Multi-functional Additively Constructed Wall System for Housing and Sheltering

Anthony Mackin[1], Zaid Hanoun[2], Jenna Migliorino[1], Aly Ahmed[1] and Islam M. Mantawy[3]
[1]Ph.D. Student
[2]MS.c Student
[3]Assistant Professor

Toronto, ON, Canada, April 2025

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Construction industry over the last decades

Comparison of construction techniques between 1950s (left) and 21st century (right).

Overview

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Conventional Construction
(forming, reinforcement placement & casting)

Additive Construction
with Optimization

Hybrid Construction
(printing formwork, reinforcement placement & casting)

Overview

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Mixes for Additive Construction

- Printability
- Fresh and Hardened Properties
- Shrinkage

Overview

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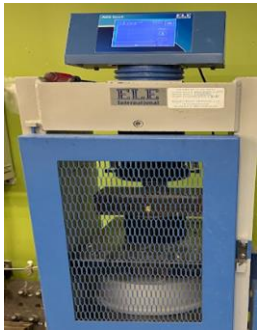
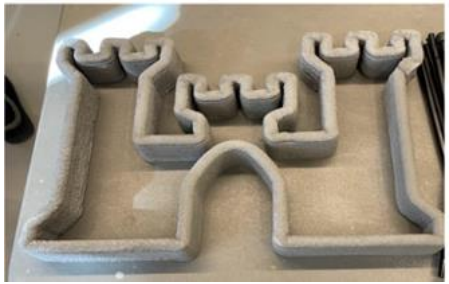
Flow Table Test
(ASTM C230/C230 M-21)

Setting Time
(ASTM C191-21)



Compressive Strength
(ASTM C109)



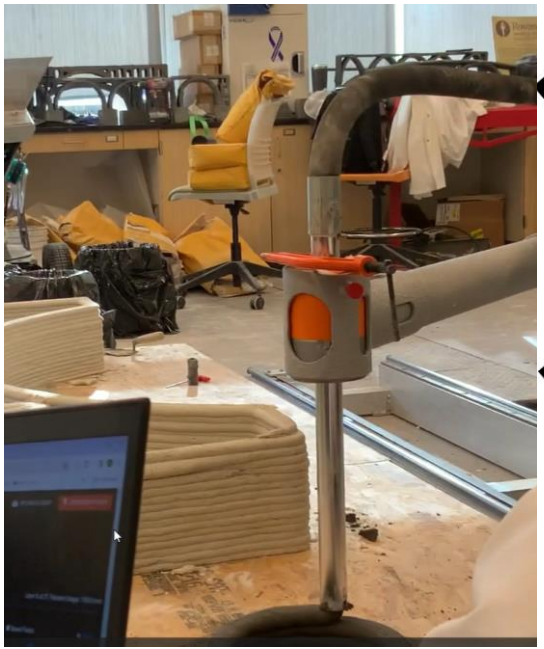
Extrudability

Buildability

Fused Layers

Scanning (LiDAR)
(Collaboration with Dr. Trias)

Different Printing Systems at ARC-LAB



Successful Extrusion and Buildability (Different Systems, 1K)

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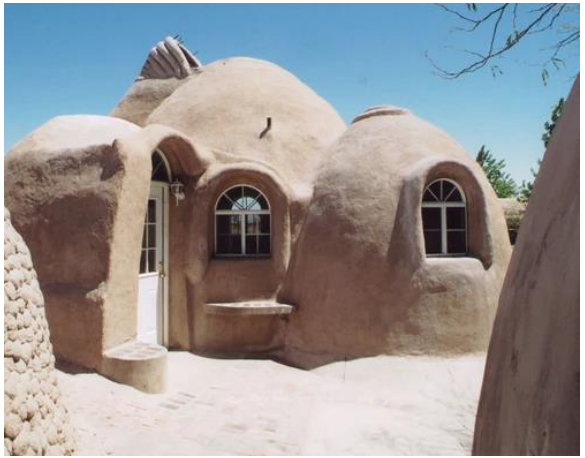
In 2023, natural disasters displaced more than 2.5 million Americans

Cerrahoglu and Maden (2022) proposed another set of important criteria for temporary shelters

- Durability
- Safety & Privacy
- Reusability
- Transportability
- Rapid Assembly
- Easy to Store
- Expandability & Compactness

Housing and Shelters



SuperAdobe (Eco-Dome)

