A LIGHTWEIGHT FAST DRYING ADOBE BRICK

by

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Approved by:

L. Dale Webb, PH.D.

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ABSTRACT

Adobe is the world's oldest and most commonly used building material. This is no coincidence. Adobe is universally available, inexpensive, durable and aesthetically pleasing. Modern material science should not overlook this vernacular material, but should use engineering techniques to improve and document it.

Adobe is often thought of as being suited only to desert environments. This need not be the case. Adobe bricks that are stabilized with asphalt emulsion or portland cement will weather well even in a tropical climate.

Here is presented a method by which high quality adobe bricks can be economically produced on a small scale and in a limited amount of space. The bricks are molded in a modified Cinva Ram at a relatively low moisture content and with voids placed so that the drainage path is minimized and the surface area is maximized. While conventional adobes cannot be handled for several days to several weeks after molding, these bricks can be handled carefully as soon as they come out of the mold and can be stacked after 48 hours in a simple solar drier.

ACKNOWLEDGMENTS

I wish to thank Dr. Dale Webb who instigated this research and gave me help and advice throughout the project. I would also like to thank the students in Dr. Webb's CE 315 lab who donated considerable elbow grease to the project.

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INTRODUCTION

Purpose of the Investigation

The manufacture of adobe brick by conventional methods requires a large amount of flat space and extended seasons without rain. There are certain areas of the world that do not meet these requirements that would benefit greatly by the small scale commercial production of adobe brick. The objective of this investigation is to develop a method where by adobe bricks can be produced in relatively wet climates using a minimum amount of flat land.

Background Information

Definition

The word adobe comes to English from the Arabic word, atob, meaning sticky paste or muck. It is most commonly used to describe sun dried mud bricks but is also used to describe structures made of these bricks and the earth with which they are made. Adobe is a well established material whose use is on the rise world wide. It is estimated that over half of the people in the world live in homes made of adobe (McHenry, 1984).

Attributes

There are several reasons why adobe is a desirable material. Very little energy is consumed in its manufacture (see Fig.1 next page). Suitable soil is available almost everywhere. Because it can be economically produced in most places, the associated transportation costs are minimal. Adobe is very durable, practically inert, and fire and vermin proof. When stabilized with asphalt emulsion it is more waterproof than fired masonry. Adobe is also conducive to a massive style of architecture which is both thermally efficient and psychologically solid.

Production Techniques

Adobe can be efficiently produced by several different methods on various scales. One of the most successful large scale production techniques to date is that developed by the Hans Sumpf company in Fresno, California. Using a lay-down machine of their own design, the Sumpf yard can produce about 30,000 bricks per day (Harley, unpubl.). The Hans Sumpf Company has shared their technology with the industry and now some of the more successful producers in New Mexico and Arizona are using Sumpf lay-down machines and automated mixing machinery that insure a uniform quality product.

The data used in Figure 1. below was collected by the Energy Research Group, University of Illinois, and the architectural firm of Richard G. Stein and Associates, New York, in 1976. The figures for adobe were calculated by the same measurement by Mr. McHenry. All of these amounts include Btus expended in handling as well as manufacture (McHenry,1984).

