Adobe Craft

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AN INTRODUCTORY COMMENT

This is a technical manual which seeks to bring together in one volume significant information from various sources bearing on small scale adobe production. The successive editions of this manual are also a chronicle, log, or journal of an avocational interest. It started with casual, arm-chair curiosity and over the years mushroomed into a personally satisfying open-ended experience.

Perhaps the seed was planted many years ago as a member of an American Friends Service Committee, college-age, summer work camp in Torreon, Mexico. The goal of the summer was a clearer appreciation and understanding of the social-economic-cultural life of our neighbors to the south. The work project was to assist in the construction of an adobe building to house a cotton gin. The daily schedule included joining the skilled and unskilled laborers in digging, moving, and mixing the soil, water, and straw to make adobe bricks and then carry them to the building site--often in 110° to 115° sun. A frequent reflection: There must be an easier way!

The years came and went with the dramatic social changes of the 40's, 50's, 60's, and early 70's. A depersonalized, technological society was putting ever greater distance between the producers, the decision-makers, and the consumers of its abundance. Greater leisure brought new interest in nature/craft/creativity-oriented life styles. As a psychologist seeking to understand the impact of these changes upon people and as a person sharing some of the same experiences, I found myself casting about for a model, an activity, an involvement which could meaningfully relate to the contemporary scene in a tangible, concrete manner.

One nudge may have come from reading an article on world housing needs and the Cinva-Ram block machine. Another certainly came from a delightful and technically informative visit with the largest commercial adobe block producer in California, and probably the world. An adventure had begun--an interest in stabilized soil as a basic, multi-use, molding material. A notion began to take shape. There should be a way of designing simple, inexpensive, yet efficient adobe-making equipment which would bridge the technological gap between the back-breaking, mud hole method and the centralized high capital investment, mass-production method.

Mobile, low-cost, flexible, efficient production equipment and a sense of creative independence were guiding objectives. This image was gradually trans-

lated into the early stages of experimental reality. The satisfactions and frustrations were shared with others. The response generated sufficient interest to suggest putting the experience together in printed form.

This is the fourth edition of the Adobe Craft Manual. It will probably not be the last. There have been delights and disappointments on this safari: discovering bits of new information, collecting soil samples from across Northern California, stimulating personal conversations, accumulating a basement full of parts left over from earlier equipment models, producing a back yard full of "test run" projects; photographing the process, moving from manuscript to printed copy, and responding to "people inquiries" from around the country and the world. The next spin-off will be leading an Adobe Making Workshop for the University of California Extension Division in an adobe community center constructed through the energies of an esteemed local public school educator-administrator who caught the "adobe bug" forty years ago.

Karl V. Schultz
Oakland, California
March 1, 1974

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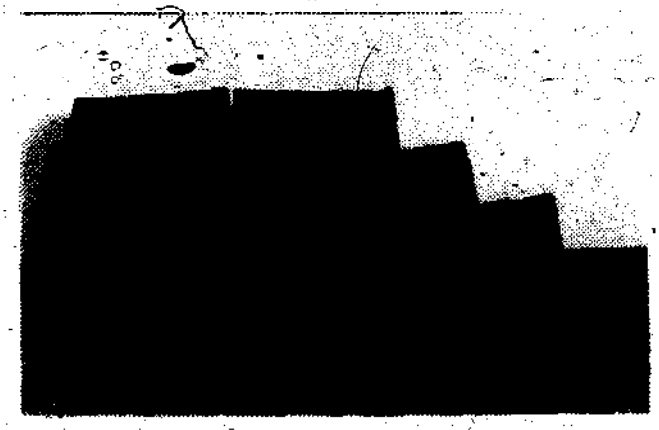
I. STABILIZED SOIL AS A BUILDING-CRAFT MATERIAL



Adobe construction has been used for centuries around the world. It is estimated that one-half the people in Africa, Asia, and Latin America live in houses using sun dried earth (4, 22). More recently, especially in Southwestern United States, adobe has been rediscovered by architects and home owners as an attractive and economical building material. This has come with technical advances and commercial large-scale production. (Various methods have been used to stabilize soil. In this manual, "adobe" or "stabilized soil" will refer to methods using emulsified asphalt as the stabilizing agent.)

The top picture on the left shows an original mud and straw adobe block from Taos, New Mexico.

The pictures below it show the effects of water erosion upon stabilized and unstabilized test blocks 1 x 2 x $3\frac{1}{2}$ inches.

The first picture shows the stabilized soil blocks on the left and the unstabilized blocks on the right.

The second picture shows the same blocks after being subjected to 45 seconds of jet spray from a garden hose held about one foot from the test blocks.

Adobe has a number of characteristics which make it attractive for construction and craft-related applications: 1) Virtually waterproof when clay/sand proportions are maintained and thorough mixing is carried out; 2) Good insulation to sound, heat, and cold; 3) Termite proof; 4) Fireproof; 5) Resistant to wind and sandstorm erosion; 6) High crushing strength (varies with soil, reported to be approximately 450 to 800

p. s. i. Uniform Building Code requirement is 300 p. s. i.); 7) Material is easily molded, molds may be removed immediately for air and sun drying; 8) Cured adobe is less dense than fired brick or concrete blocks, hence, can be readily cracked, sawed, or drilled using masonry tools; 9) Interior and exterior surface finishing are not necessary but may be applied (4, 5, 8).

Equipment developed by Adobe-Craft has been designed for a variety of settings: 1) Do-it-yourself home owner, craftsman, or artist; 2) Farm, ranch, second home setting; 3) Community equipment rental service; 4) Supplement to building supply, nursery, or landscaping business; 5) Small business and employment opportunities for youth or unskilled labor; 6) Public or private agencies concerned with constructing housing, recreational, health, or educational facilities; i. e., situations with limited funds but with access to appropriate soil and labor supply; 7) Redevelopment settings--domestic or emerging countries; 8) Equipment is suitable for community art centers, college art departments, or experimental work in schools of engineering or architecture.