Future Shack

U-Dome

Proposed Multi-Functional Wall

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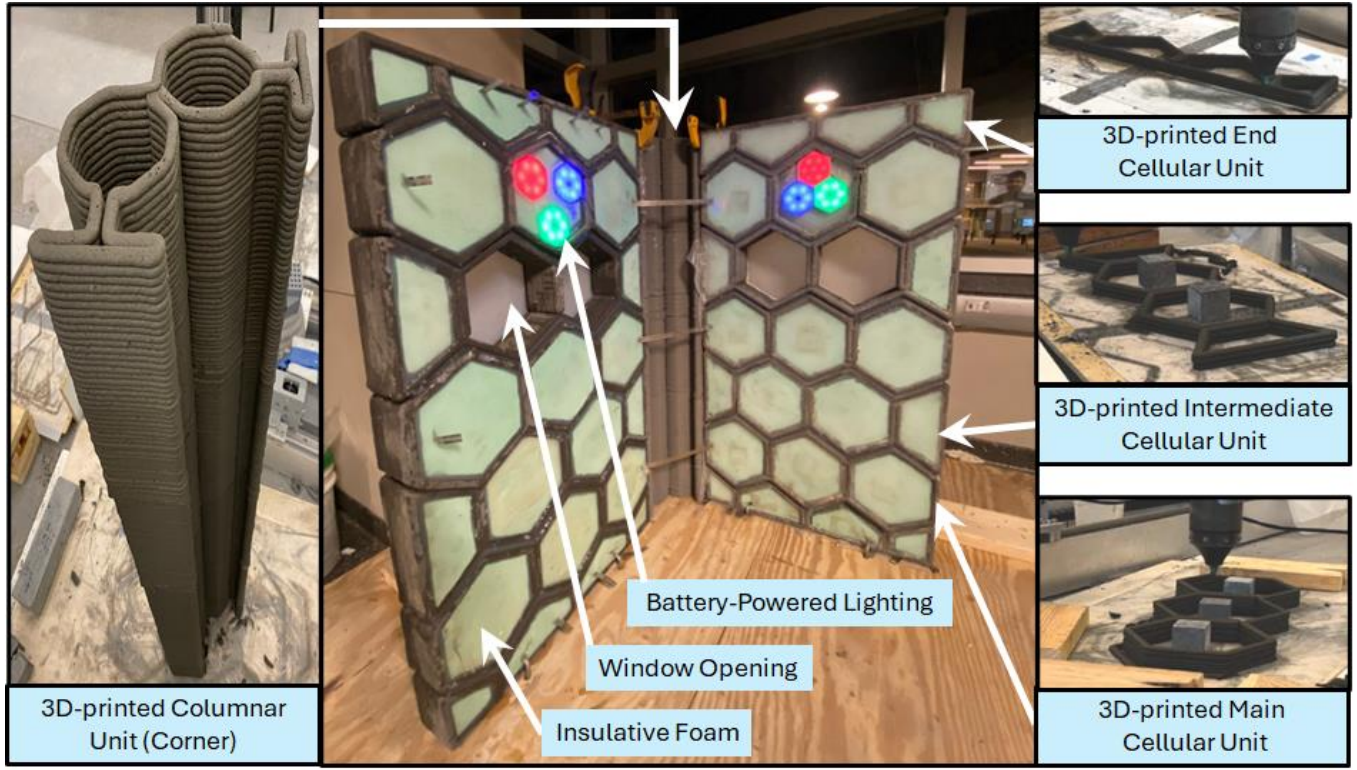
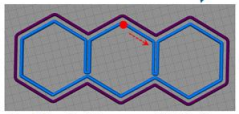


- ✓ **Durability**
- ✓ **Safety and Privacy**
- ✓ **Reusability**
- ✓ **Transportability**
- ✓ **Rapid assembly**
- ✓ **Easy to store**
- ✓ **Expandability**
- ✓ **Compactness**
- ✓ **Flexibility**

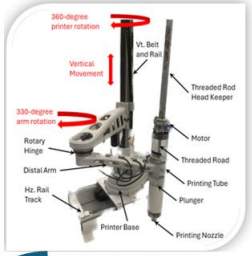
Methodology

1- Raw Materials

2- Mixing and Material Testing



3- Modeling and Slicing



4- Printing Equipment

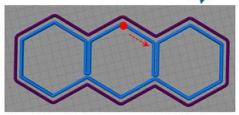
5- 3D Printing

6- Wall Assembly

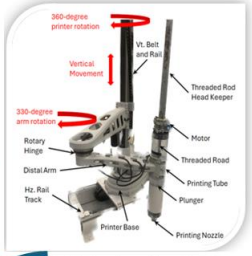
Methodology (Materials)

1- Raw Materials

2- Mixing and Material Testing



3- Modeling and Slicing



4- Printing Equipment

5- 3D Printing

6- Wall Assembly

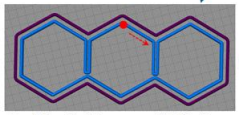
Mix Results

Printing Process	Compressive Strength (MPa)			Flow table (mm)	Vicat (min)	
	3 days	7 days	28 days		Initial setting time	Final Setting time
Before	48.4	52.9	68.9	114	61	180
After	47.5	53.7	64.1		Not Measured	

