

Adobe Brick Construction



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This is the submitted "Proposal" for CENE 476 class, spring 2015, capstone project 1,
"Adobe Brick Construction" in Flagstaff, Arizona.
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1.0 Introduction

Adobe bricks are going to be built up using local cement and soil. The main objective that is going to be done in this project is to have the most suitable adobe brick, which matches all constraints and criteria that are going to be mentioned. In addition, an improvement is going to be done on adobe bricks, which are already available in stores. This project is going to be done in and for a specific area, which is Arizona. Table 1 includes all constraints and criteria for the adobe brick project.

Table 1.1 Constrains and Criteria for each Part of Adobe Brick

	Constraints and Criteria
Project in General	<ul style="list-style-type: none">• Decrease negative impact on the area.• Provide recreational, educational, and aesthetic benefits.• Aesthetically pleasing.• Within budget.• Withstand earthquakes, hurricanes, and rain.• Strong enough to carry a certain amount of load.• Follow Arizona's uniform building code requirements for Adobe Brick.• Follow the standards and regulation for brick construction.
Soil	<ul style="list-style-type: none">• Soil's Materials should be local (Flagstaff, AZ).• Soil's Materials should be Natural 100%.• Soil Kinds that allowable to use, Clay, Sand and Silt.
Cement	<ul style="list-style-type: none">• Use local material (Flagstaff, AZ).• Let the adobe brick meet the building codes of Flagstaff, AZ.• In should be better that the final adobe brick.

2.0 Project Background

The project requires developing strong and durable adobe bricks using local materials in Flagstaff, Arizona. Adobe brick's properties can be improved by applying different adobe brick testing procedures to determine the brick's failure points and the best methods used to avoid having these failure points in the final design. The final adobe brick design should decrease the negative impacts of adobe bricks on the environment by using suitable adobe brick soil content for the location of construction, and should also increase the safety factor of having a design that will support the final structure without collapsing.

2.1 Design Challenge

Designing Adobe brick's that is suitable for Flagstaff, Arizona is challenging especially when trying to meet the following constraints and criteria:

- Use local materials in constructing the Adobe brick.
- Perform Adobe brick testing requirements on both the soil and the brick.
- Figure out the classification of the soil used in constructing the Adobe brick.
- Figure out the water content of the Adobe brick.
- Figuring out the air content of the Adobe brick.
- Figuring out the percent of clay, silt, and sand in the soil used in constructing the Adobe brick.
- Comprehend all possible brick construction methods.
- Perform mix soil design.

2.2 Design constraints and criteria

This research is done to develop a good strategy in constructing suitable Adobe bricks for Flagstaff, Arizona using local material and following Arizona's brick construction uniform building code requirements. The final design should meet the following constraints and criteria:

- Decrease negative impact on the area.
- Provide recreational, educational, and aesthetic benefits.
- Aesthetically pleasing.
- Within budget.
- Withstand earthquakes, hurricanes, and rain.
- Strong enough to carry a certain amount of load.

- Follow Arizona's uniform building code requirements for Adobe Brick.
- Follow the standards and regulation for brick construction.
- Soil Materials should be local (Flagstaff, AZ).
- Soil Materials should be 100% Natural.

2.3 Stakeholders

Adobe bricks are a solution for different housing issues. People living in houses made of adobe bricks are most affected by this project, so are the stakeholders of this project. There are different stakeholders for this project such as the employer housing, social housing builders, private rental Marketers, house consumers, Coconino County, International Building Code (IBC), and the Structural Engineering Institute (SEI). The stakeholders take on consideration of this project mostly because of the building construction and structure. Adobe bricks creation must follow the building codes and methods to be a well-designed product for the stakeholder's clients.

3.0 Team Qualification

3.1 Team Leader: Zahra'a Alqallaf

Zahra'a Alqallaf is a senior civil engineering student from Kuwait and is currently a student at Northern Arizona University, located in Flagstaff, Arizona. Zahra'a's academic career gave her experience in surveying, Hydraulic analysis, Geotechnical soil testing, project management, and technical writing which provided her with enough experience in writing a technical proposal for adobe brick design.