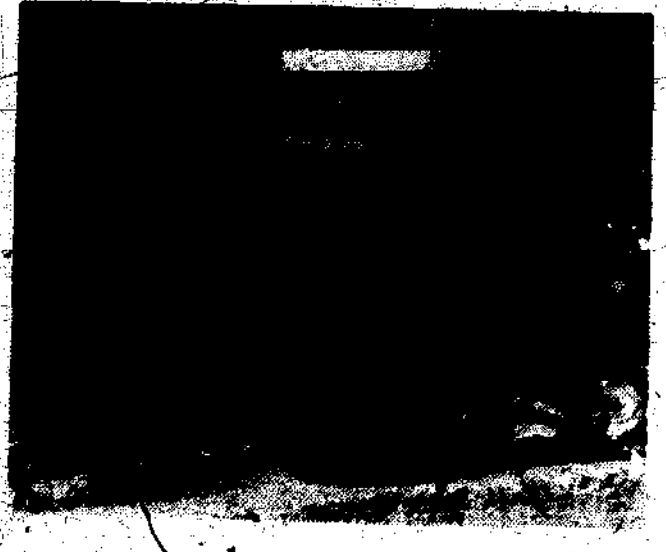
II. TECHNOLOGY OF ADOBE BRICK-MAKING

Basic steps in brick-making with stabilized earth include: 1) soil selection, 2) soil preparation (crushing-pulverizing and/or screening), 3) mixing, 4) molding, and 5) curing.

The methods and equipment described have been developed over a number of years of research and experimentation. The goals have been to design equipment with the following features: 1) An equipment "package" capable of soil-to-finished-block production. 2) Minimum capital investment compatible with efficient production using unskilled labor. 3) Equipment requiring minimum fabrication-assembly facilities; e.g., using parts and materials readily available and mass produced for other purposes, thus inexpensive. 4) Simple operation and maintenance for small-scale, highly mobile, on-site production; e.g., easily carried in auto, trailer, or pickup truck. (On-site production greatly reduces or eliminates sales and transportation costs which represent a substantial proportion of the retail price of centrally produced blocks.) 5) Flexible modulator type equipment--production capacity can be easily increased by adding units or by increasing power supply and size of units.

A. Soil Selection (4, 5, 8)

Soil should include a mixture of fine (silt-clay) particles and sand particles in proportions of approximately 1/3 clay and 2/3 sand. (Clay is defined as particles .005 mm. or less in diameter of that passing through a 200 mesh screen, and sand as particles 0.02 to 1.0 mm. in diameter.) Particles up to 1/4" in diameter can be used. Excessive clay, especially clay with high plasticity, causes shrinking and cracking. Excessive sand produces weak blocks resulting from insufficient bonding surface.



The water jar test is a simple method for determining clay-sand proportions in soil samples. Fill a glass jar about half full with a soil sample. Add water to about two-thirds of jar capacity. Shake vigorously and let settle for about half an hour. Organic matter will float on top of the water. Fine particles of clay will remain at the top of the settled soil and coarser particles will settle to the bottom. Proportions of particle sizes will indicate soil suitability. Proportions of clay and sand may be altered by adding clay or sand as needed. A wide variety of

soils are suitable for adobe brick-making. However, soils with high acidity, alkalinity, or soluble salt content should not be used.

Acidity. The primary source of acid content in soil is organic matter. This is undesirable from the point of view of mechanical strength, water absorption, and biological degradation. Soil samples should be taken from below the grass roots level.

Acid Test. Mix soil sample with distilled water. Blue litmus (pH) paper will turn red upon presence of acid.

Alkalinity. High alkali content in soil is most frequently found in arid or semi-arid regions. This suggests the presence of salts such as carbonates. Other neutral salts such as sulfates or chlorides may cause problems such as spalling and loss of strength due to slow hydration. For high durability blocks, the salt content of the soil should not exceed 0.2%, by weight, of the soil.

Alkaline Test. A number of different methods may be used for testing the presence or absence of alkaline and the amount of salt content.

1. Mix soil and distilled water. Add 5% nitric or hydrochloric acid. If there is fizzing (effervescent action), presence of alkali (carbonate) is indicated.

2. Mix soil and distilled water. Add a few drops of phenolphthalein. Red color indicates presence of alkali. Or, pink litmus paper may be used. It will turn blue with presence of alkali.

3. Use a simple conductivity bridge which has been calibrated against known salt contents.

4. Filter method to test for chloride or sulfate. Mix soil sample with water and filter. Test filtrate with litmus. (0 = high acid; 7 = neutral; 14 = high base.)

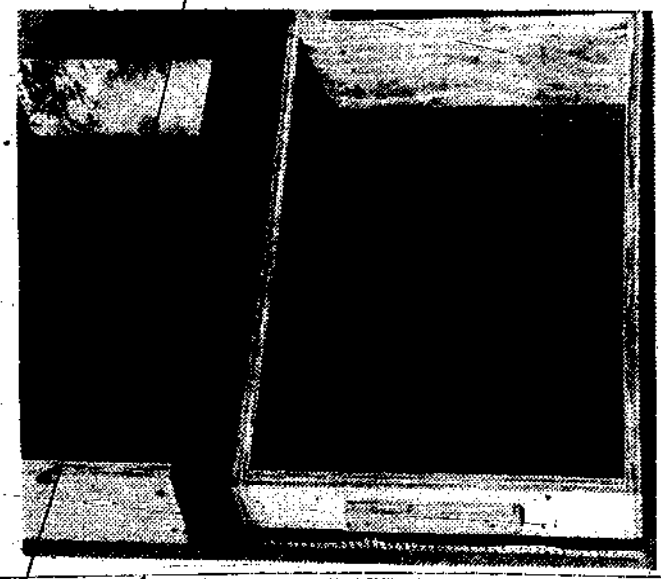
   a. If pH is under 7, proceed.

   b. If pH is above 7, add nitric acid until pH is 7 or less.

      1) To part of the above, add 2% silver nitrate solution. Precipitate indicates chloride or sulfate.

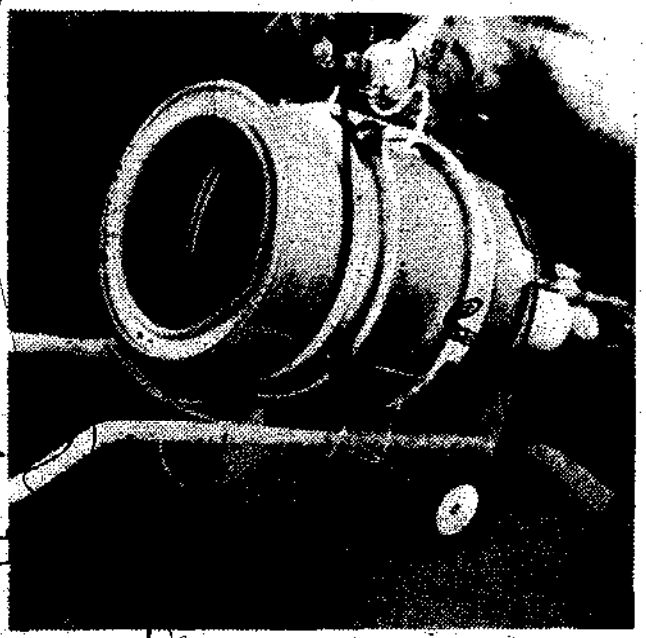
      2) To second part of b, above, add 2% barium chloride solution. Cloudy precipitate indicates sulfates.