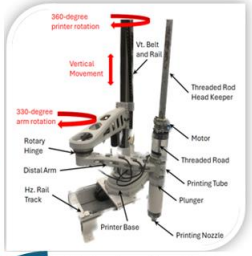
Methodology (CAD/Slicing)

1- Raw Materials

2- Mixing and Material Testing



3- Modeling and Slicing



4- Printing Equipment

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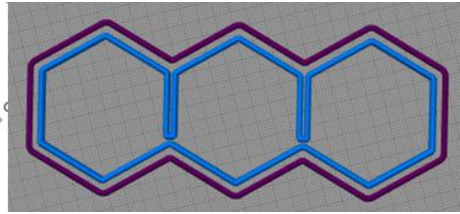
6- Wall Assembly

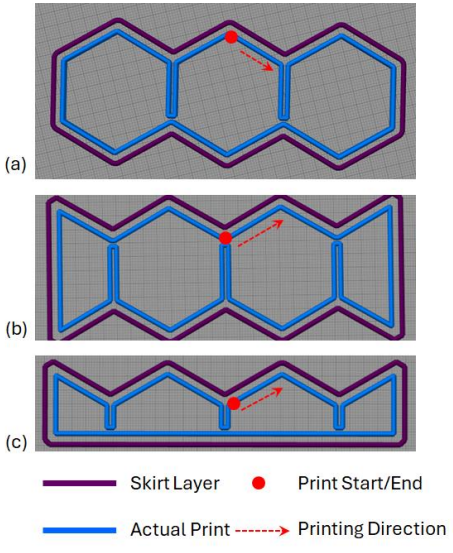
Slicer

onshape → SIMPLIFY3D →

- Floor- Lines V1.gcode
- Optimized Beam V2 New Plan.gcode
- Optimized Beam V2 Special.gcode
- Optimzed beam V3 New Plan.gcode
- Scara Printer Eagle Extra Large.gcode



Slicing



Methodology (3D-Printing)

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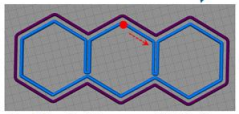
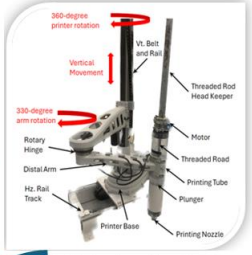
1- Raw Materials

2- Mixing and Material Testing



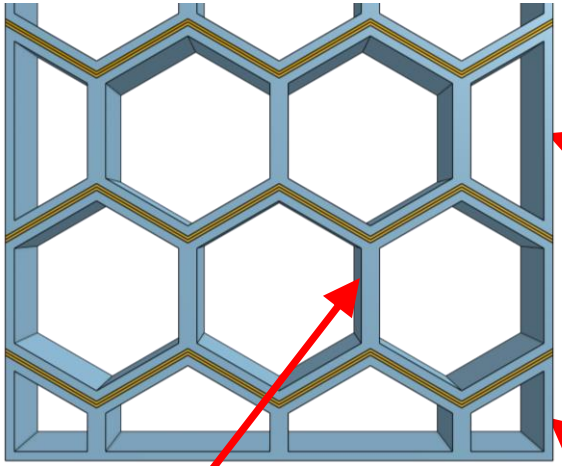
3- Modeling and Slicing



4- Printing Equipment

5- 3D Printing

6- Wall Assembly



Multi-functional Additively Constructed Wall System for Housing and Sheltering

RowanUniversity
ADDITIVE AND ROBOTIC CONSTRUCTION LABORATORY (ARC-LAB)

Methodology (3D-Printing)

American Concrete Institute

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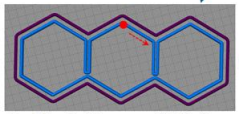
2- Mixing and Material Testing



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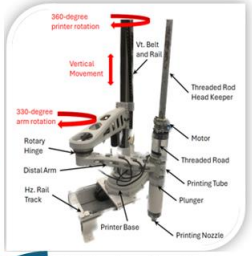
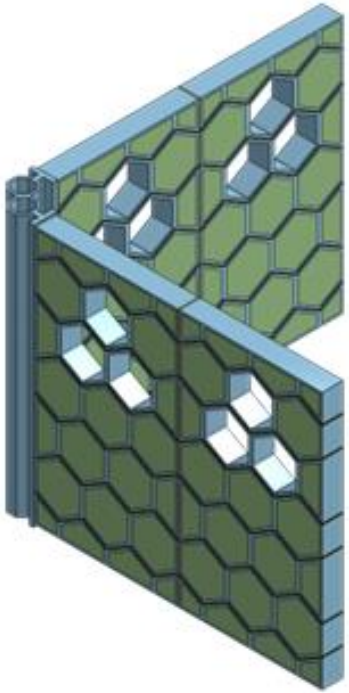
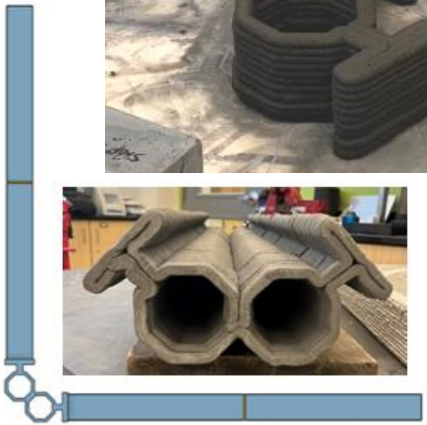