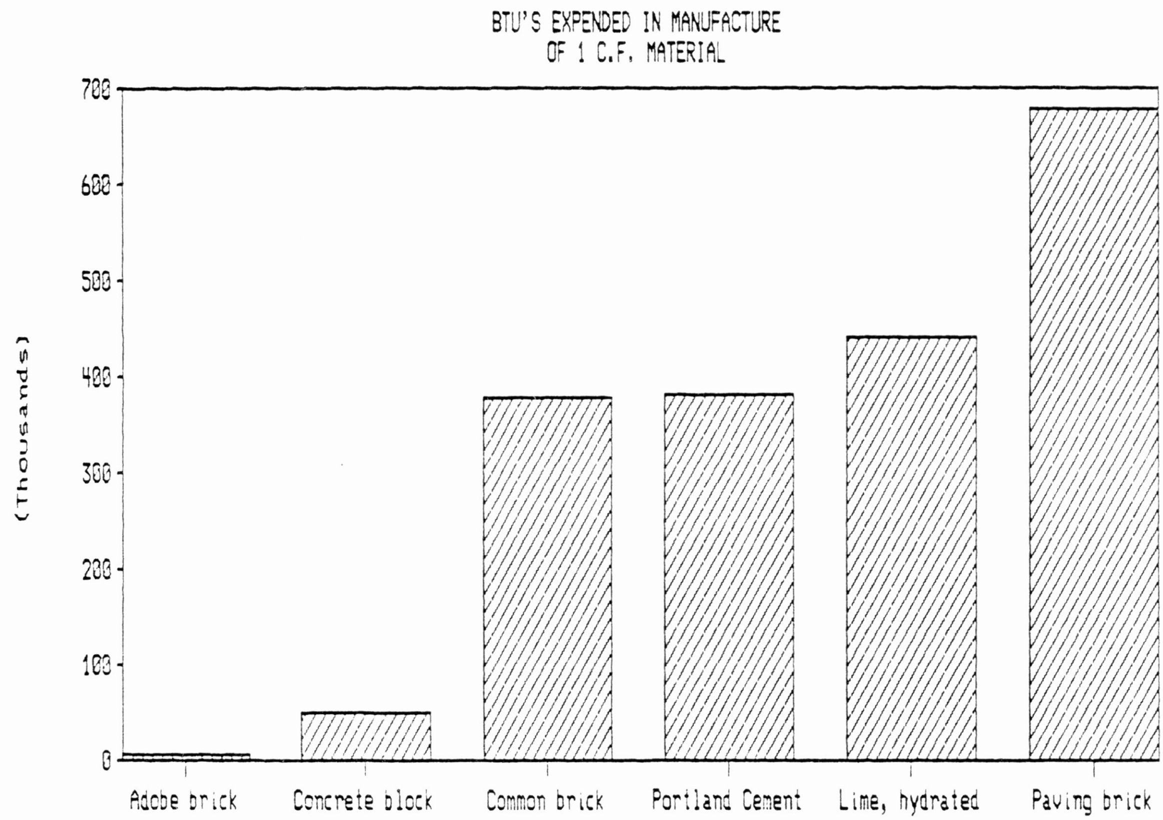


FIG.1 Energy Expended in Manufacture

One of the more successful methods of producing uniform, quality bricks on a small scale is to use a hand operated molding device such as the CINVA-RAM. This device was invented in Columbia, South America in 1957 by Raoul Ramirez and is used extensively by the Peace Corps throughout the third world (see Fig. 2).

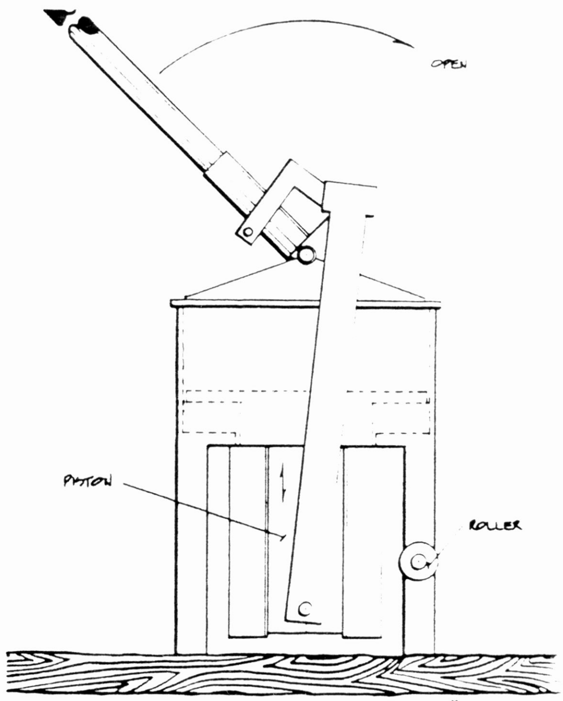


Fig.2 The Cinva Ram

With this method soil is put into the mold at a much lower moisture content than with the traditional methods. The mechanical action of the machine consolidates the soil so that the brick can be handled immediately after pressing. There is only enough pressure put on the brick to do away with large air spaces so that the bricks do not have any unresolved stresses remaining.

PUBLISHED INFORMATION ON ADOBE MANUFACTURING

There is a surprisingly large amount of information published about Adobe in general. Rex Hopson's book, ADOBE: A Comprehensive Bibliography, lists more than 1,300 books, articles, films and maps on all aspects of earth construction, particularly adobe. Although most of these items deal with the history, architecture, and physical properties of adobe buildings there are a few notable exceptions. Among the better and most cited writings on adobe manufacturing are:

Chevron Research Company. THE MANUFACTURE AND USE OF ASPHALT EMULSION STABILIZED ADOBE BRICKS.

