Alternative Concrete Masonry Unit

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Figure 1: Faswall Green Building System [1]

1.1 Research Goals

Objective

- Develop an insulated, dry-stacked modular block made from local materials (e.g. small diameter timber, cinders).

Criteria

- Insulation value of R-10 while meeting the minimum strength of 1900 psi based upon ASTM C90 [3]. Additionally the block will need to meet all modern design demands of building construction.

Figure 2: Fly Ash Bricks [2]

1.2 Background Research

Current Alternatives

- Insulated modular blocks made with wood fiber aggregate are limited.
- Not structural and simply act as formwork intended to support the hydraulic pressure of grout.
- High costs due to unavailability of necessary materials.

Figure 3: Dry Stacked Interlocking System [4]

1.3 Stakeholders

- Client: Dr. Robin Tuchscherer
- Local logging companies
- Local Brick Manufacturers

Figure 4: Logging Operation [4]

Figure 5: Block Lite Manufacturing [6]

2.1 Material Study

2.1.1 Establish Baseline

Baseline

- Collect existing concrete mixes in order to create a baseline for further design mixes that will optimize wood fiber aggregate.

Materials

- Quikrete, Rapid Set, and Sika concrete mixes will be obtained to set the baseline.

Analysis

- A compressive strength test will be conducted on the known concrete mixes following the procedure outlined in ASTM C140.

Figure 6: Quikrete [8]

2.1 Material Study

2.1.2 Small Diameter Timber Analysis

Method

- Meeting with a timber scientist to determine the process that the small diameter timber must undergo prior to be being used in a concrete mix.

Figure 7: Small Diameter Timber [8]

2.2 Prototyping

2.2.1 Material Collection

Collection

- Ribelin Logging Company located in Flagstaff, Arizona.
- Cinders will be collected on site at Cinder Hills OHV area located in the Coconino National Forest 13 miles northeast of downtown Flagstaff [8].

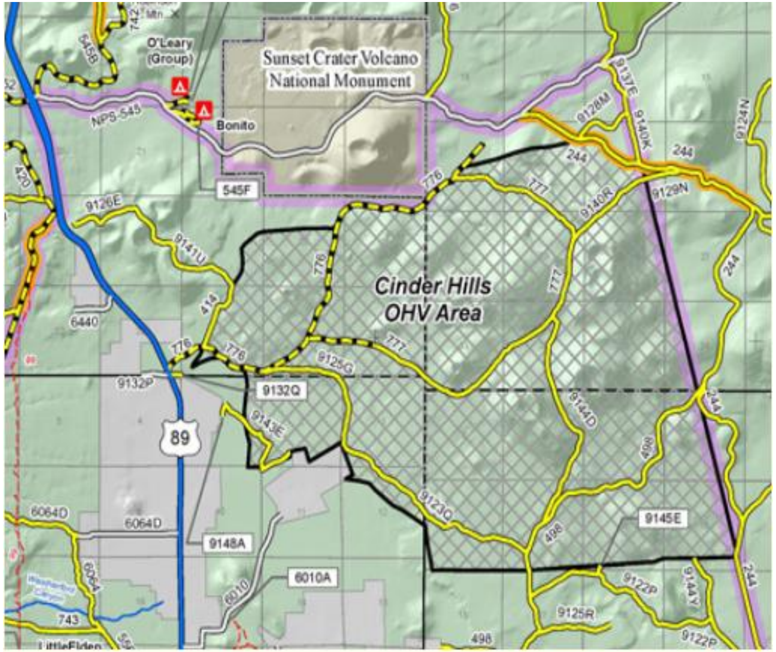


Figure 8: Collection Site [8]

2.2 Prototyping

2.2.2 Design

Production

- A total of 48 prototypes will be constructed out of three different mix ratios.

Dimensions

- Prototypes will be right circular cylinders measuring 8” in height and 4” in diameter [9].

Figure 9: Square Rectangular Concrete Mold [10]

2.3 Product Testing

2.3.1 Embodied Energy Study

- An embodied energy study will be completed in order to define the insulative properties of the prototypes.
- The team will meet with Alan Francis a professor at NAU to discuss the appropriate insulative test required.

