Rapidly Deployable Relief Housing

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Introduction

The goal of this project is to design rapidly deployable housing structures for victims of natural disasters. This project is being conducted with MADCO3D in Rochester, NH to design 3D printed concrete blocks to be arranged into a structure at the site of the disaster.

Objectives

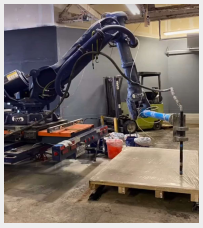
Design a structure to be
- Rapidly deployable
- Sturdy, securable, and event resistant
- Reconfigurable
- Off-grid capable

Building Metrics

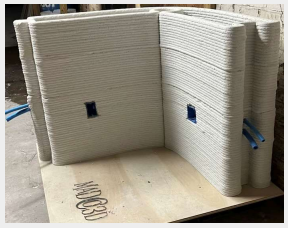
- Walls made to withstand 100-120 mph winds (category 2 hurricane winds)
- Roof made at 10-degree pitch to shed snow (per Colorado code)
- Floor of shipping container designed to hold weight of home with a factor of safety of 2
- Ceiling height must be at least 7'
- Home built compatible for plumbing and electricity
- 304 square foot (19'x16') interior allows for up to four occupants

Concrete 3D Printing

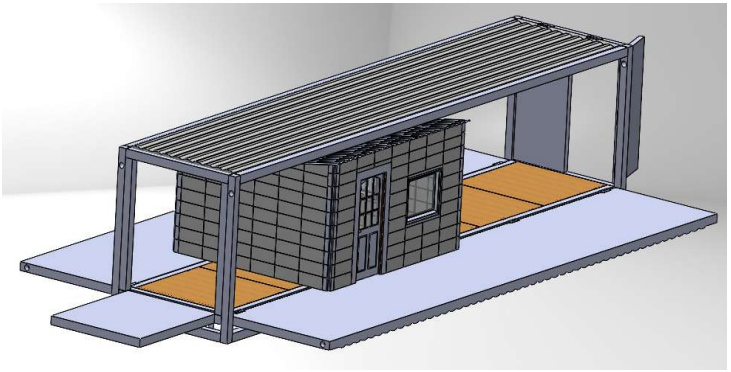
- Pieces are created using a hose attached to a robotic arm
- Arm follows a toolpath while a hose dispenses concrete with equal z-steps
- Fiberglass rebar used to reenforce walls by laying individual bars between layers of concrete
- Extra accelerant head can be attached to printing head to speed drying of concrete during print
- Holes for electrical and plumbing are carved out during print
- Foam supports are used to support overhangs during print



Robotic concrete printing arm

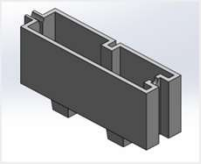


Concrete blocks with electrical outlets

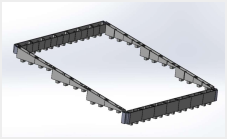


Model of deployed relief housing in custom shipping container

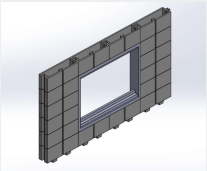
Design



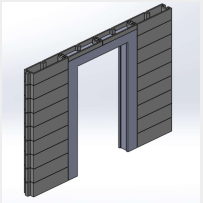
Individual Block
- Heaviest block is 50 lbs.
- Most used block 3'x1'x1' with 1.5" concrete thickness
- Interior slot for dry wall and support beams
- Bottom has extended piece to stack on other blocks
- Ends of block has male and female ends to link blocks
- Groves at block links for wires and tubing through walls



Roofline
- 10-Degree roofline made with unique angled blocks along the top to be drilled into securing roof
- Corner pieces made to connect at 90-degrees
- Roofline consists of five blocks specific to the roof
- Roof made of ten metal roof panels (12'x3.5')



Window Frame
- Made for 5'x4' laminated glass window
- Pine wood frame for weight and durability
- Compatible for any location on walls
- Designed with female end and male end for linkage
- Bottom of window is pressed in first, then top of frame allows window to swing in to latched position



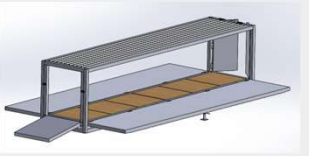
Door Frame
- Made for 3.5'x8' exterior door with laminated glass panes
- Pine wood frame for weight and durability
- Designed for taller side of home
- Stands on floor to be built around
- Has male and female ends for linkage with blocks

Deployment and Assembly

House Jack
- Height range of 12" to 19"
- 10" by 10" platform on top and bottom
- Easy twist motion to change heights under load
- 10 total bolted into shipping container, 3 on each wall and 4 on frame
- Factor of safety of 5 each

Mobile Sky Hook
- Boom max height of 10' 1"
- Boom length max of 3' 10"
- Capable of lifting 1000 lbs.
- Wheels for mobility

Shipping Container
- Walls fold down to become flooring for housing
- Front folds down to become ramp for accessibility
- Ramp angles range from 7 to 12 degrees
- Septic tank and water tank underneath flooring welded to frame, 395 gallons each
- Door hinges used to connect frame to walls and allow them to move into place while being flush against the floor
- Corten Steel material
- Barrell bolt latches for ramp and rear doors
- Taken off tractor trailer truck by forklift



Next Steps

- Incorporating curved pieces into design to allow for unique structures and reconfigurability
- Determine logistics of multiple structures per container
- Incorporating medical and communication buildings
- Design more building layouts using same building block designs
- Conduct further concrete 3D printing experiments on new tool paths and concrete curing techniques

90-Degree building block

45-Degree building block