International Institute of Housing Technology. THE MANUFACTURE OF ASPHALT-EMULSION-STABILIZED SOIL BRICKS AND BRICK MAKER'S MANUAL.

Paul G. McHenry. ADOBE AND RAMMED EARTH BUILDINGS.

Texas Transportation Institute Bulletin, no.21. HANDBOOK FOR BUILDING HOMES OF EARTH.

Mr. McHenry's Adobe and Rammed Earth Buildings is a particularly good up to date book on all aspects of adobe building including a good chapter on manufacturing.

ANALYSIS OF THE PROBLEM

Requirements

Two of the major requirements for the manufacture of adobe bricks by traditional methods are proper climate and enough flat space. It is necessary to have periods of dry weather to mold and cure the bricks. It is also necessary to have a large enough flat area that the bricks can lay undisturbed for several weeks.

Dry weather

The first of these requirements is not usually much of a problem for a small project. Most areas of the world offer some season where you can be reasonably sure of a few dry weeks. Even if a rare shower does pop up it is not difficult or expensive to temporarily cover the uncured bricks with plastic film. Climate can be more of a problem for the commercial manufacturer, who must produce bricks for much of the year. In a rainy climate it is necessary to dry the bricks in covered sheds. Using conventional methods this would necessitate very large and therefore expensive buildings.

Flat space

The second requirement, flat space, is again not much of a problem for a small project and a potentially insurmountable obstacle to the quantity manufacturer. With conventional techniques the adobe bricks are molded at a high moisture content and left in place for at least three days and for as much as two weeks. To produce very many bricks, it is necessary to have quite a few acres of flat land. In many areas of the world, such as the Caribbean, flat land is either unavailable or too expensive to be used in this manner.

Proposed Solutions

The obvious solution to these two limitations is to speed up the manufacturing process. By reducing the time that it takes for the adobes to be strong enough to be handled and stacked, the requirement for space is reduced. If not much space is needed then the weather protection becomes manageable. Stabilized adobes are waterproof and can sit out in the rain after the initial drying period, so it is only necessary to cover the bricks during this critical time.

Low Initial Water Content

To use the least amount of space this drying time must be minimized. To achieve this goal, I have modified the process in three ways. First, by using the Cinva Ram, I am able to use a soil mixture with a relatively low moisture content (15% - 18%). This obviously helps as there is less water to remove.

Increased Surface Area

Second, the drying of adobe is accomplished by the evaporation of water from the surface of the brick. By increasing the surface area, the amount of water that can be removed per unit of time is increased proportionally.

Reduced Drainage Path

Third, the length of the drainage path also effects the time necessary to dry the brick. By "drainage path", I simply mean the maximum distance that water has to travel to reach the surface of the brick. This may be the most important factor in reducing drying time.

Design Considerations

Using the Cinva Ram makes it possible to mold bricks at a lower moisture content. By modifying the ram I was also able to increase the surface area of the bricks by 19% and to decrease the maximum drainage path 46% (from 1.75 inches to 0.9 inches).

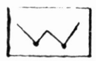
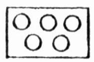
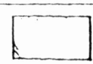
Brick Shape

My final design for the shape of the modified bricks was dictated by the following factors:

1. Maximum surface area
2. Minimum drainage path
3. No sharp angles that concentrate stress
4. Easy to fill mold
5. Easy to remove brick from mold
6. Minimum reduction in strength (as apposed to solid brick)

After trying various combinations of shapes of void space and wicking material (see Fig.3 next page), I decided to use a shape common to the fired brick industry. This was not just a coincidence as the design considerations for a fired brick are similar to that for adobe.

Figure 3. Modified Adobe Bricks.