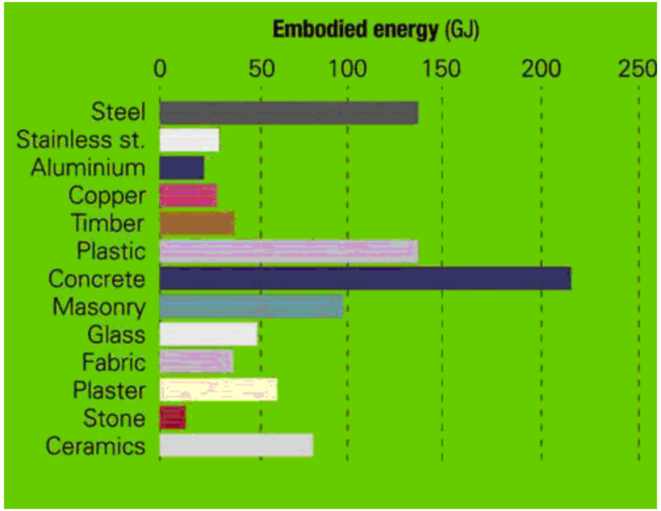


Figure 10: Embodied Energy [11]

2.3 Product Testing

2.3.2 Compressive Strength (ASTM C39)

Definition

- Determines the compressive strength of cylindrical concrete specimens.

Method

- The test method consists of applying a compressive axial load to molded cylinders until failure occurs [12].

Analysis

- Compressive strength is then calculated by dividing the maximum load by the cross sectional area of the prototype.

Figure 11: Compressive Strength Test [13]

2.3 Product Testing

2.3.3 Tensile Strength (ASTM C496)

Definition

- Determines the splitting tensile strength of cylindrical concrete specimens.

Method

- Apply a diametral compressive force along the length of a cylindrical concrete specimen until failure occurs [15].

Analysis

- Maximum load sustained by the specimen is divided by appropriate geometrical factors to obtain the splitting tensile strength [15].

Figure 12: Tensile Strength Test [14]

2.3 Product Testing

2.3.4 Freeze Thaw (ASTM 666)

Definition

- Determines the resistance of concrete specimens to rapidly repeated cycles of freezing and thawing.

Method

- The cylinders will be subjected to 5-8 freeze thaw cycles per day with a total of 300 cycles at the conclusion of the freeze-thaw test [16].

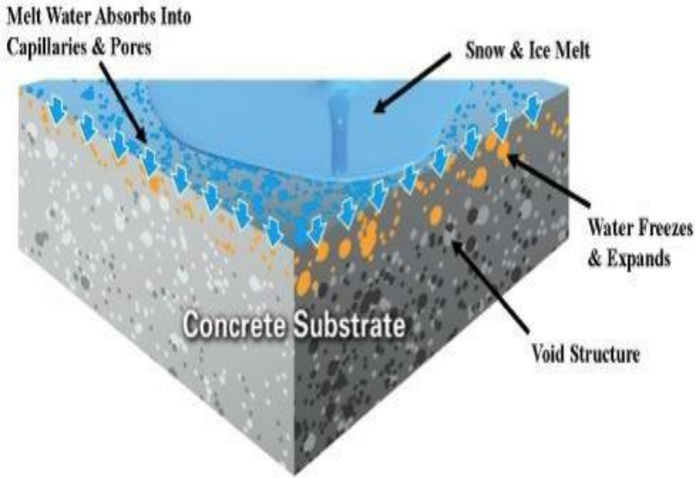


Figure 13: Tensile Strength Test [17]

2.4 Feasibility Study

2.4.1 Block Lite Tour

- Touring a local brick manufacture to further understand the processes that go into mass producing modular blocks.

Figure 14: Block Lite [6]

2.4.2 Current Production Methods

- Examine current modular block production that is using wood fiber as an aggregate.

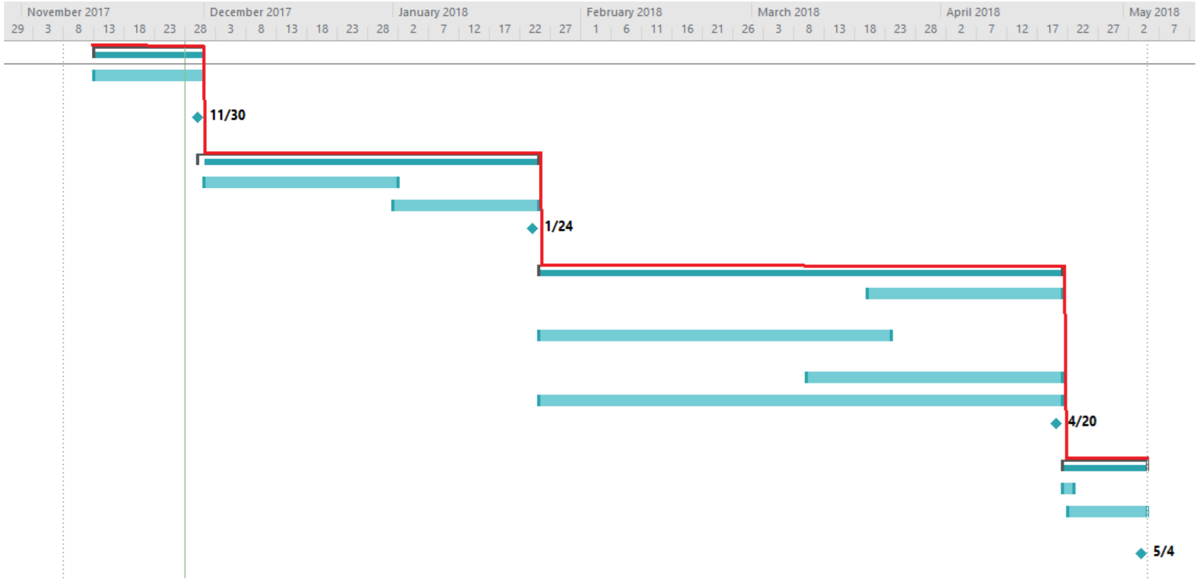
Figure 15: Nitterhouse Masonry [18]