B. Soil Preparation (Screening, Pulverizing/Crushing)



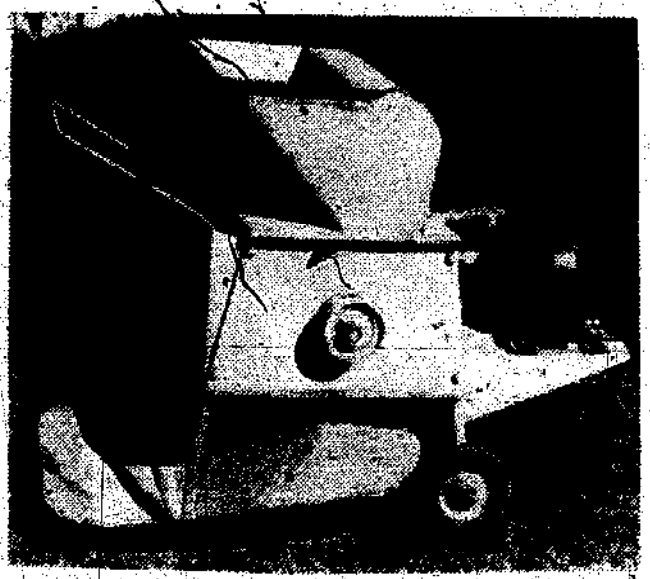
Soil may be prepared for adobe making by screening and/or crushing-pulverizing. Screening may be done with several types of simple equipment. The picture on the left shows two soil sample sifters, each about 4" x 10" x 15". One has 1/4" hardware cloth and the other 1/8" mesh.

A larger hand sifter may be made with a simple rectangular wood frame, approximately 2 1/2' x 5' on which is mounted 1/4" hardware cloth. One end of the frame is elevated. As the soil is thrown on the frame, the fine soil drops through the screen and the coarser material rolls down in front.



A power-driven barrel sifter is much more efficient. The model shown in the picture used a 24" x 15" barrel discarded by a local paint firm. (A 30 or 55 gallon barrel would give greater capacity if desired.) A cone of 1/4" hardware cloth clamped onto a section of 4" plastic drain pipe was then inserted into a hole cut into the bottom of the barrel. Oval holes were cut around the circumference of the barrel bottom.

This unit rotates on eight skate wheels inside two hoops made of 1/2" flexible conduit. The motor and V-belt drive are mounted on top of the unit. This entire unit rests upon a hand truck chassis.



Unsifted soil is shoveled into the front. Fine soil drops from the slots around the bottom of the barrel, and the lumps or rocks roll out through the section of plastic pipe. An additional screen may be attached to the discharge pipe, thus producing a three-size screening operation. For further parts and assembly instruction detail, see Appendix B.*

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*A previous model shown in the 1972 Adobe Craft Manual used a large plastic garbage container mounted on a wheelbarrow chassis. This was effective but less compact, and parts were more time consuming to fabricate and assemble.

Pulverizing-crushing may be done by converting a yard model compost maker. The large hole screen used for composting is replaced by a 1/8" thick steel plate ~~with 1/4~~" holes prepunched. A 1 hp motor with double 5/8" belts with pulverizing blades rotating about 1,000 rpm was very effective with low density sandstone and clay-type soils. Material must be dry. Do not use high density rock. Wear safety goggles. A small hammer mill type crusher is recommended for high density rock.

C. Mixing

The essential ingredients of stabilized soil adobe mix are as follows:

1. Soil: 25% to 45% clay and 55% to 75% sand (or crushed rock, sand equivalent).

2. Emulsified asphalt (Chevron SS 1h),* a hard, slow-setting emulsion. Do not store where exposed to freezing temperatures. Will tend to settle after a month or two if not used. Agitate periodically before using if stored longer.

3. Water.

Research from various sources is generally in agreement that 5% (4.5% - 6%), by weight, of asphalt to adobe mix produces the optimum blocks (4, 5, 8). Block strength decreases as the proportion of asphalt increases beyond 5%.

This translates into the following alternative batch formulas:

1. 1 cup emulsified asphalt
   4 cups water
   3 quarts of soil (est.)

2. 1 gallon emulsified asphalt (approx. wt. 8.3 lbs.)
   4 gallons water (approx. wt. 33 lbs.)
   10 - 12 gallons soil (approx. wt. 120 - 140 lbs.)

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*Research reports (4, 8) indicate that road oil (rapid curing RC 250, and medium curing MC 70) have also been used effectively. Distillate-type solvents are used rather than an emulsifier and water as in the SS 1h. The price is about the same. Approximately half as much road oil as emulsion is needed for the same effect. However, in checking with several large petroleum companies, it was found that these may no longer be available at least for the duration of the petroleum products crisis.

Equals 5.5 blocks, 4 x 8 x 16 inches
Equals 12½ blocks, 3 x 6 x 12 inches
Equals 2½ sq. ft. of adobe wall 8 inches thick

3. 55 gallons emulsified asphalt (1 barrel)
220 gallons water
6,850 lbs. (est.) soil at approximately 12 lbs. per gallon equals 570 gallons soil.
Equals 305 blocks, 4 x 8 x 16 inches
Equals 725 blocks, 3 x 6 x 12 inches
Equals 383 sq. ft. of poured adobe wall 8 inches thick (less shrinkage in drying)