Group	Design #1	Design #2	Cross-Sec. Area #1	Cross-Sec. Area #2	Force-(Kips) #1	Force-(Kips) #2	Strength (psi) #1	Strength (psi) #2	#1 Clay Content @ 55% of Soil	#2
7	Paper  Rein-forced		62.1 in^2	65.36 in^2	13.16^k	7.1^k	211.9	108.6	1 Soil to 2 Sand= 18% Clay	1 Sand to 2 Soil= 36% Clay
2	Paper Rein-forced		63.25 in^2	56.5 in^2	13.9^k	71.5^k	219.8	1265.5	1 Soil to 2 Sand= 17% Clay	17% Clay, Sand Cement, Glue
3	Paper Rein-forced		69.03 in^2	60.5 in^2	6^k	24.65^k	86.92	407.44	2 Sand to 1 Soil= 18% Clay	1 Sand to 2 Soil= 36% Clay
1	Paper Rein-forced		63.25 in^2	65.4 in^2	17.5^k	64^k	280.6	918.6	4 Sand to 1 Soil= 11% Clay	4 Sand to 1 Soil= w/cement added 11% Clay
5	-		-	59.25 in^2	-	7.10^k	-	119.8	-	2 Sand to 1 Soil= 18% Clay
6	Paper Rein-forced		62.75 in^2	65.35 in^2	8.3^k	16.4^k	132.3	250.96	2 Sand to 1 Soil= 18% Clay	2 Sand to 1 Soil= 18% Clay
-		 Solid No Paper	-	63.28 in^2	-	18.25^k	-	288.4	-	55% Clay

The shape I chose was a rectangular brick 11.5" by 5.5" (the size of the Cinva Ram mold) with three equally spaced round 1.75" diameter holes through the 4" thickness. (see Fig.4)

Fig.4 Modified Adobe Bricks

This design not only resulted in a faster drying time but also reduced the weight of the brick by 11%. The reduction in weight, while not as important as the decrease in drying time, is a benefit in that it increases the number of bricks that can be transported in one load as well as the overall ease of handling.

Modification of the CINVA RAM

Preliminary Tests

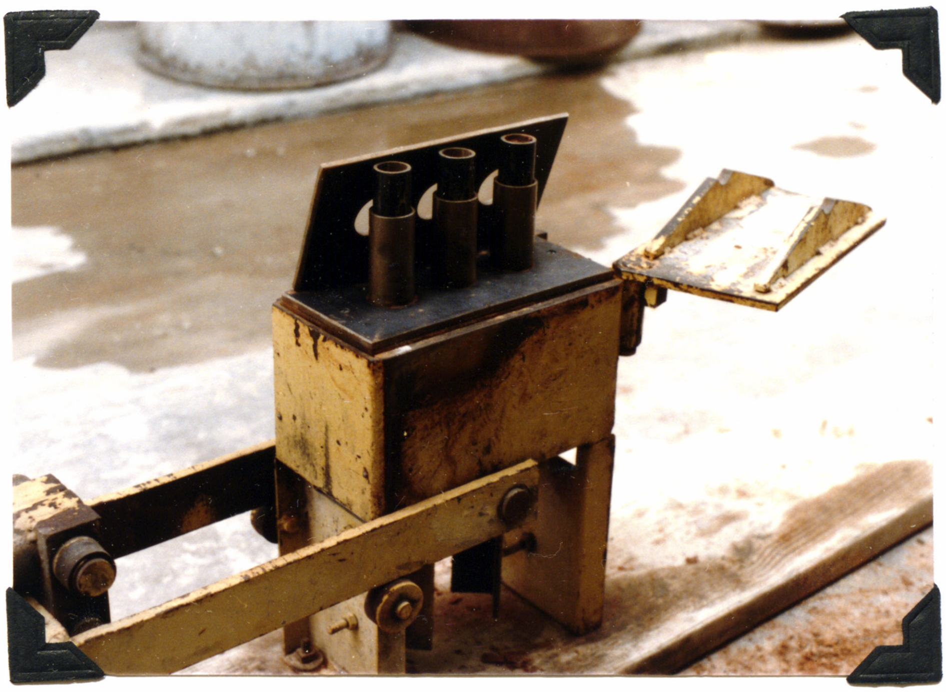
I made the preliminary test bricks in the three hole configuration by carefully placing paper tubes filled with sand into the ram and then hand packing the adobe soil around these tubes. These bricks were then pressed in the normal manner, the sand was drained, and the paper tubes removed. While this method was satisfactory for making a few test bricks, it was necessary to devise a method by which bricks could be made quickly and easily.

Final Design

I designed, and had built, an insert for the CINVA RAM using 1/4" steel plate, several lengths of 1" and 1-1/4" steel pipe, and three valve springs from a Ford tractor (see Fig.6 on next page). There is a groove cut into the outside wall of the smaller pipe and a pin set through the wall of the larger pipe and into the groove. This allows movement only within the desired range. The range of movement was further adjusted by welding a stop inside of the smaller pipe to hold the spring.

The insert is designed to accommodate small variances in the thickness of the brick. This was necessary to eliminate the need to be precise in measuring the soil that is put into the mold. Small variations in the thickness of the brick can be easily compensated for by varying the thickness of the mortar joints.