4- Printing Equipment

5- 3D Printing

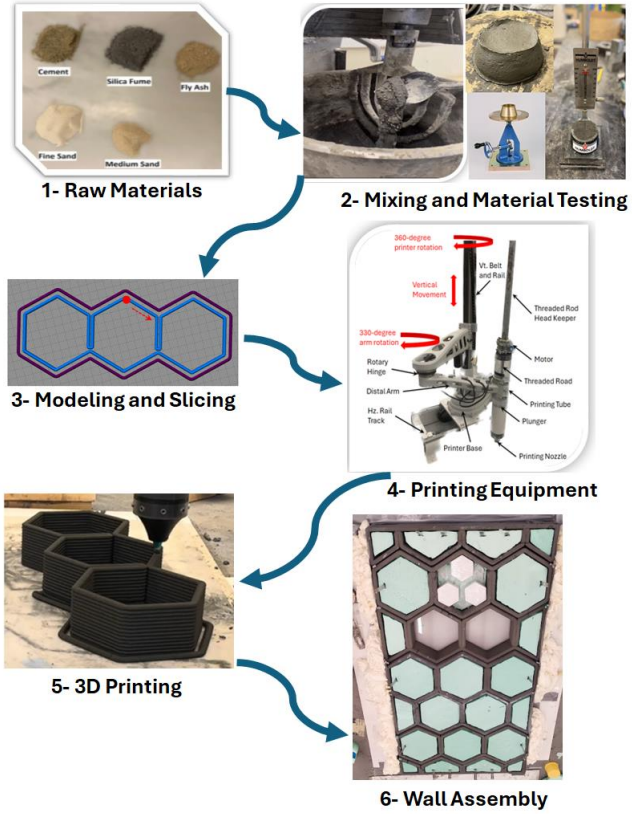
6- Wall Assembly

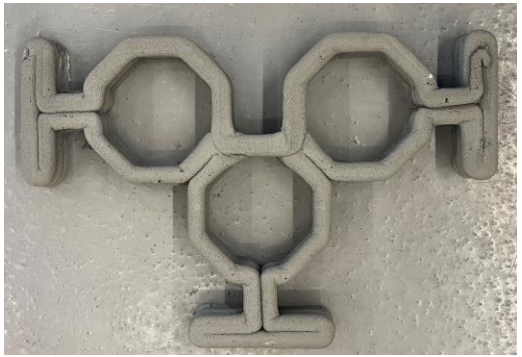




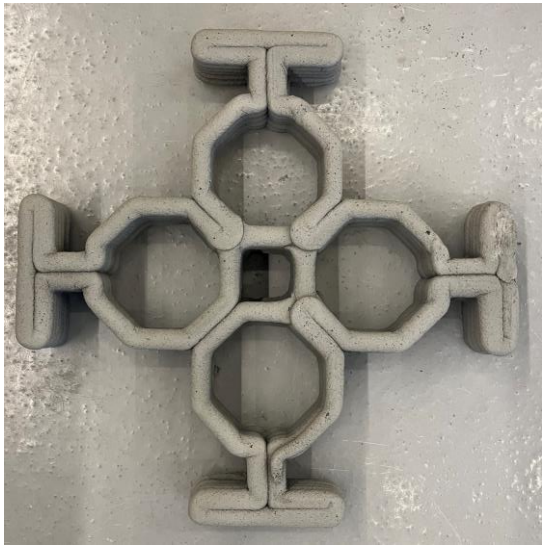
Corner Connection

Methodology (3D-Printing)





Edge Connection



Interior Connection

Methodology (Assembly)

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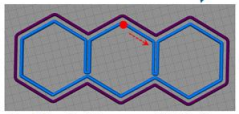
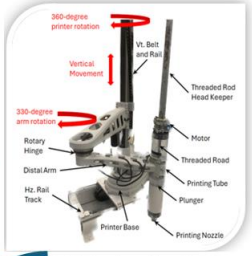
1- Raw Materials

