NORTHERN ARIZONA UNIVERSITY

Alternative Concrete Masonry Unit

60% Design Report

CENE 486

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Tables & Figures

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Acknowledgements

The team would like to express their appreciation to all of those who were involved during our research and development efforts.We are particularly grateful for the assistance given by Dr. Robin Tuchscherer, Mr. Robert Morgan and Dr. Dianne McDonnell who gave us guidance and advice throughout the course of the project. Additionally a special thanks to the company Block-Lite for providing our team with materials required for our baseline mix.

1.0 Project Introduction

1.1 Alternative Concrete Masonry Unit

The purpose for this research project is to create an alternative building block. The alternative building product will be a dry stacked, insulated, load bearing modular block that is composed from local materials such as cinders and cement as well as local waste products such as small diameter timber. This new alternative building product is to be constructed in order that it reaches a minimum insulation value of R-10 in addition to meeting all of the necessary strength requirements.

1.2 Project Justification

In the current market insulated modular blocks made with wood fiber aggregate are limited. The blocks that are available are not structural and simply act as formwork intended to support the hydraulic pressure of grout. Additionally due to costs the availability of current blocks relies heavily on regional availability of the necessary materials. The environmental impacts of using concrete can be reduced by using a greener alternative option within its mix. The world's yearly cement production of 1.6 billion tons accounts for about 7% of the global loading of carbon dioxide into the atmosphere [1].

1.3 Constraints & Limitations

The constraints of the research project is that the concrete masonry unit (CMU) must obtain an insulation value of at least R-10, a compressive strength of 1900 psi as well as meeting all demands of modern building construction. Additionally the CMU will be constructed strictly out of materials that have been gathered from the Flagstaff area.

1.4 Objectives

The objective of the research is to develop an alternative to the markets dry stacked modular block by developing a mix that is made out of materials local to flagstaff such as small diameter timber that is left from logging companies as well as the cinders that are present within the Flagstaff area. Another objective is to assure that the designed modular block meets the minimum strength requirement and can be mass produced within a local factory.

2.0 Technical Research

2.1 Field Work

2.1.1 Material Collection

One of the main objectives of the project is to incorporate local waste material when designing a concrete masonry unit. Due to this design constraint, all material that will be used in the CMU's concrete mix was collected locally to Flagstaff, AZ. Fine cinder was collected on-site at Cinder Hill OHV area located 13 miles northeast of downtown Flagstaff. Approximately 5.34 cubic feet of fine cinder was collected from the area. Fine cinder was considered to be anything that passed through a ⅜" sieve. After the completion of the sieve analysis a total of 3 cubic feet of fine cinder was collected to be used in the concrete mix. Block-Lite is a local masonry company that constructs and sells concrete modular blocks to be used in construction and landscaping. Block-Lite was generous enough to donate the other raw materials that were needed in the concrete mix. Raw materials that were collected from Block-Lite include, 8 cubic feet of construction sand, 3 cubic feet of course cinder, and a single bag of portland cement having a unit weight of 94 lbs/ft^3. Course cinder is considered anything that is approximately ⅜" in diameter. Block-Lite had previously sieved all material so the sieving of the course cinder was not necessary. Small diameter timber was considered to be anything under 2" in length and 1" in diameter. The small diameter timber was collected from burn piles located near Mt. Elden in Flagstaff, AZ. For the testing phase of the project it will need approximately 160 4"x 8" plastic cylinder molds in order to pour and test the concrete mix designs per ASTM standards. The concrete molds were purchased from Gilson Company Inc. and shipped to Flagstaff, AZ. The plastic cylinders satisfy both the ASTM 192 and ASTM C470 standards.

2.2 Predominate Analysis

2.2.1 Material Study

2.2.1.1 Small Diameter Timber Analysis

Prior to being used within a concrete mix the small diameter timber must go through a mineralization process. "The objective is to impregnate the wood particles to avoid the reactions of the "cement inhibitors" after the mixing process" [2]. In order to accomplish this the small diameter timber was put through a process called the K-X treatment. The K-X treatment is used by Faswall who is a company that creates green building modular blocks using small diameter timber. The ideal size of the small diameter timber is 1/32"-½" in diameter and 3/16"-1 ½" in length [3]. Additionally the small diameter timber must be free from any dirt and dust prior to the treatment. In order to fulfil this criteria the small diameter timber was passed through a ½" sieve in order to eliminate any dirt and dust that may have been collected. After the initial sieve the small diameter timber was then sorted through selecting only the members that fit the treatments criteria. With the small diameter timber prepared the initial phase of the K-X treatment can be started. The first stage of the K-X treatment requires the small diameter timber to soak in an aluminum sulphate-water solution. The solution will close the timbers particle pores and cavities. The aluminium sulphate has “a ratio of 1.5-2% of to the amount of portland cement used in a conventional cement mix and is diluted with 7-8 parts of water. The small diameter wood chips are required to soak for a minimum of 4 minutes and a thorough mixing of the aggregate is important. This second stage of the K-X treatment adds kaolin powder to the original solution. Kaolin is a clay mineral that will mineralize the small diameter timber creating a product that is no longer affected by degradation. The small diameter timber must be evenly coated in the kaolin powder and has a minimum soaking time of 3 minutes with consistent mixing of the aggregate throughout. It is essential that the small diameter timber has a thin even coat of kaolin powder surrounding it’s exterior. With the completion of the second stage the small diameter timber has now been transformed into K-X treated wood chips and can be used within a concrete mix.