Fig.6 Insert for CINVA RAM



TESTING THE DESIGN

Soil Selection

Recent studies have shown that quality adobe bricks can be made from a wide range of soils. In a series of tests conducted by the U.S. Department of the Interior, National Park Service, soil samples were taken from a large number of successful adobe buildings, most of which are at least 100 years old. An analysis of these samples showed a surprisingly wide range of particle size distribution (McHenry, 1984). In another study conducted in Colorado under a DOE Grant (#DE-FG48-81R801008), sample bricks and structures were made at random locations using naturally occurring soils. Although these soils ranged from coarse gravel to heavy clays, almost all of them made good adobes.

As a result of these studies, it is now thought that, within certain limits, particle size and clay content are of minimal importance in selecting an adobe soil. Soils with very little clay will not hold together and thus will have little compressive strength and resistance to weathering. Soils with very much clay will be difficult to work with, will need a high proportion of asphalt emulsion (because of the increased surface area), and will usually crack badly during the drying process.

If you have a variety of soils available, it would be best to choose the sandiest mix that will produce the desired strength. This will reduce production costs by conserving asphalt emulsion and making mixing simpler.

In the preliminary tests on brick shape (see Fig.5), I used an expansive clay soil that happened to be handy. This soil was difficult to work with but served its purpose in that it magnified the difficulties and advantages of the various experimental shapes.

After deciding on an optimum shape and building a device to produce bricks in that shape, I tested various soils to find one that would be easy to work with and would produce good bricks (see appendix B). The soil I chose is a red sandy clay (ASHTO designation SC) that had been used as backfill around a culvert at the Engineering Annex on Highway 21. This soil seemed to be ideal at first but after extensive testing I have come to the conclusion that it would have been better if it had a slightly higher clay content.

Most building codes in the United States require adobe bricks to average 300 psi compressive strength (see appendix A). The modified bricks in this test did not quite achieve this strength. I think that with a slightly higher clay content that this would not have been a problem.

Testing the Bricks

Moisture Content

After constructing the insert for the Cinva Ram and obtaining several pickup loads of the chosen soil, I made and tested about 60 bricks. I found the ram to work best when the soil had a water content [(weight of water/weight of solids)x 100] of about 15% to 17%. If the soil was wetter than this, it tended to squirt out of the seams in the ram and stick to the edges of the mold. When the soil was dryer than this, it was hard to handle the brick without damaging it.

Release Agents

I tried using several different release agents to facilitate removing the brick from the mold but found that it worked best when the mold was clean and dry. Motor oil was messy and did not really help much. Pam, a vegetable oil spray, worked well before the mold got dirty but would be expensive and required that the mold be cleaned after every three or four bricks. Water actually made it more difficult to remove the bricks intact. I found that with about a 16% moisture content the bricks were removed fairly easily, leaving little residue in the mold.

Drying

A fast and inexpensive way to dry adobe bricks in a small manufacturing operation would be in a solar dryer. This would be very similar to a greenhouse. It would have a clear plastic shell with a black floor and a ventilation system (fans) to remove moisture from the air. To simulate these conditions, as I did not have a greenhouse, I dried the bricks in an environmental chamber that was kept at 140^{o} Fahrenheit and at 25% relative humidity. This is slightly hotter and dryer than it would be in a solar dryer and thus stressed the bricks more. As the soil I used was very sandy, both the solid bricks and the modified bricks dried quickly. The modified bricks were completely dry (less than 2% w) in about 36 hours. The solid bricks were dry in about 60 hours.

Compressive Strength

Standard compression tests with an Instron Universal Testing Machine showed that both the solid and the modified bricks gained compressive strength as they dried. The solid bricks gained little strength in the first 12 hours and slowly in the second 12 hour period. The modified bricks gained strength at a steady rate until they were completely dry after 36 hours (see Fig.7 next page).