2- Mixing and Material Testing



3- Modeling and Slicing



4- Printing Equipment

5- 3D Printing

6- Wall Assembly

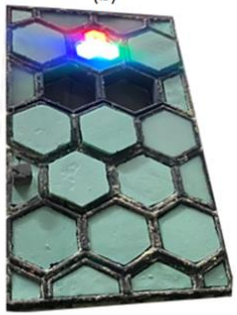
(a)

(b)

(c)

(d)

(e)



(f)

(g)

(h)

Methodology (Production Line)

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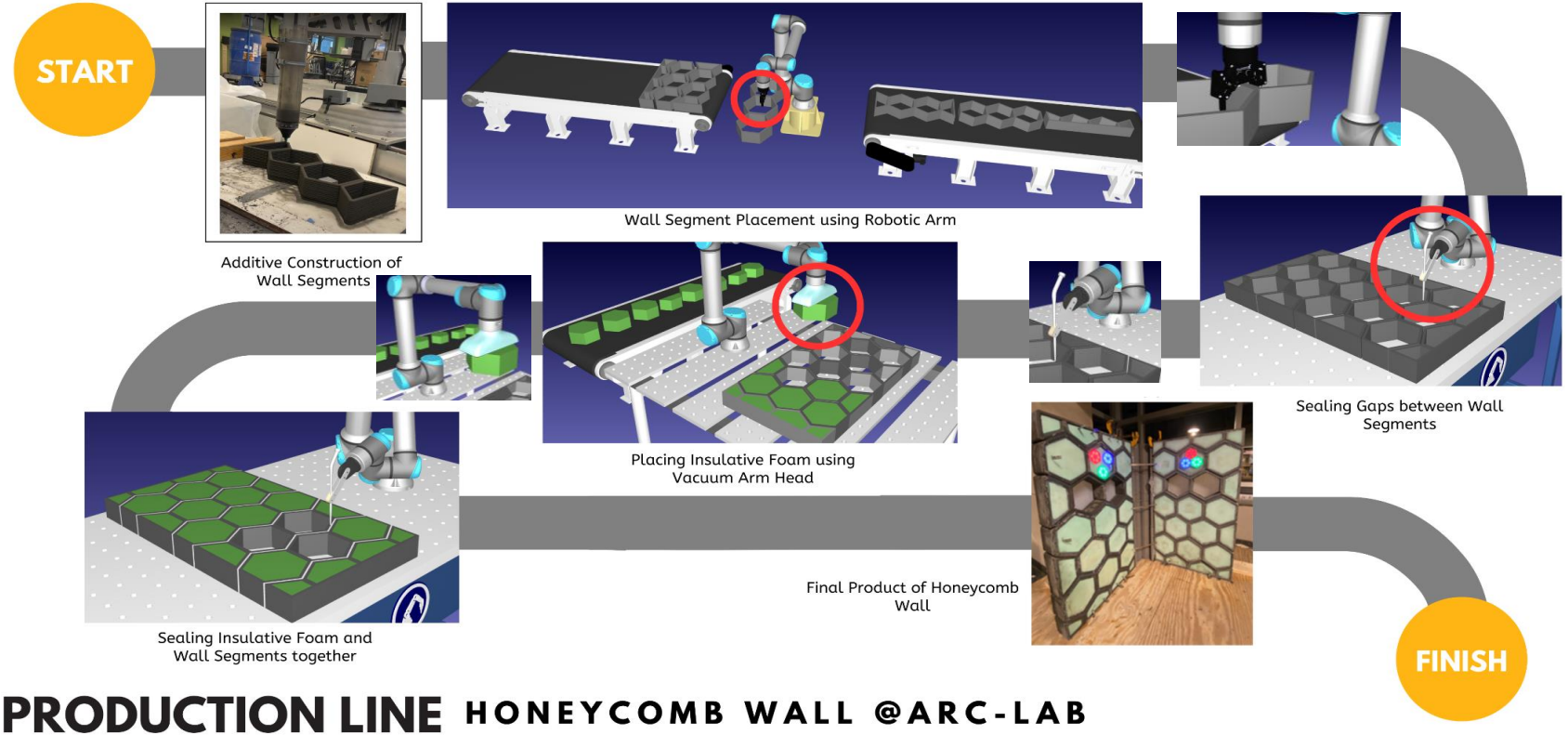

