Designing Modular Bioreactor Garden Containers

Team 5-1

Zoe Cadman, Rowan Fitzgerald, Melissa Guillen, Avanti Prabakaran

DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING

A. JAMES CLARK SCHOOL OF ENGINEERING

Problem Definition

- The non-profit organization, Ridge to Reefs, builds **bioreactor gardens** to treat septic tank effluent for homes in coastal regions.
- The gardens are built in place with a plastic liner and filled with media.

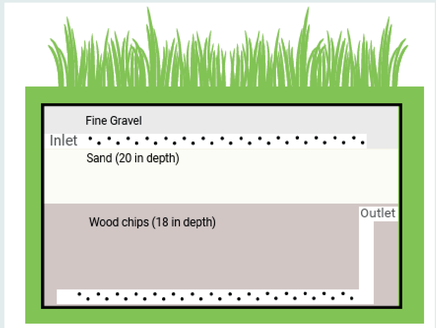


Figure 1: Cross-sectional view of bioreactor garden

- Creating a container can simplify the construction process, make the design **modular and scalable** for water use, and reduce flooding concerns.

Our Goal: Find a balance between strength and weight in mortar mix for interlocked container panels.

Design Method

- Perlite: volcanic glass that greatly reduces concrete weight
- Biochar: sustainable material that can reduce cement amount
  - Each designed mix had a high amount of either perlite or biochar to test their effects
  - Stackable, modular panel design to make scalability easier for larger or smaller water uses
    - Fits together with rebar going through the joints
  - Basalt fibers act as lightweight and uniform tensile reinforcement while avoiding corrosion

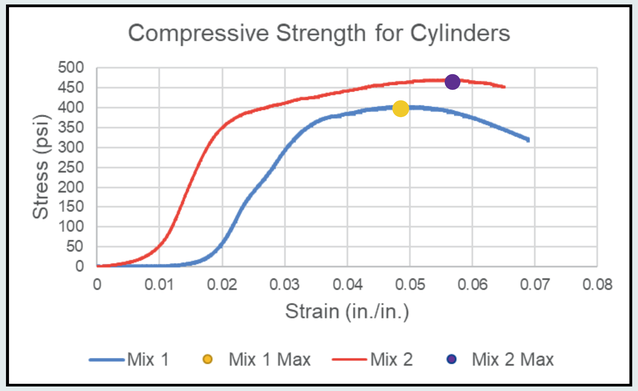
Final Concrete Mix Ratios:

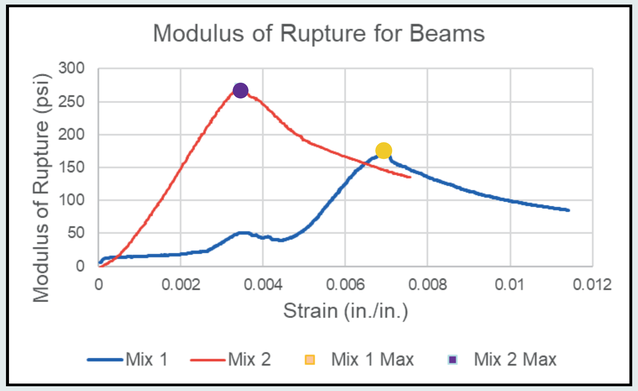
Mix #	Portland Cement	Sand	Biochar	Perlite	Basalt Fiber	Pozzolan Ash
1	1 part	2 parts	1 part	0.5 parts	2% by volume	0 parts
2	1 part	0.5 parts	0.1 parts	2 parts	3% by cement weight	0.25 parts

Test Results

Destructive Tests:

- ASTM D790 - Beam 3-Point Loading
- ASTM C39/C39M - Cylinder Compression Test





Non-Destructive Tests on Panels:

- ASTM C 805 - Rebound Hammer Test
- ASTM C597-22 - Ultrasonic Pulse Velocity

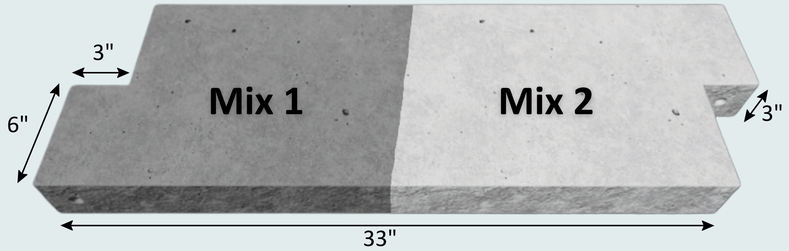
Non-Destructive Test Results:

Mix #	Average Hammer Rebound (R)	Average UPV (km/s)
1	29.7778	3.091
2	20.6667	2.9995

Medium mortar quality range 3-3.5 km/s

Higher R indicates harder surface resistance

Model



- More biochar
- 111.6 pcf
- Elastic Modulus: 25 ksi
- Dynamic Modulus: 2611 ksi
- 170 psi flexural strength @0.006 in

- More perlite
- 92.2 pcf
- Elastic Modulus: 37 ksi
- Dynamic Modulus: 2410 ksi
- 270 psi flexural strength @0.003 in

- The entire container wall system can be built of the same panel shape, maintaining modularity.
- Panels can be interlocked horizontally without limit, vertically with a recommended limit of 3 panels.

Final Design Recommendations

Increase Mold Durability

- Mass production of panels will require more durable molds
  - Moisture in curing concrete caused warping in wood
  - Aluminum or plastic molds are recommended

Consider Mix 2 Ratios

- High quantities of biochar significantly reduce strength
- Perlite allows for lightweight mortar, which meets RTR goals
- High concentration of basalt fibers and pozzolan ash allow for 15% more compressive strength

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