Stabilization

To facilitate testing most of the bricks were unstabilized. The relative difference between the properties of the solid and the modified bricks should be the same regardless of soil type and stabilization. I did however do tests on the soil to determine the optimum amount of asphalt emulsion to use. I made test bricks at 2,3,4,5,6,7, and 8% asphalt emulsion (by weight). I used a type CSS1H asphalt given to me by Tom Harley of the Hans Sumpf Company. These bricks were dried thoroughly and then weighed. The bricks were then placed on a constantly saturated cloth surface for seven days and then weighed again. Most if not all building codes require a brick to absorb less than 2.5% moisture by weight to be called stabilized. The results of this test were as follows:

% EMULSION	Wt. DRY	Wt. WET	% GAIN
2	649g	670g	3.16%
3	709g	731g	3.03%
4	650g	665g	2.23%
5	651g	665g	2.07%
6	655g	668g	1.91%
7	651g	665g	2.23%
8	631g	640g	1.51%

This test determines that only 4% (by weight) asphalt emulsion is necessary to stabilize this soil. This is a relatively small amount due to the large particle size and correspondingly small total surface area. This would be a major benefit to using a sandy soil such as this. The Hans Sumpf Company uses about 5.5% asphalt emulsion and most New Mexico manufacturers of stabilized adobes need 10% to 15% to achieve less than 2.5% absorption (McHenry,1984).

CONCLUSIONS

Adobe is the quintessence of appropriate technology applied to material science. Its availability, the ease with which it is made and used, and its inherent properties make it the building material for most of the world's population. Everything that can be done to study and improve this material and its uses should be done.

The modified shape studied here results in a substantially reduced drainage path and an increase in surface area. This can double the compressive strength obtained in the first few days of drying. Looked at another way; adobe bricks made in the modified shape described here, are strong enough to handle and stack in half the time necessary for solid adobe bricks.

This will result in substantial savings where dry weather and flat land are scarce.

The Cinva Ram with the mechanical insert described here will make good bricks of the modified shape. I have some reservations though, concerning the amount of labor necessary using this method. A commercial producer of adobes should investigate a more mechanized method of producing these cored bricks, even in developing countries where capitol is scarce and unskilled labor is cheap. A simple extruder could probably be made that would speed up production considerably.

I am convinced that the way to speed up drying and thereby reduce the need for covered space is to make the adobes in a shape similar to the one developed here. I would like to see more work done to design a simple automated process to make these bricks.

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APPENDIXES

The following is the adobe portion of the City of El Paso Building Code. This code was adopted in 1980 by the El Paso City Council and in 1982 as an appendix to the Standard Building Code. This code is one of the better ones used in the United States and as a part of the Standard Building Code could easily be incorporated into the building codes of most Texas communities.

EL PASO CODE

AN ORDINANCE AMENDING CHAPTER 6, ARTICLE II OF THE EL PASO CITY CODE, SECTION 6-14 (BUILDING CODE, ADOPTED AMENDMENTS), THE PENALTY BEING AS PROVIDED IN SECTION 1-6 OF THE CODE.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF EL PASO

That the following sections of Chapter 6 of the El Paso City Code (Buildings) be and are hereby amended to read as follows:

Section 6-14, incorporating the book entitled "Standard Building Code, 1976 Edition," with certain amendments thereto, is amended to read as follows:

Chapter VI, Classification of Buildings by Construction, Section 607 (A), is hereby amended to read as follows:

607 (A), Type VII, Construction.

1) General. The scope of this section is to define adobe types, specifications and accepted construction practices. The provisions of this section are not intended to prevent alternatives uses and methods not covered herein. It is intended that this document be a living document able to incorporate new information on uses and methods of manufacture and construction of adobe.

2) Classes of adobe.

a) Unstabilized Adobes. Unstabilized adobes are adobes which do not meet the water absorption specifications of paragraph 3)b) (3) below. This shall hold even if some water absorption protective agent has been added. The determination as to whether an adobe is stabilized or unstabilized is to test for compliance with paragraph 3)b) (1)-(3) below. Exterior walls of unstabilized adobe are allowed but must comply with paragraph 4)i) requiring Portland cement plaster applied to the outside. Use of unstabilized adobes as prohibited within 4 inches above the finished floor grade. Stabilized adobes may be used for the first 4 inches above finished floor grade. Mortar must be Type O of adobe soil (either stabilized or unstabilized).

b) Stabilized Adobes. The term stabilized is defined to mean adobes made of soil to which certain admixtures are added in the manufacturing process in order to limit the adobe's water absorption in order for it to comply with paragraph 3)b) (3) below. Exterior walls constructed of stabilized adobe require no additional protection. Stucco is not required. In order for the wall to so comply, the mortar must be of Type N or adobe soil treated with an additive to make the mortar comply with the same water absorption requirement in paragraph 3)b) (3) below.

3) Material specifications and testing procedures for adobe.

a) Unstabilized adobe.