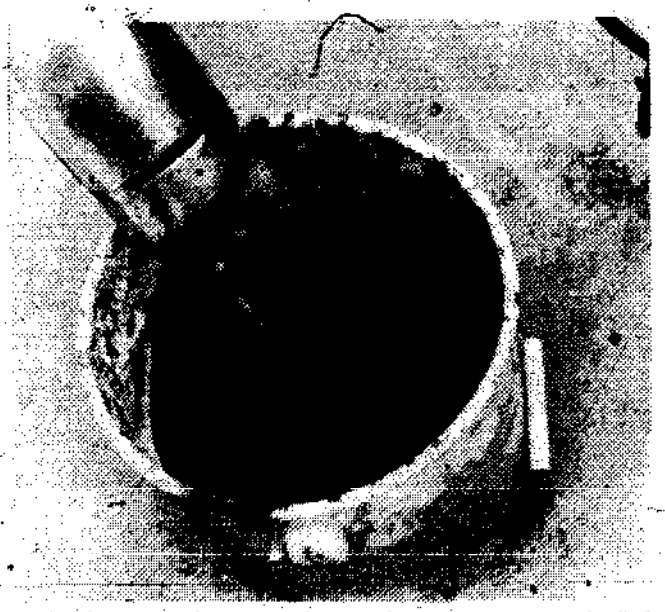
4. .6 gallon emulsified asphalt
2.4 gallons water
1 cu. ft. soil (est.) equals
Seven and one-half gallons soil equals 90 lbs. (approx)

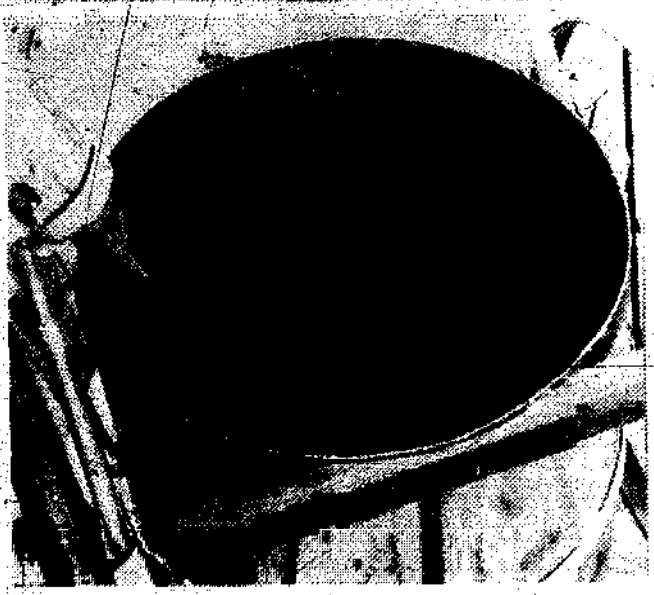
The above formulas will require adaptation to minor variations specific to each setting; e.g., sand/clay characteristics of the soil and moisture content of the soil. The soil stabilizing process takes place in stages. First, the thorough mixing surrounds the soil particles with a thin film of asphalt emulsion. Then the water evaporates leaving the asphalt around the soil particles now resistant to further absorption of moisture. Thus, the finer the soil particles in the mix, the more surface to be covered and the more asphalt is needed. The higher the moisture content of the soil, the less water needs to be added to give the mix the proper consistency.

The following mixing approach has been recommended by the International Institute of Housing Technology (8, pg. 31). Mix a first batch, controlling the asphalt and water proportions and varying the soil as needed. If more than the prescribed number of blocks are produced by the test mix, then the proportion of asphalt should be increased (for the given soil). If fewer than the prescribed number of blocks are produced, the amount of asphalt should be reduced (for the given soil).

The most convenient method of mixing is to first pour the premixed water and asphalt into the mixing container and then initiate the mixing action, slowly adding the soil until it reaches the proper (thick, soupy mud) consistency. If it is not moist enough, it will stick to the mold surfaces or resist flowing into the mold. If it is too wet, it does not retain its shape when the mold form is removed. (A simple test for proper consistency is to draw a stick through the mix surface; a smooth, wet indention remains. Thorough mixing is essential. Mixing is incomplete if there are any residual streaks or marbled effects.

Mixing Equipment. Mixing action similar to a common kitchen osterizer has been found most effective for mobile type equipment. The combinations of power input, rotation speed, and propeller blade pitch may be varied depending on materials available.





A small batch mixer may be made using a 1/3 hp (variable speed preferred) electric hand drill. A four- to six-inch two-bladed or S-shaped propeller made of strap steel mounted on a 3/8" threaded rod was found to be very effective in a one to five gallon pail. Mixing time is about one minute at approximately 600 rpm.

To reduce splashing, the mixing action is started slowly (if variable speed motor), and with the asphalt-water mixture above propeller level. Then soil is added slowly. As the mixture becomes thicker, the motor speed can be increased.

A number of mixer models were developed prior to the one shown on the left. Further refinements or improvements may come with use in different settings.

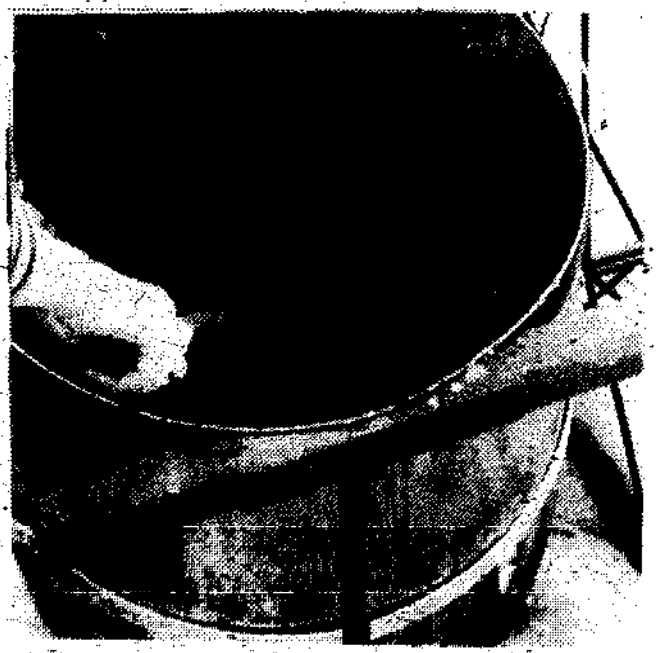
The mixer in the pictures used an 18" diameter and 20" deep end section from a stainless steel tank purchased from a local scrap metal dealer for $20. Flexible conduit was bent to form the handle. Twenty-four inch garden cultivator wheels were used. The curved bottom is essential for effective mixing action. This mixer will mix up to about twelve gallons of adobe in three to five minutes with one man pouring (or with elevated continuous controlled soil feed) and one man operating the mixer.

A common 15, 30, or 55 gallon steel drum section could also be used. A gold pan or wok can be dropped into the bottom and welded or sealed with mastic type caulking compound.

