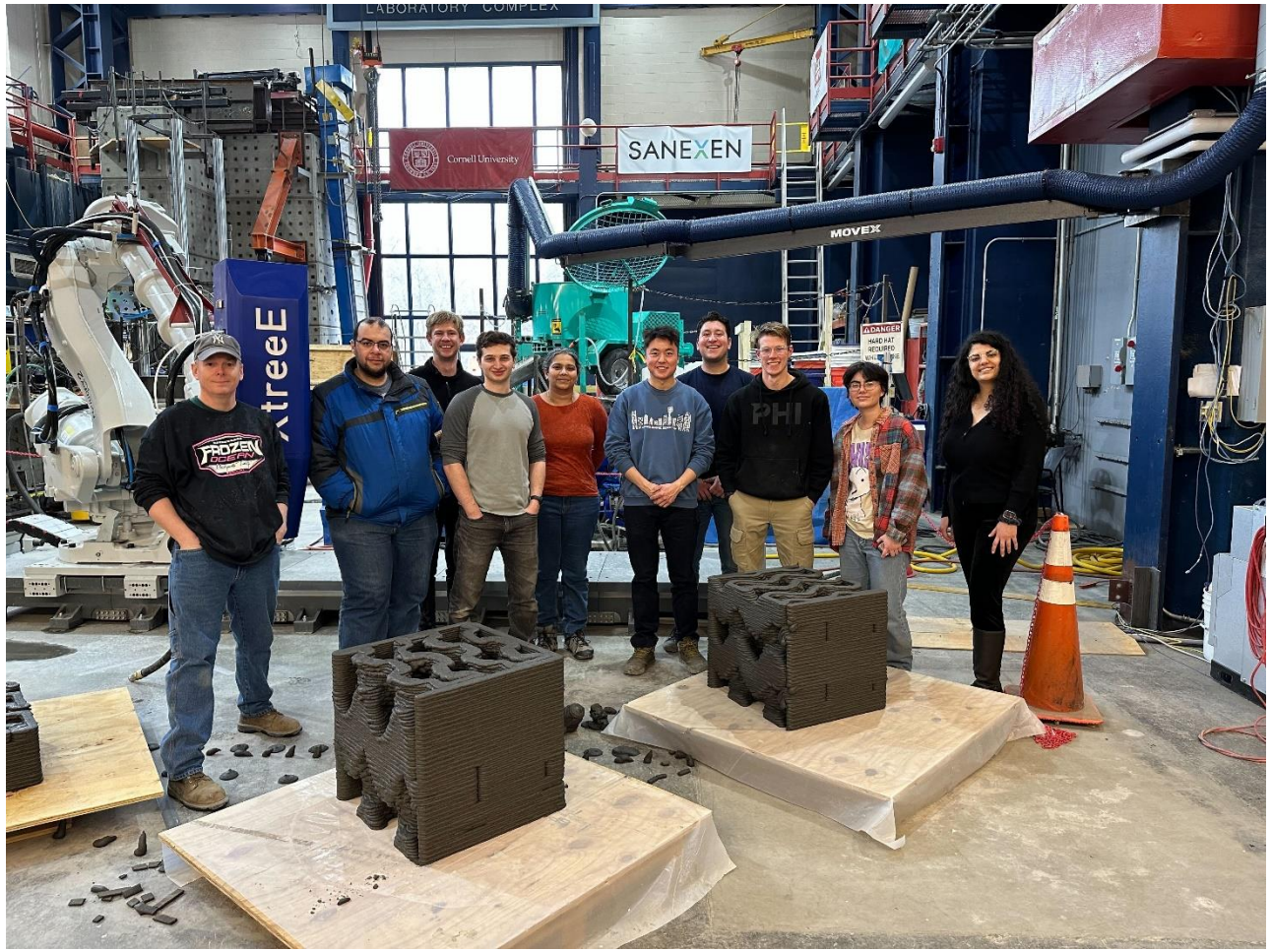
Buildability

- Single and double walled samples were printed.
- Both C and S15 collapsed after 6 layers of single walled print.

Conclusion

- Incorporating SBR into the concrete mixture resulted in a decrease in compressive strength while increased the flexural strength.
- Increasing the content of SBR results in decrease in both static yield stress and thixotropy.
- Printable SBR-modified concrete mixture were achieved.
- No interlayer debondig were observed in short beam test for SBR-modified concrete.
- Improving the printability while maintaining printability is a major challenge.

Research Team



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