3.2 Team Supervisor: Hawra'a Farman

Hawra'a Farman is a senior civil engineering student from Kuwait and is currently a student at Northern Arizona University, located in Flagstaff, Arizona. Hawra'a took several classes that increased her geotechnical background information, which will help her to work on this adobe brick project. She also has an inventor degree from Kuwait scientific center on 2009 in a project that might help her to have more information about this adobe brick project.

3.3 Design Specialist: Zahra'a Alhusaini

Zahra'a Alhusaini is a senior civil engineering student from Kuwait and is currently a student at Northern Arizona University, located in Flagstaff, Arizona. Zahra'a has several

background information regarding this adobe construction process, since she had courses related to the project such as chemistry, geotechnical engineering 1 and 2, which provided her with enough experience in soil testing to guide her in performing necessary brick testing procedures.

4.0 Scope of Service

This section includes all the primary deliverables required to complete the project and meet the client's goals. Properly addressing the scope is necessary to minimize possible confusion or misunderstanding between the client and the consultant on the final deliverables of the project.

Task 1: Preparatory Research

Conducting a preparatory research is a necessity to fully understand the project and its deliverables, and as a result will facilitate the project design and construction process by analyzing the pertinent work of other investigators leading up to the final proposed work.

Task 1.1 Background Research

This section services several purposes to help clarify any confusing regarding any parts of the project. The background research evaluates the consultant understanding of the deliverables, states any confusing regarding the pertinent work of other investigators regarding the project, and clarifies the consultant proposed work on what needs to be done to complete the final objectives of the project. This proposal will focus on explaining the necessary tasks required to design a strong adobe brick suitable for Flagstaff, Arizona.

Task 2: Professional Consultation

Seeking consultation from a more experienced person in the project field of study is necessary to gain proper guidance on how to approach each requirement regarding the final proposal. And is also necessary to clarify any misunderstanding concerning the final project.

Task 3: Soil Analysis

The soil that will be used for this project will consist of sand, clay and silt. However, before mixing there are several steps that have to be completed to get a good amount of

clear sand, clay, and silt. The percentage for soil that should be added to the entire mixture equals 25-30%.

- A good amount of local soil will be obtained.
- Large particles or impurities (rocks, plant, etc.) will be taken out of the soil.
- 25-30% of the adobe brick mixture will be soil.

Task 3.1 Atterberg limit test:

The Atterberg limit test will be done to determine the water content in the soils. The soil may include a percent of water that will affect the Brick's behavior after designing the brick and may causes failure.

Task 3.1.1 Liquid Limit List

Liquid limit test is a necessary test that will be performed to determine the moisture content of the adobe brick soil content.

Task 3.2 Efflorescence test

This test will be conducted to determine the brick's quality by determining the presence of Alkalis in the bricks that could cause white layers and cracks from the adsorption of water in the soil.

Task 3.3 Sieve Analysis

This test will be conducted to identify the soil types from the particle size distribution that passes through sieves during the test and as a result will determine the desired soils that will be used in the adobe brick mixture. The soils passing #200 will be classified as clay and the soils passing #4 sieves will be classified as sand and gravel.

Task 4: Cement Analysis

The type of cement that is going to be used for this adobe brick project will be chosen depending on constraints and criteria mentioned in the background information section.

Cement will mixed with water and poured into a mold to have a specific shape for the adobe brick. There will be percentage for each item included in the adobe brick and

adobe brick mixture will have 60-70% of cement. Soil will also be in that mixture as mentioned in this report.

Task 5: Brick Testing

Brick testing is necessary for evaluating the quality of the brick in general and the quality of the soil used in constructing the brick. Geotechnical engineers came up with various testing procedures that could define and describe the soil's behavior. The following are some of the major geotechnical testing required for constructing the adobe brick.

Task 5.1 Hardness and Soundness Test

This test is done to observe the sound of the bricks to determine if it's a good quality brick and hard to stand for long time to stand different weather conditions.

Task 5.2 Size, Shape, and Color Test

The shape, size and color test of the bricks will be done to meets the standards and regulations of the building codes for Adobe bricks.

Task 5.3 Structure Test

Structure test will be done on the bricks to determine the errors and poor points in the bricks after molding. Considering the cracks and holes to prevent collapsing and failures in the building.

Task 5.4 Compressive Strength Test

Measure the pressure and forces that the bricks withstand after building from different materials. This test is conducted by taking the average compressive strength results of the five bricks. Also this helps to prevent collapsing due to the heavy load that the bricks can't stand.