3.1 Research Schedule

Table 1: Project Tasks

Material Study	**14 days**	**Mon 11/13/17**	**Thu 11/30/17**
Small Diameter Timber Analysis	14 days	Mon 11/13/17	Thu 11/30/17
Material Study Complete	0 days	Thu 11/30/17	Thu 11/30/17
Prototyping	**40 days**	**Thu 11/30/17**	**Wed 1/24/18**
Material Collection	22 days	Fri 12/1/17	Mon 1/1/18
Design	18 days	Mon 1/1/18	Wed 1/24/18
Prototyping Complete	0 days	Wed 1/24/18	Wed 1/24/18
Product Testing	**62 days**	**Thu 1/25/18**	**Fri 4/20/18**
Embodied Energy Study	24 days	Tue 3/20/18	Fri 4/20/18
Compressive Strength	42 days	Thu 1/25/18	Fri 3/23/18
Tensile Strength	31 days	Sat 3/10/18	Fri 4/20/18
Freeze-Thaw	62 days	Thu 1/25/18	Fri 4/20/18
Product Testing Complete	0 days	Fri 4/20/18	Fri 4/20/18
Feasibility Study	**11 days**	**Sat 4/21/18**	**Fri 5/4/18**
Block Lite Tour	2 days	Sat 4/21/18	Sun 4/22/18
Current Available Options	11 days	Sun 4/22/18	Fri 5/4/18
Feasibility Study Complete	**0 days**	**Fri 5/4/18**	**Fri 5/4/18**
Total Length of Project	**125 days**	**Mon 11/13/17**	**Fri 5/4/18**

Table 2: Gantt Chart



3.2 Staffing

Table 3: Project Staffing

	Research Manager (RM)	Research Engineer (RE)	Lab Technician (LT)
Task	Time (hrs)		
2.1.1 Small Diameter Timber Analysis	10	25	0
2.2.1 Material Collection	12	32	0
2.2.2 Design	60	30	0
2.3.1 Embodied Energy Study	10	15	35
2.3.2 Compressive Strength	10	25	50
2.3.3 Tensile Strength	10	25	40
2.3.4 Freeze Thaw	10	30	60
2.4.1 Block Lite Tour	8	8	0
2.4.2 Current Available Options	10	15	0
Total Hours:	140	205	185
		Total:	530

4.0 Cost of Engineering Services

Table 4: Cost of Engineering Services

Cost of Engineering Services				
	Personnel	Hours (hrs)	Base Pay ($/hr)*	Cost ($)
	RM	140	$150.00	$21,000.00
	RE	205	$90.00	$18,450.00
	LT	185	$60.00	$11,100.00
			Total:	$50,550.00
Equipment			Total:	$600.00
Travel			Total:	$25.00
			Total:	$51,175.00
*All base pay rates include overhead and benefits				

5.0 Project Limitations

5.1 Challenges

- Brick manufactures do not typically post their mix ratios for the general public.
- At most they will share their water cement ratio , but other than that obtaining information will need to be obtained via guided tour.
- Limited data on eco dry stacked modular bricks of having sufficient structural properties as well as having a correct R-value of 10

5.2 Exclusions

- Refrain from doing an environmental assessment of the proposed design mix.
- Refrain from doing any research in regards to available materials in any other location other than Flagstaff.

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[9] ASTM C470 / C470M-15, Standard Specification for Molds for Forming Concrete Test Cylinders Vertically, ASTM International, West Conshohocken, PA, 2015, www.astm.org

[10] Concrete Tests, http://stickstoneswater.blogspot.com/2011/11/tests-on-concrete-compressive-strength.html [Accessed: 27-Nov-2017]

[11] Embodied Energy, http://www.yourhome.gov.au/materials/embodied-energy [Accessed: 26-Nov-2017]

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[15] ASTM C496 / C496M-17, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens, ASTM International, West Conshohocken, PA, 2017, www.astm.org

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[16] ASTM C666 / C666M-15, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing, ASTM International, West Conshohocken, PA, 2015, www.astm.org

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