PRODUCTION LINE HONEYCOMB WALL @ARC-LAB

Experimental Testing

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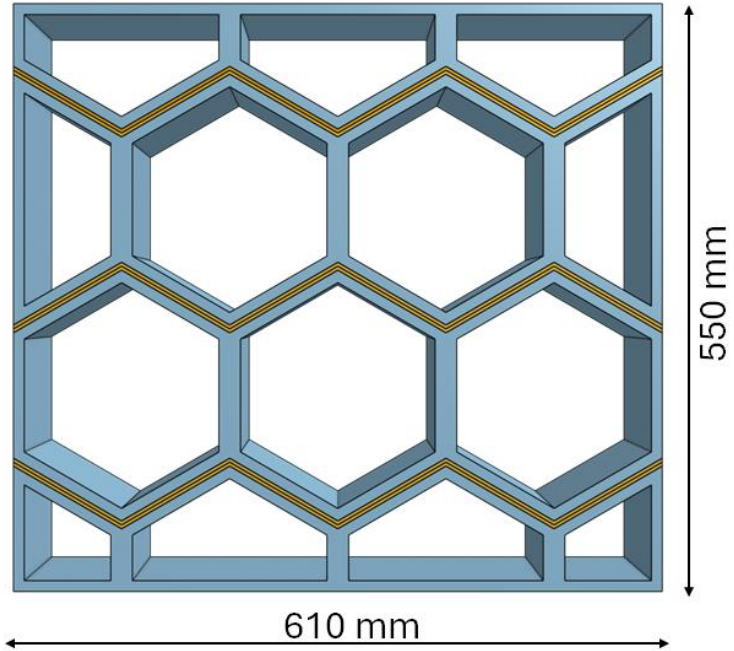
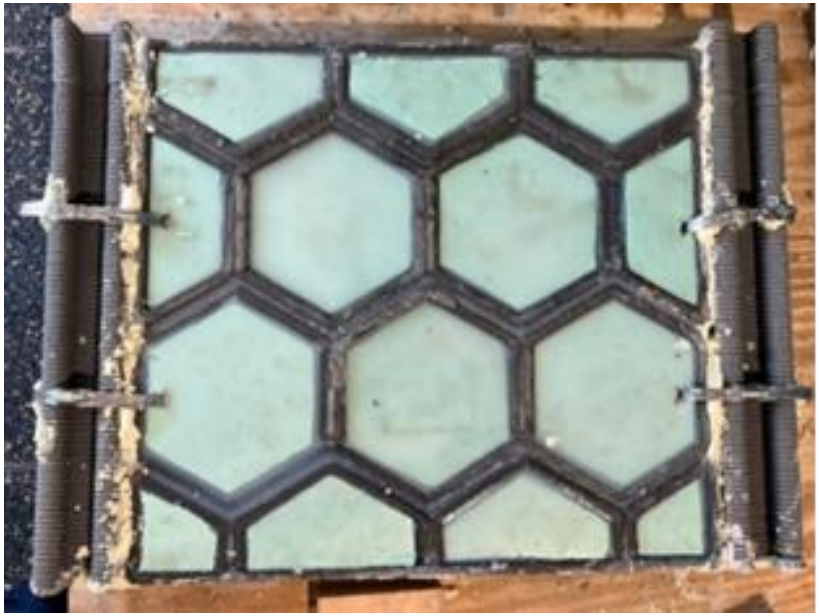
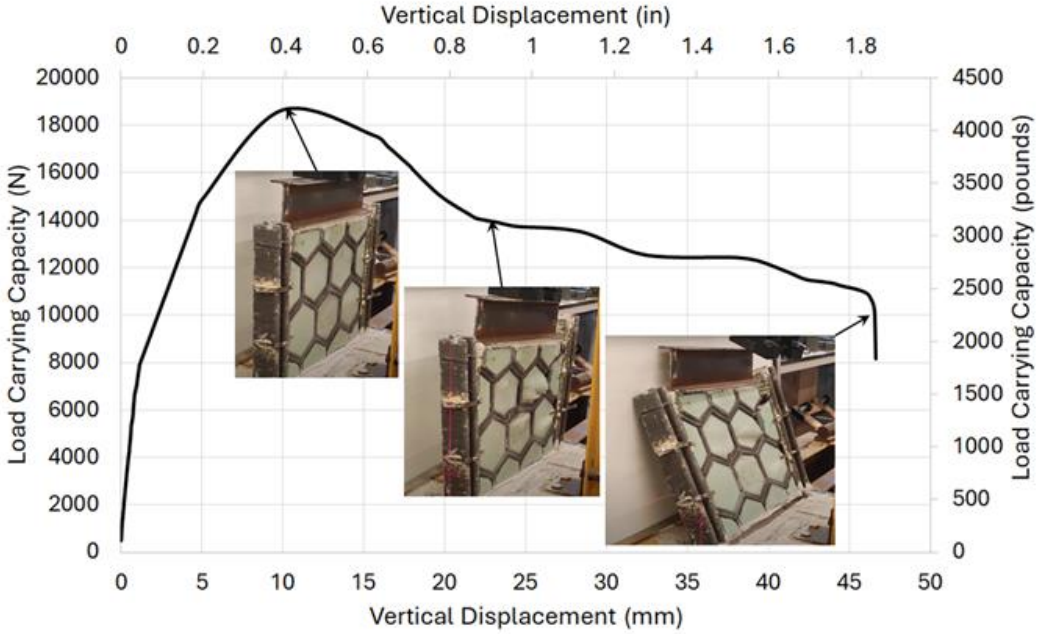