A strip of wood across the top of the container stabilizes the propeller shaft so it can sweep around the bottom of the mixing container. Some operators may prefer to control the motor-propeller unit by hand.

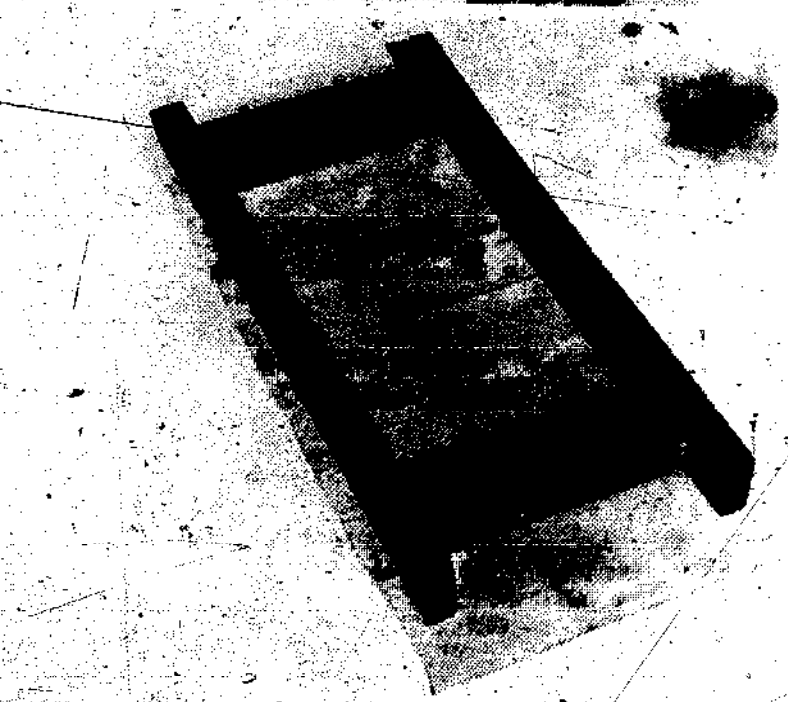
When not in use, the motor and mixing shaft (S-shaped strap steel blade, or marine propeller) are placed in a bucket of water with a special support. This prevents the adobe mix from drying on the blades. (See Appendix C for further parts and assembly detail.)

Commercial producers use an open trough pug mill type mixer with low-pitch mixing blades, staggered spacing about six inches apart, either single or double horizontal shafts. Measured input of asphalt emulsion, water and soil are introduced at one end and the mixed adobe discharge at the other.



It is reported that a plaster or dough mixer can be used for mixing adobe but that a common cement mixer is not effective (8).

Care should be taken that the entire batch is mixed to the same consistency. Unmixed soil will tend to stick to the bottom if it has been poured in too rapidly or not mixed thoroughly.



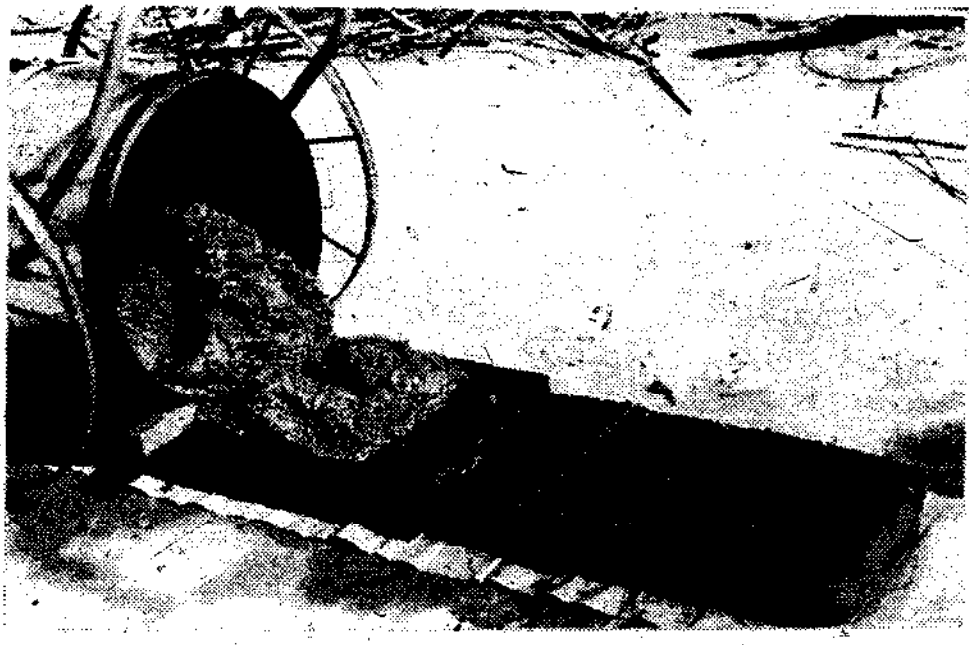
Proper consistency may be checked by drawing a stick or thin piece of wood through the mix. If it is too wet, the mark will quickly close. If it is too dry, the sides leave an irregular, crumbling edge. Proper moisture content will be shown when the stick leaves a smooth depression which remains after the stick has been removed.

The stabilizing block under the container can be removed and the adobe batch rolled to the molding area. The mold form should be clean and wet and placed over a sheet of craft paper, sand, or straw. The bumper on the mixing container rests on the top of the mold form to assist in discharge of the adobe directly into the mold.

The adobe may then be spread with a long-handled trowel-like spreader. Special care should be given to press the adobe firmly into the corners of the mold.

