Early Performance Evaluation of 3D Printed Concrete Walls Using Scaled Prototypes Simulation

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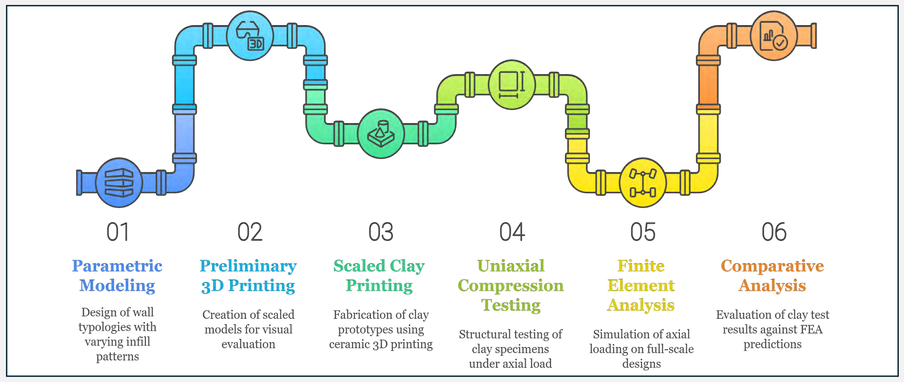
Introduction

- Parametric design and additive manufacturing enable precise control over wall geometry and material distribution
- Extrusion-based printing allows internal infill to be tailored for improved structural efficiency
- Exploring many design variations at full scale is costly and impractical
- This study combines parametric modeling, scaled ceramic printing, and finite element analysis
- Experimental testing and simulation are used to evaluate structural behavior
- Key geometric features influencing load transfer, failure, and efficiency are identified
- Findings provide insight into geometry-driven design for additively manufactured wall systems

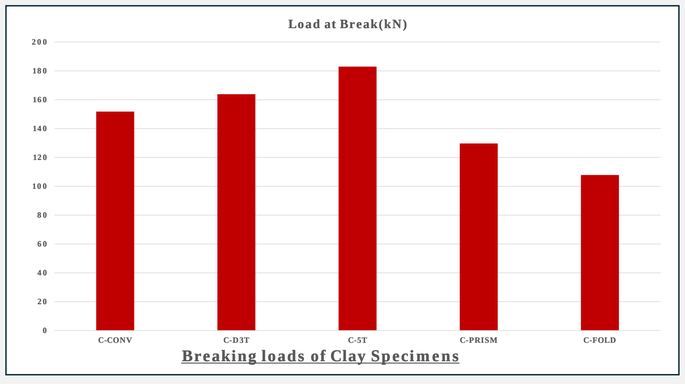
Research Application

- Reduce material costs in additively manufactured walls through optimized internal geometries
- Improve structural safety by identifying geometries with more gradual, predictable failure behavior
- Support development of design guidelines for next-generation 3D printed housing systems

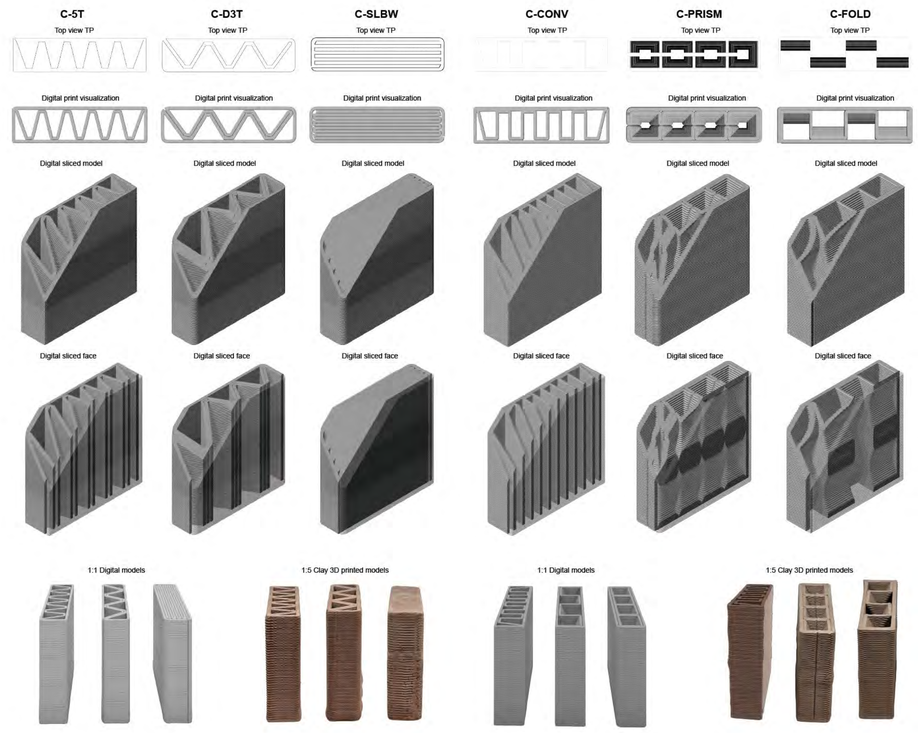
Six-phase workflow Methodology



Results

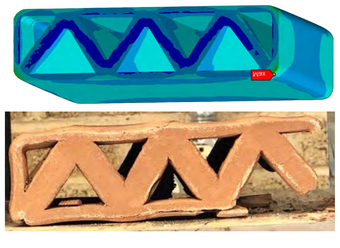


Digital wall models and corresponding 1:5 clay printed specimens.



