Detecting Defects and Deformation of Cellular Lightweight Concrete Masonry through Mining Point-Cloud Data

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INTRODUCTION

Objective

- 420 million hectares of forests lost since 1990 [1]
  - 37% of this was lost for timber harvesting [2]
  - Although forests are traditionally thought of as carbon sinks, they can release even more carbon into the atmosphere when cut down.
- Lumber and wood framing susceptible to
  - -Water damage
  - -Fire
  - -Insects and rodents
  - -Low thermal conductivity
- Our goal is to effectively create a concrete that can replace timber as a main residential construction material, therefore eliminating the issues listed.
- This concrete would not only be lighter, more durable, and less prone to environmental wear, but it would also act as a carbon sink, neutralizing CO2 emissions from its own cement production. This out of concern of cement production contributing to 3.45% of global CO2 emissions. [3], a number that will only continue to increase.
- My objective is to better understand the transformations under shear and normal stresses of these blocks in three dimensions. This includes using 3D point data to accurately capture its behavior.

Approach

- Blocks developed by CLC Global. UWM is assisting in the commercialization of this block by conducting multiple tests and analyses.
- Creating a light concrete block
  - -Concrete "foam" called cellular lightweight concrete (CLC)
  - -Open pores in the blocks to create ability to be lightweight.
  - -These pores can be filled with CO2 they create, making them a carbon sink
  - -Want to create a concrete block that could rival the weight of timber
- Production of a concrete block roughly 1/3 the weight of normal unit weight of 150lbs/cubic foot.
- Must be easily stackable
  - -Mortar-less masonry installation
  - - Creates a much more efficient brick laying process (10x the speed of traditional brick- laying)

Image of AIMU blocks made of CLC and stacked to show interlocking capabilities for zero lateral movement.

AIMUs stacked to resemble real-world use for a wall.

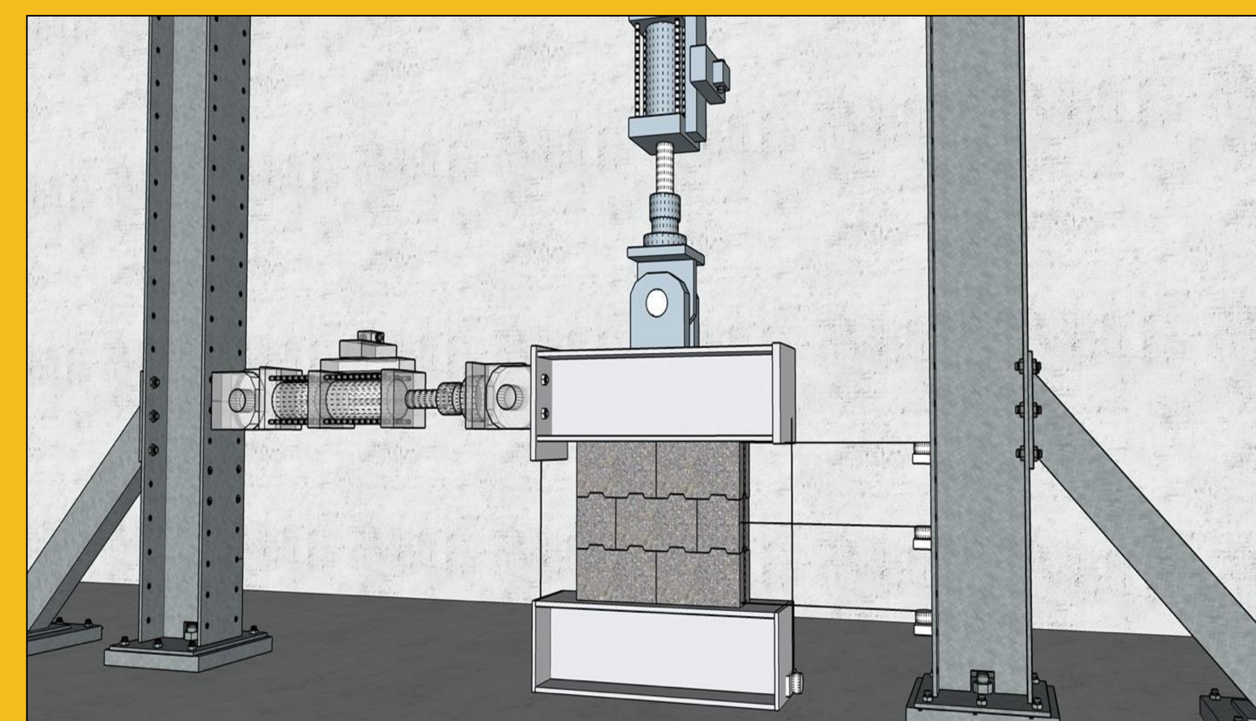

Figure 1: Test of dry-stackable AIMU blocks for local crushing properties using two flat top and bottom blocks, with two regular blocks in the center.