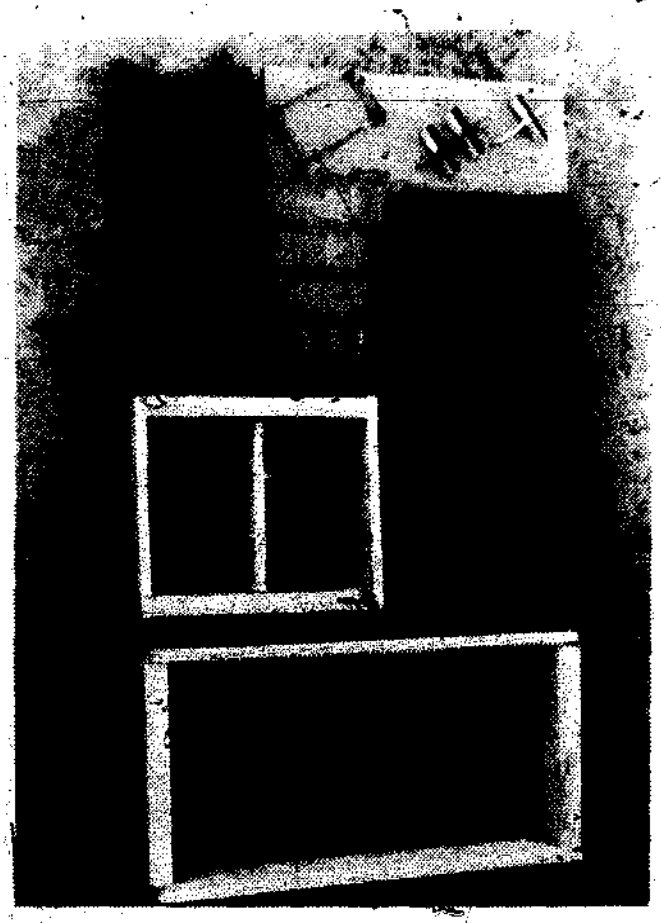
When the mold has been filled, it may be removed immediately. If the mix has been made properly, the wet bricks will slump slightly but not loose their shape.

The mold can then be moved to the next position to empty the remainder of the mix. The operation is then repeated. The mold should be cleaned as often as necessary to prevent any drying of residue adobe on the mold surface.



D. Molding

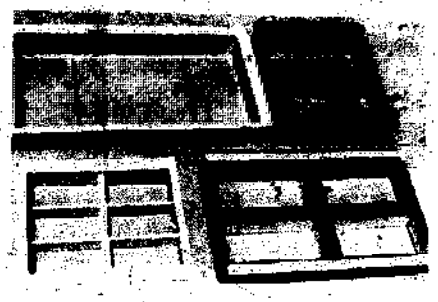
Effective molding depends on proper soil selection, thorough mixing, proper moisture content, adequate mold surfaces, and spreading action to completely fill the voids in the molds.



Clean, smooth, waterproof mold surfaces are essential for effective molding. The simplest and least expensive is fir, 2 x 4 inches, inside surfaces sanded smooth, used for the mold frame. This frame is bonded together with waterproof glue and then soaked in discarded motor oil to make water resistant.

A special smooth, black-coated plywood used by contractors in making concrete forms is effective. Vinyl, acrylic, polyethylene, formica, fiber glass, steel or aluminum may also be used.

Experimentally promising results have been obtained by using steel bands or wire tensioned across the bottom of the mold frame instead of partitions. As the mold is lifted, the bricks are cut to size. This leaves a more textured surface on the cut surfaces of the dried brick. It reduces air contact and may cause partial bonding of surfaces which are in contact while drying, especially if the mix is too wet. This type of mold is easier to make and simpler to clean.



The lips on the top and sides of the mold serve as a guide for the spreader and make it easier to lift. In hot weather, the residue on the molds dries quickly. Clean the mold surfaces as soon as possible after molding--soak, spray, or brush with water.

E. Curing

Proper curing calls for slow, even drying. Too rapid drying results in cracking. Damp, cool atmosphere prolongs the drying process. Rain on exposed bricks does not affect blocks if it occurs one or two days after molding. In hot climates, the drying process may be prolonged by spraying bricks occasionally, by covering them with straw, or molding in the afternoon so initial drying process takes place overnight. A day or two after molding, the bricks are sufficiently firm to be turned on their side to expose the bottom surface. This prevents cracking or warping.

If storing is necessary before curing is complete, blocks may be stacked to allow air circulation between blocks. Curing time will vary with size of block and climatic conditions. (4" x 8" x 16" blocks may take up to three weeks.)

F. Production and Competitive Materials Cost Estimates (San Francisco-Bay Area, 1974)

Production cost estimates for making adobe blocks are based upon the following: soil costs of $2 to $3 per ton FOB local quarry ("quarry waste" has been found to most closely approximate adobe soil requirements), and Chevron SS 1h emulsified asphalt at 44¢ per gallon in 55-gallon barrels FOB Oakland plant. (It is also available from tanker trucks in bulk at 20¢ per gallon, plus delivery charge in quantities of five tons or more.)

Adobe Block Size	Approx. Weight	Materials' Cost		Total Materials' Cost
		Soil	SS 1h	
2 x 4 x 8	4 lbs.	.004	.009	.013
2 3/4 x 6 x 12	12 lbs.	.012	.027	.039
3 1/2 x 4 x 16	14 lbs.	.014	.03	.044
7 1/2 x 4 x 16	30 lbs.	.029	.066	.095

Labor cost is difficult to estimate and will vary with wages, skill, and efficiency of production layout. Using unskilled labor at $2.50 per hour, cost is estimated at about two to eight cents per block, depending on size of block and quantity made.

Competitive building materials and commercially sold adobe block retail 1974 prices listed below are excluding delivery charges and sales tax.

			Retail Price
Common Brick	2 x 4 x 8	=	.125
Concrete Block	4 x 8 x 16	=	.31
Concrete Block	8 x 8 x 16	=	.47
Slump Stone	4 x 4 x 16	=	.27
Slump Stone	8 x 4 x 16	=	.42
Adobe Block	$3\frac{1}{2}$ x 4 x 16	=	.25
Adobe Block	$5\frac{1}{2}$ x 4 x 16	=	.26
Adobe Block	$7\frac{1}{2}$ x 4 x 16	=	.33
Adobe Block	12 x 4 x 16	=	.50

III. BUILDING WITH ADOBE*

Adobe is most often thought of as a building material for warm, dry climates such as the Pacific Southwest in the United States. This is because natural adobe was made without a modern soil stabilizer. There are records of adobe or rammed earth construction in New England, Midwest, and the Great Plains states. With present day use of soil stabilizers such as emulsified asphalt, the range of applications and climatic conditions is greatly expanded. Possibilities should be very promising.

There are three basic types of adobe construction: solid wall block adobe; post-adobe with curtain or screen-type, nonload-bearing walls; and poured adobe which can be used in solid wall, post-adobe, or veneer-adobe type construction.

Common to all adobe construction are a number of principles or approaches. Reinforced concrete foundations are recommended for permanent residential construction. Foundations should be built to extend six inches above the surrounding ground level. (Adobe foundations have been used with satisfactory results for less permanent buildings or in especially dry climates).

Waterproofing all joints is very important--concrete to adobe, adobe to metal, and adobe to wood (as in window and door frames and wall to roof plate). Mastic, asphalt, or tar may be used. Adobe shrinks slightly in drying. For example, if blocks are not thoroughly dried, they will pull away from the mortar joints after being laid.