Task 5.4.1 Compression Test Results between Different Materials:

Compression test between different types of soils in Table 5.7. The table shows the results of cement Adobe bricks having the highest score of dry compression and wet compression test which it's more suitable for the building.

Task 5.5 Uniform Building Code Requirements

Most counties across the United States follow the Uniform Building Code requirements, and many leading institutions will not finance dwellings that do not comply with the code. A summary of the uniform building code requirements for adobe brick are shown below.

- The clay content of the soil used in producing adobe bricks must be greater than 25% and less than 45%.
- Bricks will be designed to be stabilized with emulsified asphalt and shall not absorb more than 2.5% water by weight (based on the dry weight of the adobe brick).
- Bricks shall not have more than three shrinkage cracks. No shrinkage crack shall exceed 3 inches (7.6cm.) in length or be more than 1/4 inch (0.6 cm.) wide.
- The minimum compressive strength acceptable is 300 pounds (136.1 kg.) per square inch (6.5 sq. cm.)
- The average modulus of rupture for five bricks must be 50 pounds (22.7 kg.) per square inch (6.5 sq.cm.), with no one individual brick testing out less than 35 pounds (15.8 kg.) per square inch (6.5sq.cm.).

Task 6: Brick Development Process

Designing suitable adobe bricks for Flagstaff, Arizona's environment is one of the main tasks required to complete the objectives of this project. The brick design process can be illustrated in the following points. The team will develop the adobe brick according to the following design process.

- The team will select a good site in flagstaff, AZ that is near a suitable soil and has a large level area for drying and curing the bricks.
- The team will dig a pit about 2 feet deep and of any Convenient size. Then the pit will be soaked thoroughly for 12 hours.
- The soil will be placed in the pit and enough water will be added while mixing.
- The mixture will be transported to a drying area, which will be sprinkled with sand to prevent the wet blocks from binding to the surface of the drying area.
- The team will wet the forms thoroughly and Fill them with the mix and compact the corners thoroughly with a straight edge.
- The team will strike off the forms and remove the bricks from the forms, leaving the wet adobe bricks to dry for several days before handling.
- The team will wash and reuse the forms immediately, without disturbing the bricks.

This process will be repeated several times to have more than one sample of brick for testing.

Task 8: Project Management

Task 8.1 Development Process

The brick development process is an important part of the project that displays the overall team's efforts in meeting all the requirements of the final project to the client. The design process will include all the performed soil and brick testing, cement testing, Adobe brick design method, and the uniform building code requirements of Flagstaff, Arizona.

Task 8.2 Team Meetings

Team meetings are held every week to discuss the team's progress in meeting every upcoming deliverable for this class. Team meetings are also held to discuss any feedback provided by the instructor or technical advisor regarding any aspect of the project. Team meetings are important tools for managing team tasks and productivity.

Task 8.3 Final Report

The final proposal is the main deliverable for this project. It includes the Background research, Scope, estimated project schedule, and cost analysis.

Task 8.4 Final Presentation

The final presentation is an important task that needs to be completed in order to gain the client's attention and approval of the project, where the team is required to prepare a short presentation to their client that describes their overall Adobe brick background research, scope, deliverables, project estimated schedule, and the cost analysis of the project.

Task 8.5 Project Website

Designing a project website is one of the deliverables of this project. An effective website should fulfill some key elements to grab the client's attention which are appearance, content, functionality, and usability.

Task 8.6 Project Schedule

The schedule for this project will be illustrated as a Gantt chart as shown in the appendices part. The Gantt chart will include all the task that needs to be completed to develop the adobe brick, time line, dependencies, critical path, which is the path that the team will follow to complete each task and present their final deliverables. The schedule time length is between the end of January 2015 and the end of December 2015

5.0 Exclusions

The Team shall not analyze or study the items below due to the given time length to complete the project deliverables.

- Cement types.
- Soil Types.
- Multiple sites for soil content.
- Load Path.
- Constructing a building out of the designed adobe brick.