METHODOLOGY

- Research of this project includes five separate research tasks, my research is focused on tasks 3 and 4.
- Since the AIMU (Aerated Interlocking Masonry Units) blocks are so light, they have a compressive strength of around 500psi. The low strengths allow local crushing in placing blocks such that the blocks do not have to be precise. My first task is to identify the dimension variation of AIMU blocks from the design.
- To obtain an initial idea of dimensional variation of lab-created blocks in comparison with an ideal block, I need to overlay a 3D image of a scanned block over a 3D image of a block of perfect geometry.
- Tasks 3 and 4 involves investigating properties of AIMU blocks under compression and shear. We would like to know how the blocks initiate and develop damage. Traditional sensors do not work well because of the low strength material. We plan to use a EinScan 2X Pro laser scanner during the tests and my goal is to develop algorithms to process the 3D laser scanned data (5 million points per block currently and the resolution can be higher).
  - - Every one of these points contains coordinates in the x, y, and z axis
  - -My goal is to track this point-cloud data as it moves in each axis as the AIMU block undergoes deformation
- To accurately test these properties, Professor Zhao and myself will be developing a code for 3D laser scanners that are able to detect deformation as it occurs. This gives a better understanding of how the block will behave with other blocks stacked on or below it.
- AIMU blocks will be stuck together using a glue mortar that is 0.0x in. thick, where x depends upon my research on the geometry variations.
- Deformation during tests can be localized to a few inches or specimen wide. This is the challenge my research will tackle

PROGRESSES

- Tested AIMU's for useability in the lab
- 3D scanning of AIMU blocks
- These dimension variations can be seen in both Figures 2 and 3 of my results. The red part of the block represents the 3D model creates while the green color displays a scanned block created in the lab.
- MeshLab program used to study scans as well as overlays.
- Testing MATLAB program for usability of writing program to detect surface deformations

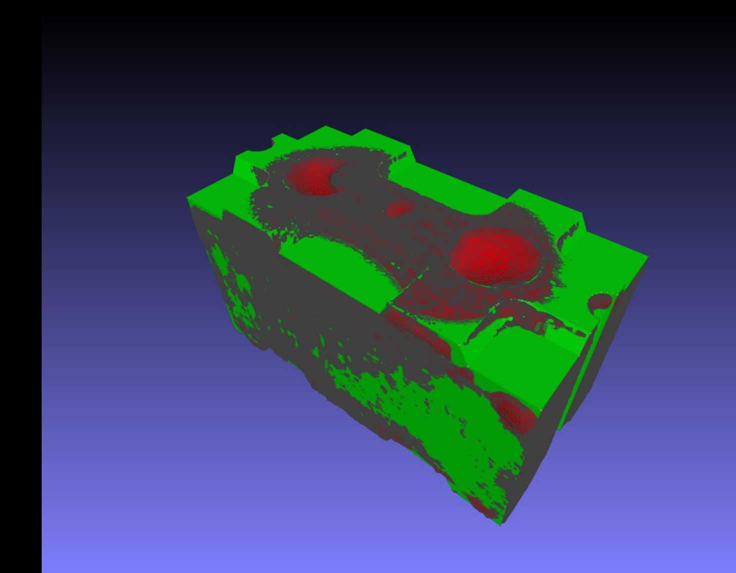

Figure 2

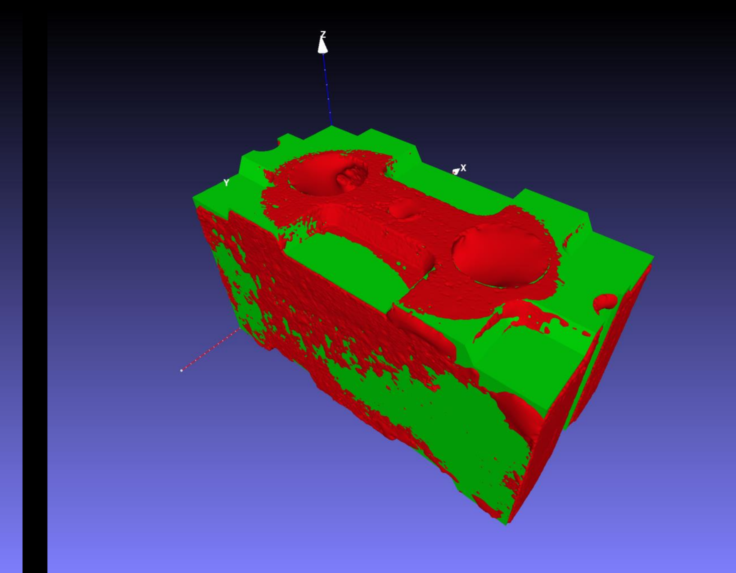

Figure 3

Summary

The concrete foam AIMU blocks have been designed, developed, tested and are proven to be an effective alternative to heavy, traditional concrete masonry. With the initial scans of the AIMU block almost complete, we can use them as a model to compare to real AIMU blocks being produced. A code developed will be able to detect surface deformations from loading and give feedback as to where a deformation of 0.0x in. occurs. This benchmark of 0.0x in. is crucial for being able to properly lay the adherent on the top of each block to ensure it stays secure with the block above it. Not only would the production of AIMU blocks produce a stronger, weather resistant alternative to wood, but it would also provide a carbon-neutral alternative by filling the voids of these blocks with CO2 produced in its cement production.

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