Adobe construction also calls for effective bonding together of structural elements. This may be done by using 3/8 inch reinforcing rod, as in the case of foundation, walls, and roof structure. Various methods have been used to tie wood to adobe. A section of wood can be routed out to allow adobe to flow into the recess. A corrugated strip of metal may be nailed to the wood and then laid eight to ten inches into the adobe wall at twelve inch spacing. Door and window frames may be anchored into adobe by driving two or three 20-penny nails into the jam every second or third mortar joint. Concrete may be used instead of wood for support posts, bond beams between adobe walls and roof, lintels, window sills, etc. Steel reinforcing rod (3/8") may be used vertically, horizontally, or diagonally. Such reinforcing is especially recommended, or may be required, in solid wall construction.

If there are any parts of the structure where there may be sustained exposure to moisture, wood should be treated. Rot-resistant wood, such as redwood, or concrete may be used. Variations in use of materials will depend on special circumstances of the locality in which an adobe structure is built, stress requirements, and availability of alternate materials.

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*For more complete architectural and construction specification detail, see Appendix A and Bibliography, including Uniform Building Code, Standard No. 24-15, Unburned Clay Masonry. Also contact your local building inspector.

A. Solid Wall Adobe Construction

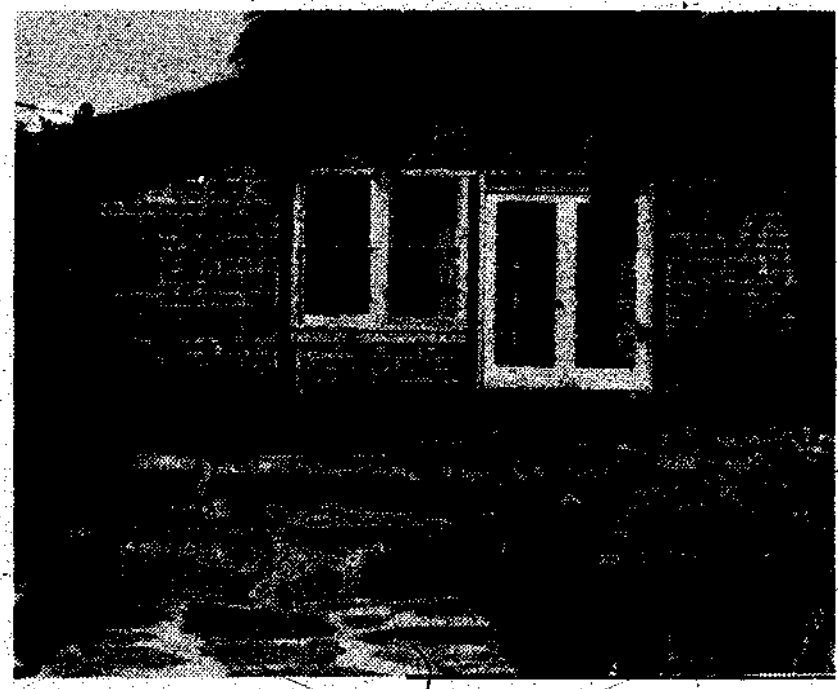
The basic rugged, massive quality of adobe shows itself best in the solid wall adobe structure. The deep recesses of the doors and windows accentuate the warmth and strength of adobe and also shade the windows. The thick walls also add to the insulating quality of adobe which makes homes so comfortable, especially in warm climates--protecting against the heat in the day and giving it off at night, thus keeping relatively constant temperatures inside.

In solid-wall construction, the load-bearing walls are typically sixteen inches thick. The adobe community center in the picture was built with 4 x 8 x 18 inch adobe blocks which were then painted.

B. Post-Adobe Construction

In post-adobe construction, the load-bearing frame, usually 8 x 8 inch redwood posts, has nonload-bearing screen or curtain walls. A concrete foundation provides a firm base for mounting the posts and for the adobe walls.

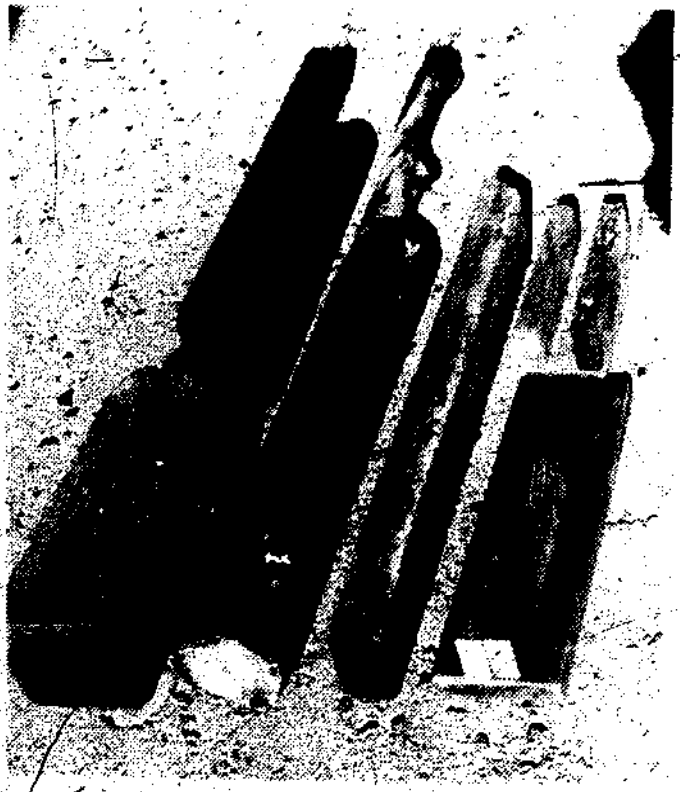
The post-adobe residence shown in the pictures has natural exterior walls with sealed and painted interior walls. Posts are 8 x 8 inch redwood, routed out wiring to be run in the posts. Posts are set fiv feet apart to accommodate three and a half 16 inch adobe blocks. Frame of posts and roof beams was built first and then walls of adobe filled in. Joint mortar was made of adobe mix to which cement was added. Perimeter radiant heating was used on the interior with units along the base of the walls.