(1) Soil. The performance of adobe units in tests prescribed in subparagraphs 3)a)2) through 3)a)5) shall determine suitability of soil material. By this standard any adobe unit, whether it be manufactured by traditional or modern techniques, must meet the same objective standard.

(2) Compressive Strength.

(a) The units shall have an average compressive strength of 300 pounds per square inch when tested in accordance with ASTM C67. One sample out of five may have a compressive strength of not less than 200 pounds per square inch.

(b) Reserved.

(3) Module of Rupture. The unit shall average 50 pounds per square inch in modulus of rupture when tested according to the following procedure:

(a) A cured unit shall be laid over (cylindrical) supports two inches (2") in diameter, located two inches (2") from each end, and extending across the full width of the unit.

(b) A cylinder two inches (2") in diameter shall be laid midway between and parallel to the supports.

(c) Load shall be applied to the cylinder at the rate of 500 pounds per minute until rupture occurs.

(d) The modulus of rupture is equal to $\frac{3WL\ 2}{2Bd}$

W = Load of rupture
L = Distance between supports
B = Width of brick
d = Thickness of brick

(4) Moisture Content. The moisture content of the unit shall not be more than four percent by weight.

(5) Shrinkage Cracks. No units shall contain more than three shrinkage cracks, and no shrinkage crack shall exceed three inches (3") in length or one-eight (1/8) in width.

b) Stabilized adobe.

(1) All specifications included in 3)a) (1) - (5) to apply to stabilized adobe.

(2) Soil for stabilized adobe shall, in addition to 3)a) (1), be chemically compatible with the stabilizing materials.

(3) Absorption. A dried four-inch (4") cube cut from a stabilized sample unit shall absorb not more than two and one-half percent moisture by weight when placed upon a constantly water saturated porous surface for seven (7) days.

4) Adobe construction.

a) General. The height of every laterally unsupported wall of unburned clay units shall be not more than 10 times the thickness of such walls. Exterior walls which are laterally supported with those supports located no more than 24 feet apart, are allowed a minimum thickness of 10 inches for single story and a minimum thickness of 14 inches for the bottom story of a two-story with the upper story allowed a minimum thickness of 10 inches. Interior bearing walls are allowed a minimum thickness of 8 inches.

b) Foundation under adobe walls. All adobe walls and partitions hereafter erected shall rest on foundation walls constructed of solid masonary [sic] or concrete, which shall be brought up to a point at least eight inches above the finished grade outside or under the building. Where stem wall insulation is used, a variance is allowed for the stem wall width to be two inches (2") smaller than the width of the adobe wall it supports.

c) Exterior walls. All walls of adobe (stabilized or unstabilized) shall not have thickness less than that allowed in paragraph 4)a) above. Mortar shall be in accordance with paragraph 2)a) and 2)b) above, depending on the class of adobe being used. All adobe brick shall be laid up with fullflush (bed) joints. All adobe shall be laid in a full running bond in the direction of the wall. In no case can the bond be less than 4 inches. Walls of treated adobe which do not require a protective coating must be laid up with full bed and full head (end) joints.

d) Piers, columns and short walls. Adobe shall not be used for narrow isolated isolated piers or columns in a bearing capacity. Wall sections less than twenty-four inches shall be considered as isolated piers, in which case the lintel shall be designed to span the distance of both openings and the pier.

e) Tie beams. All adobe walls shall contain a continuous tie beam at point of bearing.

(1) Concrete tie beam. Shall be a minimum size six inches (6") depth by width of wall up to a ten inch (10") width. For walls thicker than ten inches, a ten inch (10") tie beam will suffice. All concrete tie beams shall be continuously reinforced with a minimum of two number 4 reinforcing rods each floor and ceiling plate line.

(2) Wood tie beams. Shall be minimum size six inches (6") depth by wall width up to ten inch (10") width. For walls thicker than ten inches, a tie beam of ten inch (10") thickness shall suffice. The wooden tie beam shall be overlapped, or spliced, at least six inches (6") at all joints. All joints shall have a wall bearing of at least twelve inches (12"). Wood tie beams may be solid in the six inch (6") dimension or may be built up then by applying layers of lumber. No layer shall be less than indicated one inch (1"). Wood joints, vigas or beams shall be spiked to the wood tie beam with large nails or large screws. All wooden tie beams to be treated to prevent decay.

f) Lintels. All lintels shall be considered as structural members and designed in accordance with applicable provisions of Chapter XII of the City Building Code and may be of wood, concrete or steel. (Chapter XII - Minimum Design Loads.)