6.0 Broader Impacts

Broader impact describes the environmental, health, and economic impacts of the Adobe brick design. The materials will be used from the earth should bricks testing method has simple techniques that does not have major impacts on the environment. Increase the factor of safety by considering the safety processes for building and the brick building code requirement for more professional design. The adobe brick construction method and design will produce healthy living environment and maintain indoor air quality. The adobe brick design should be affordable and have a reasonable cost for the clients

7.0 Costs and Staffing

This section discusses the project's cost analysis. Table 1 shows the project's staff classification for the adobe brick project and what their codes are. Table 2 shows the number of hours required to complete each task in order to complete the project's objectives. From table 2 the total hours to complete the entire project was found to be 476 hours and the total staff cost for entire project duration was found to be \$45,656 .Then the total project equipment cost was found to be \$ 16380 as shown in table 3.And by summing the cost of the staff and equipment, the final cost for the entire project was found to be \$62,036. Table, 2, 3 and 4 are provided under the appendix.

7.0 References

"7 Test to Justify Brick Quality | A Civil Engineer." *A Civil Engineer*. N.p., n.d. Web. 19 Jan. 2015.

***ABCs of Making Adobe Bricks* (n.d.): n. pag. Web. 17 Jan. 2015.**

Adobe Brick, Mortar and Clay Plaster Mix, Tucson Arizona. N.p., n.d. Web. 19 Jan. 2015.

"Articles." *Good Website Characteristics*. N.p., n.d. Web. 28 Feb. 2015.

"Brick History." *Brick History*. N.p., n.d. Web. 1 Feb. 2015. "Soil Mechanics & Foundations." *Lecture 3.1*. 15-20, n.d. Web. 17 Feb. 2015.

"Clay Mine Adobe: Mud Adobe Brick, Mortar and Clay Plaster Mix, Tucson Arizona." *Clay Mine Adobe: Mud*

"Leadership Lesson: Tools for Effective Team Meetings - How I Learned to Stop Worrying and Love My Team - Faculty Vitae - Group on Faculty Affairs (GFA) - Member Center - AAMC." *Leadership Lesson: Tools for Effective Team Meetings - How I Learned to Stop Worrying and Love My Team - Faculty Vitae - Group on Faculty Affairs (GFA) - Member Center - AAMC*. N.p., n.d. Web. 28 Feb. 2015.

Limits, Soil Consistency Atterberg, and Ch. 3. (Das. CE 240 Soil Mechanics & Foundations Lecture 3.1 (n.d.): n. pag. Web. 24 Feb. 2015. The, This Section Is Like. BACKGROUND OF THE PROBLEM SECTION WHAT DO YOU NEED TO CONSIDER? (n.d.): n. pag. Web. 27 Feb. 2015.

"Making Adobe Bricks." *Mother Earth News*. N.p., n.d. Web. 17 Jan. 2015.

Padavic. *Resurrection: Rammed Earth Construction* (n.d.): n. pag. Web. 21 Jan. 2015.

National Parks Service. U.S. Department of the Interior, n.d. Web. 24 Jan. 2015.

"Rammed Earth." *Admin_666*. N.p., n.d. Web. 17 Jan. 2015.

United States. National Park Service. "Preservation Brief 5: Preservation of Historic Adobe Buildings."

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Table 8.1. Staff classification and their codes

Classification	Code
Senior Engineer	SE
Engineer	E
Lab Technician	I.T
Administrative Assistance	A.A

Table 8.2. Staff time calculations

Task No.	Task	S.E Hours	E Hours	L.T Hours	A.A Hours	Total Staff Hours
1	Preparatory Research	20	20	0	0	40
1.1	Background Research	20	20	0	0	40
2	Professional Consultation	16	10	7	0	33
3	Soil analysis	16	20	45	17	98
4	Cement Analysis	10	20	17	20	67
5	Soil And Brick Testing	14	15	45	32	106
6	Project Management	30	35	32	35	132
6.1	Construction Process	20	25	26	30	101
6.2	Team Meetings	10	10	6	5	31
	Total Hours	106	120	146	104	

Table 8.3. Equipment cost

Equipment	Total Cost
Wood Forms	2800
Soil Series	490
Mixing Tool	1680
Lab Rent	9800
Soil Testing	1610
Total	16380

Table 8.4. Adobe brick project cost

Project Requirements	Cost
Staff	\$45,656
Equipment	\$16,380
Total	\$62,036