Comparison of Test Result Against FEA

C-D3T

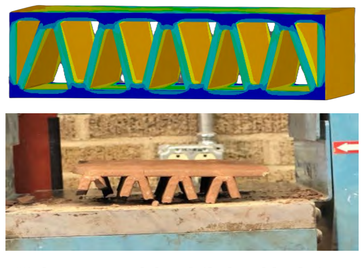


Lower strength but exhibited a gradual, controlled failure with load redistribution

C-CONV

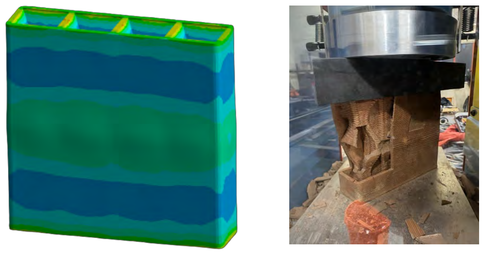
Failed abruptly due to delamination and loss of internal load paths.

C-5T



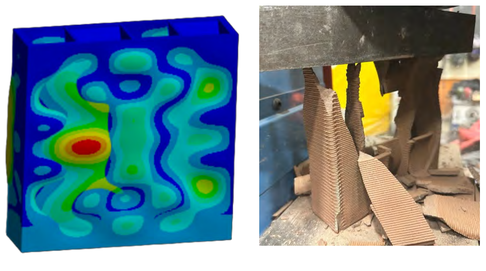
Highest strength but failed suddenly in a brittle shear collapse.

C-PRISM



Failed through longitudinal splitting followed by complete separation due to weak load paths.

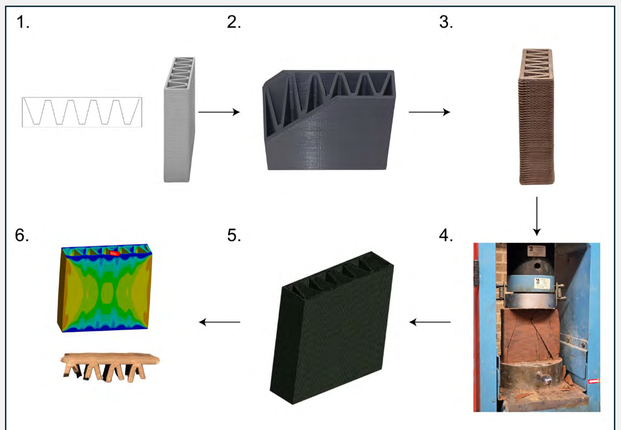
C-FOLD



Highest strength but failed suddenly in a brittle shear collapse.

Conclusion

Internal geometry controls structural behavior. Truss-based infill enables efficient load transfer and gradual failure, while disconnected patterns fail suddenly due to poor load paths. Maintaining geometric continuity is key to designing strong, material-efficient wall systems.



Summary process map: Design - Manufacturing - Testing - Analysis

Acknowledgement

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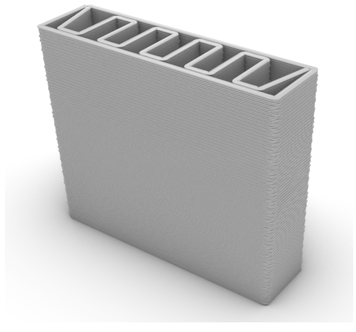
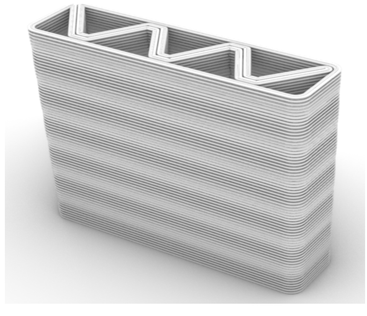
Future Works

Full-Scale 3D Concrete Printing of Shortlisted Profiles



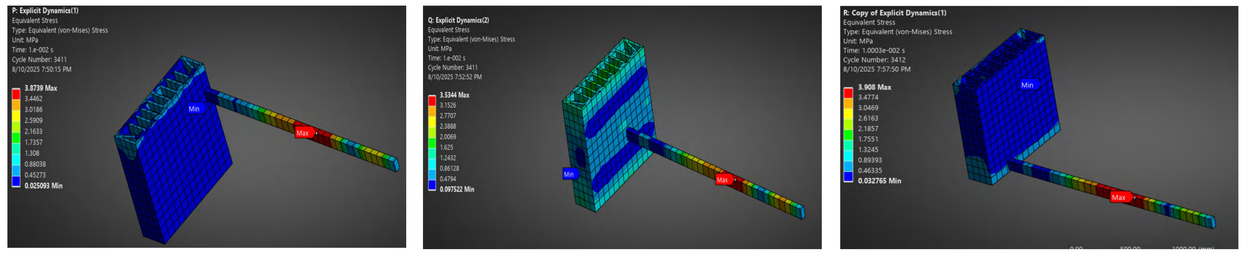
Full-Scale CONV



Full-Scale D3T

Debris Impact Analysis (National Wind Institute, Texas Tech University)

Full-Scale CONV



Full-Scale D3T