g) Interior stud partitions. Interior stud partitions shall be adequately secured to the adobe wall.

h) Parapet walls. All adobe parapet walls shall be water proofed.

i) Plastering. All exterior walls of unstabilized adobe shall be plastered on the outside with Portland cement plaster, minimum thickness 3/4 inches in accordance with Chapter 18. Protective coatings other than plaster are allowed, provided such coating is equivalent to Portland cement plaster in protecting the unstabilized adobes against deterioration and/or loss of strength due to water. If wall is 14 inches or thicker, mud plaster may be used. When using Portland cement plaster, metal wire mesh minimum 20-gauge by one and one-half inch (1 1/2") opening shall be securely attached to the exterior adobe wall surface by nails or staples with minimum penetration of one and one-half inches (1 1/2"). Such mesh fasteners shall have a maximum spacing of sixteen inches (16") from each other. All exposed wood surfaces in adobe walls shall be treated with an approved wood preservative before the application of wire mesh.

PASSED AND APPROVED THIS 26th DAY of FEBRUARY 1980.
STATE OF TEXAS

ADOBE NOTES

1/09/85

Tested three samples of possible soil. Two were from Rosas Trucking's borrow pit on Rock Prairie Rd. The sample labeled "1" was sand with a white clay. This was the most common soil at the site and was what could be expected if a load was ordered. The second sample labeled "2" was from a bank just to the left of the entrance as you enter it. This was the same sand with more of a red clay. The third sample tested was a clay from the College Station Sanitary Landfill. As a control I tested some of the soil I got from the Hans Sumpf Adobe yard in Fresno California.

I made small molded blocks of the samples and let them dry for two days. All of these samples seemed to make good hard blocks. I also filled mason jars with the soils and water and shook them vigorously and then let them settle. The three samples from this area settled with a clear layer of water on top (even the clay from the landfill). The Sumpf sample on the other hand retained clay in suspension/solution.

Sample 1.

This looked to be the better of the three soils. It seemed to have a little more clay and less silt than the other sandy soil. It eventually settled clear but took longer than sample 2.

Sample 2.

This sample at first appeared to have more clay in it than did sample 1 but in fifteen minutes it had settled with a clear layer of water on top. It seems that most of the fines in sample 2. are silts.

Sample 3.

This is the clay from the landfill cover. It is a heavy sticky clay and would be difficult to work with. Although it took longer (24+ hours), this sample also settled with a clear layer of water at the top.

Sumpf Soil

This soil felt sandy when moistened and rubbed between the fingers. It made foam that lasted quite a while when it was shaken in the jar. After settling for 48 hours this sample still had clay in the top layer of water. It also showed a better range of particle sizes than did the other three samples.

Brazos Bottom Fill

On Friday Jan 11, 1985 I made several test bricks with the Cinva Ram. The sandy soils I tried (Samples 1 & 2) were too fragile and could not be removed from the ram with out crumbling. The heavy clays from the landfill were too sticky and difficult to work with. I tried mixing these soils and got an acceptable brick but the labor involved in mixing a large uniform sample would be prohibitive.

About this time Randy Lastname came into the lab with a couple hundred pounds of a soil that he was preparing for use in compaction labs for CE-365. This soil seemed to be just what I need. It is a red sandy clay with more clay than my sandy samples. I made a settlement test and a brick with this soil.

Randy said that Richard Bartoskewitz a CE professor arranged for him to get this soil from the Engineering Annex on Highway 21. It had been used for fill around a large culvert that had recently been installed there.

The test brick that I made with this Brazos Bottom Soil looks pretty good. It came out of the ram easily and held together well during a considerable amount of handling. I left this brick in the 140° 25% relative humidity chamber for a week. It dried with only a few short expansion cracks. The edges were more crumbly than a Sumpf brick. I took this test brick directly from the 140° to the 20° outside. It made this temperature change without noticeable effect. I then dropped the brick onto concrete from waist height. About 1/8 th of an inch of the edge that struck the concrete crumbled but the brick was still structurally sound.

Alex's Soil

Alex found a soil near his home that has a fairly high clay content but is still workable. It settled much like the Sumpf soil, the water above the sample was still cloudy after a week. We made several bricks from this soil and dried them for a week in the 140^{o} room. Even though all of these bricks cracked pretty badly they held together and were harder than the Brazos Bottom Bricks. This soil is an ideal candidate for our experiments with a modified shape. If by shortening the drainage path we can prevent this soil from cracking then we will have a superior brick.