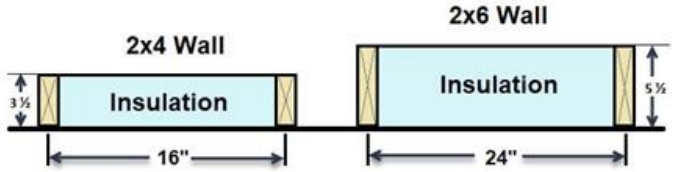


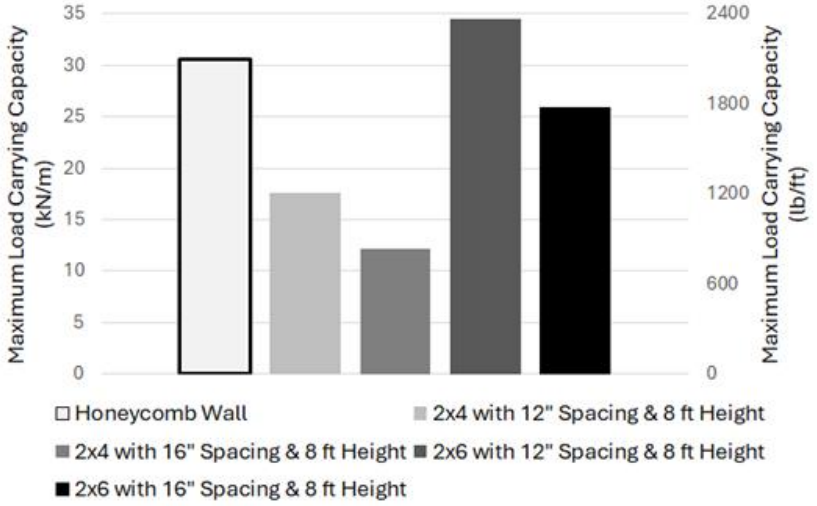
Experimental Testing

Experimental Testing

American Concrete Institute

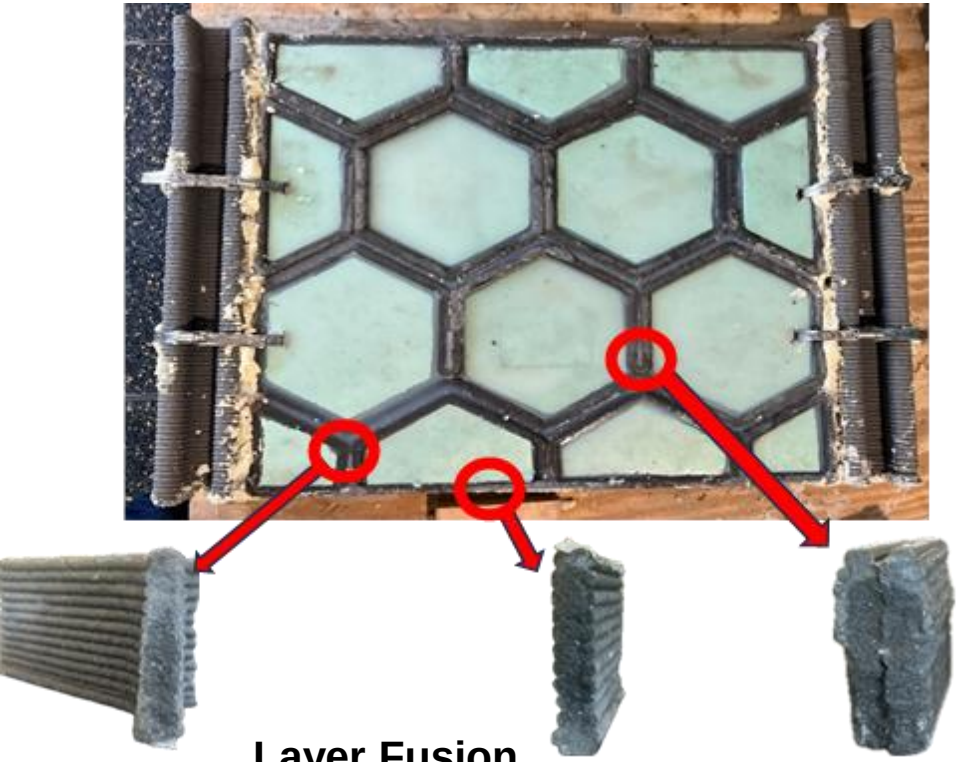




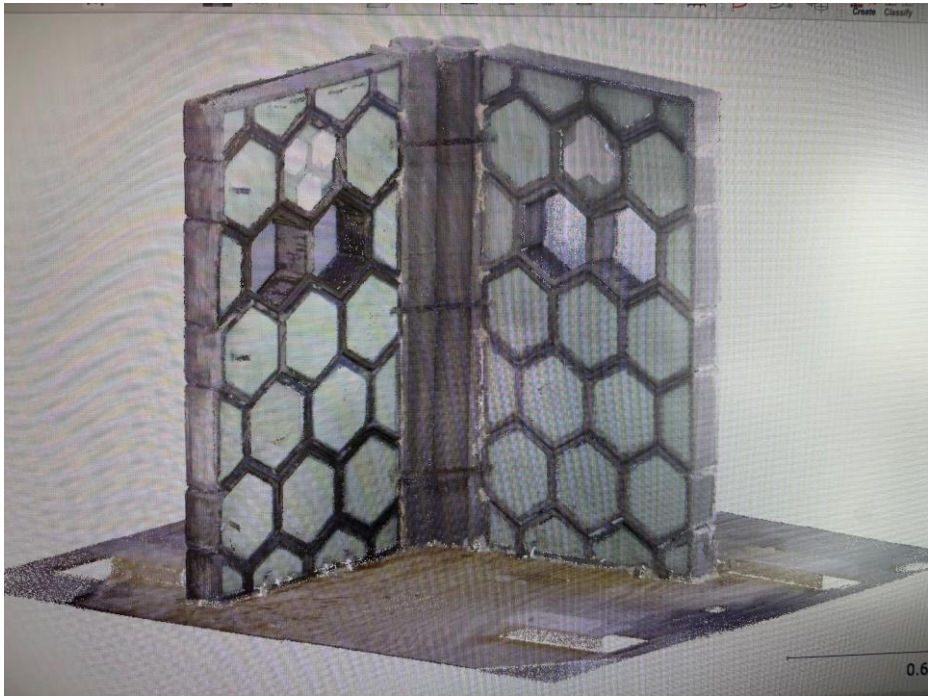


Experimental Testing

American Concrete Institute



Layer Fusion



LIDAR Scanning for Assembly

Article in CBM

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Construction and Building Materials xxx (xxxx) 138941

Contents lists available at ScienceDirect

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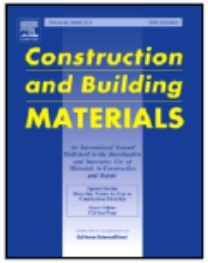

Multi-functional additively constructed honeycomb walls for housing and sheltering