2.2.2 Create Baseline

A total of 3 different mix designs will be analyzed for the research project. Each mix design will contain a different percentage of small diameter timber. In order to compare the test results of the created mix designs a baseline mix will be used. Block-Lite was generous enough to share the mix ratio that they currently are using to produce their CMU’s. The three alternative mix designs will be based off of the same ratios.

2.3 Alternatives Pursued

2.3.1 Concrete Mix Design

2.3.1.1 Baseline Mix

The baseline concrete masonry unit mix design was provided by a Flagstaff local brick manufacturer Block Lite. The baseline design mix for their CMU’s was provided to us as a by part volumetric ratio and goes as follows : 3 part sand : 1 part cement : 2 part fine cinder : ½ part water . There will be a total of 40 specimens created with the provided CMU mix from Block-Lite. 10 specimens of will be required for each of the strength tests that will be conducted on all of the concrete masonry unit blocks which include a compressive strength test, a splitting tensile strength test, a freeze-thaw analysis, and an embodied energy study to determine the insulative properties of the mix designs.

2.3.1.2 Design Mix 1

The first proposed mix design is described as by volumetric parts and is as follows : 3 part sand, 1 part cement, 2 part fine cinder, ½ part water with 10% of the coarse cinder be replaced with the petrified wood chips that were treated during the small diameter timber analysis as discussed earlier in this report. There will be a total of 40 specimens created with the provided CMU mix from Block-Lite. 10 specimens of will be required for each of the strength tests that will be conducted on all of the concrete masonry unit blocks which include a compressive strength test, a splitting tensile strength test, a freeze-thaw analysis, and an embodied energy study to determine the insulative properties of the mix designs.

2.3.1.3 Design Mix 2

The second proposed mix design is described as by volumetric parts and is as follows : 3 part sand, 1 part cement, 2 part fine cinder, ½ part water with 15% of the coarse cinder be replaced with the petrified wood chips that were treated during the small diameter timber analysis as discussed earlier in this report. There will be a total of 40 specimens created with the provided CMU mix from Block-Lite. 10 specimens of will be required for each of the strength tests that will be conducted on all of the concrete masonry unit blocks which include a compressive strength test, a splitting tensile strength test, a freeze-thaw analysis, and an embodied energy study to determine the insulative properties of the mix designs.

2.3.1.4 Design Mix 3

The third proposed mix design is described as by volumetric parts and is as follows : 3 part sand, 1 part cement, 2 part fine cinder, ½ part water with 20% of the coarse cinder be replaced with the petrified wood chips that were treated during the small diameter timber analysis as discussed earlier in this report. There will be a total of 40 specimens created with the provided CMU mix from Block-Lite. 10 specimens of will be required for each of the strength tests that will be conducted on all of the concrete masonry unit blocks which include a compressive strength test, a splitting tensile strength test, a freeze-thaw analysis, and an embodied energy study to determine the insulative properties of the mix designs.

2.4 Final Design Recommendations

2.4.1 Product Testing

2.4.1.1 Compressive Strength

[Insert compressive strength data]

2.4.1.2 Tensile Strength

[Insert tensile strength data]

2.4.1.3 Freeze Thaw

[Insert freeze thaw data]

2.4.1.4 Thermal Resistance

[Insert thermal resistance data]

2.4.2 Feasibility Study

2.4.2.1 Block Lite Tour

[Insert tour data]

2.4.2.2 Current Available Options

[Insert available options data]

2.5 Statistical Analysis

[Insert statistical analysis data]

3.0 Summary of Engineering Work

3.1 Discussion of Engineering Work

[Insert discussion of work]

3.2 Original Gantt Chart

[Insert original gantt chart]

3.3 New Gantt Chart

[Insert new gantt chart]

4.0 Summary of Engineering Costs

4.1 Discussion of Engineering Costs

[Insert discussion of costs]

4.2 Original Staffing

[Insert original staffing table]

4.3 New Staffing

[Insert new staffing table]

4.4 Original Engineering Costs

[Insert original costs]

4.5 New Engineering Costs

[Insert new costs]

5.0 Conclusion

[Insert conclusion discussion]

6.0 References

[1] K. Mehta, "Reducing the Environmental Impact of Concrete", 2017. [Online]. Available: http://maquinamole.net/EcoSmartconcrete.com/docs/trmehta01.pdf. [Accessed: 14- Feb- 2018].

[2] H. Walter and L. M. Walter-Gurzeler, “Coated free aggregate usable in wood concrete technology and method of making the same,” 28-May-1991.

7.0 Appendices

[Insert appendices]