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Civil and Environmental Engineering, Henry M. Rowan College of Engineering, Rowan University, Glassboro, NJ 08028, USA

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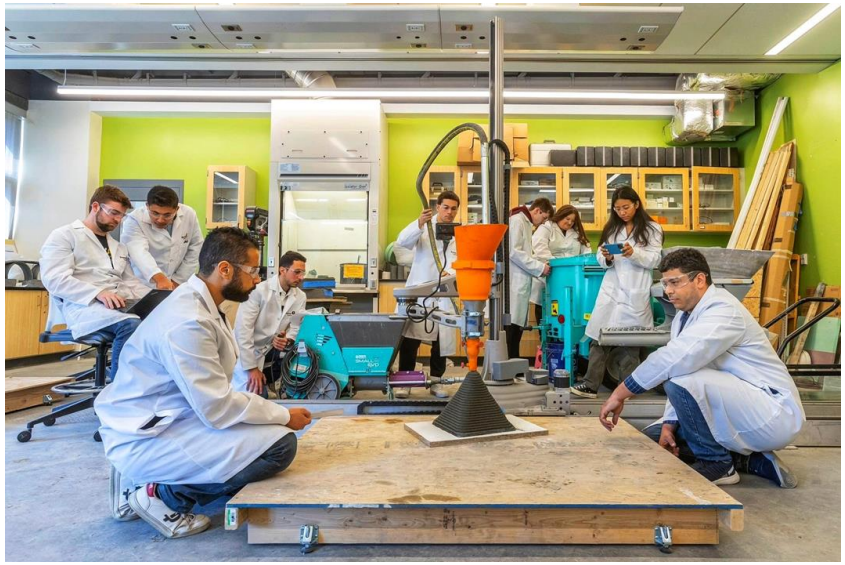
Acknowledgment

This work was made possible by a U.S. Department of Education Graduate Assistance in Areas of National Need (GAANN) Grant Number P200A210109.



ARC Lab Team, Rowan University.

Thank you.

Anthony Mackin

PhD Student

mackin93@rowan.edu

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Toronto, ON, Canada, April 2025