C. Poured Adobe Construction*

The primary difference between poured adobe and adobe block construction is using the wet mix directly rather than molding the blocks and then mortaring them together to make a wall. This method has a number of advantages. The need for a block molding area and equipment is eliminated. The time and materials cost of moving individual blocks and mortaring joints is eliminated. If reinforcing wire or rods are used, the wet adobe will flow around them. Joints of all kinds are easier to make--concrete to adobe or adobe to wood or metal (e.g., foundation, plate-roof, door and window, etc.). Wiring and plumbing installation can be done prior to pouring (the building code requires that wall width be increased proportionally). Finished surface texture and designs are more flexible. It has been estimated that poured adobe construction requires about one-half the time per square foot of wall as is required in block construction. Poured adobe may be used for solid wall, post-adobe, or veneer adobe construction. It may also be used in combination with other traditional or contemporary approaches--frame, stone, geodesic dome, etc.

For solid wall, poured adobe residential-type construction, walls should probably be sixteen inches thick. Post-adobe poured walls should be six to eight inches thick. Adobe veneer should be one to two inches thick. (Wall thickness requirements depend upon applicable building codes, local circumstances, and the nature of reinforcement, if any, that is used.) Mastic or asphalt may be used for sealing joints.



Poured adobe construction, particularly post-adobe construction, has a number of basic materials-assembly considerations:

1. Selection of weight-bearing components
2. Methods or materials (aids) for bonding-stabilizing the materials used to construct the basic structural framework.
3. Materials, if any used, to support and/or reinforce the wet adobe, both in the initial drying process and in the final cured state.
4. Methods of mounting these materials on the skeleton framework.

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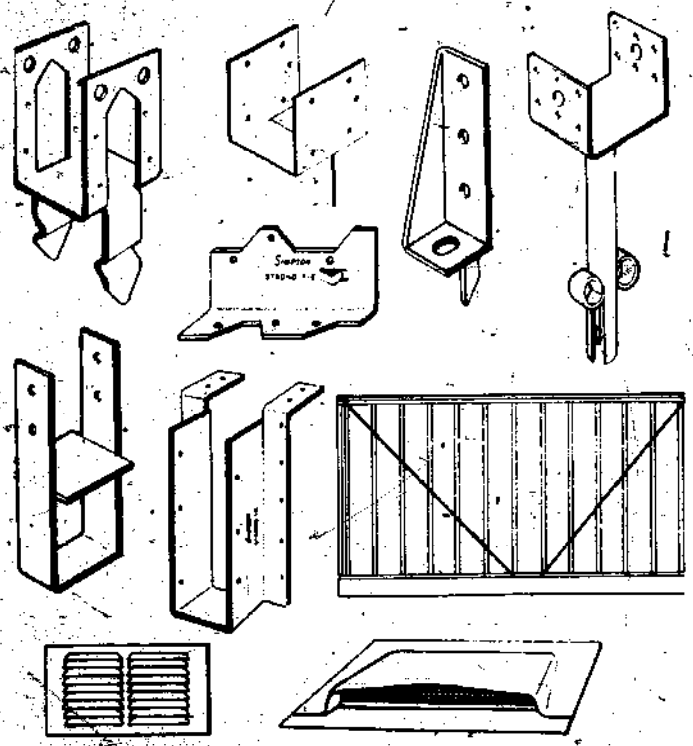
*There do not seem to be established Uniform Building Code standards for "poured adobe."



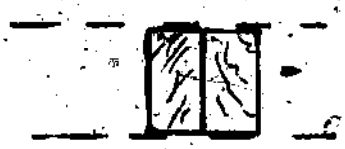
1. Materials adapted to structural framework; e.g., telephone poles, 8 x 8 inch timbers, railroad ties, customized posts--4 x 4 inches, plus 1' x 8"s, etc., four, six, or eight inch rigid plastic drain pipe perforated or solid.

2. Aides in structural frame assembly: anchors, framing hangers, connectors, etc. (Building Code Approved, Simpson Company, or equivalent)

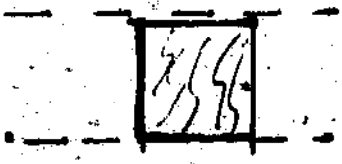
3. Adobe support-reinforcing materials: Primitive woven branches used in frontier type construction to support mud.

Plastic mesh (Christmas tree net) one inch wire mesh. Metal lath (expanded metal) provides better support than wire mesh.

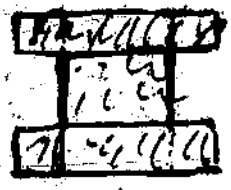
Alternative post designs



Two 2" x 4"s



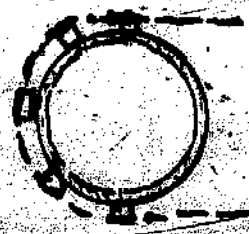
4" x 4"



4" x 4"
+
Two 1" x 8"

8" x 8"
routed

Telephone pole
or log

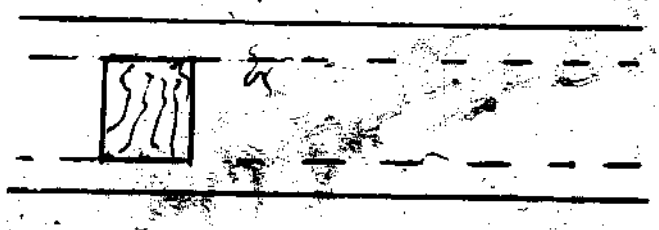


Drain pipe
with furing
spacers

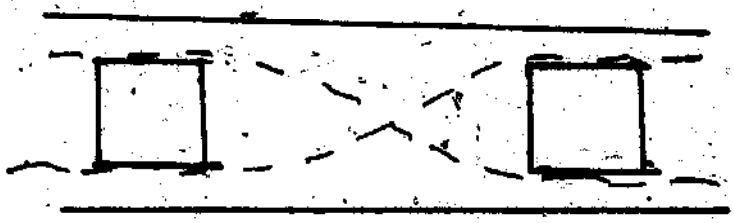
4. Methods of mounting wire or mesh on structural frame work

Wire or mesh may be mounted:

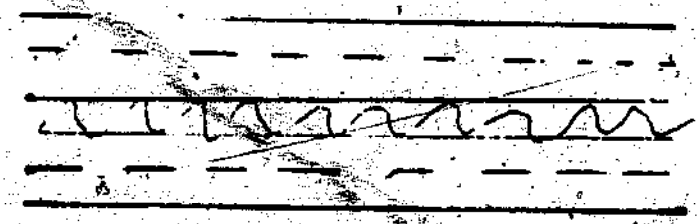
Parallel. On either side of a post about one-inch inside what will be the finished adobe wall.

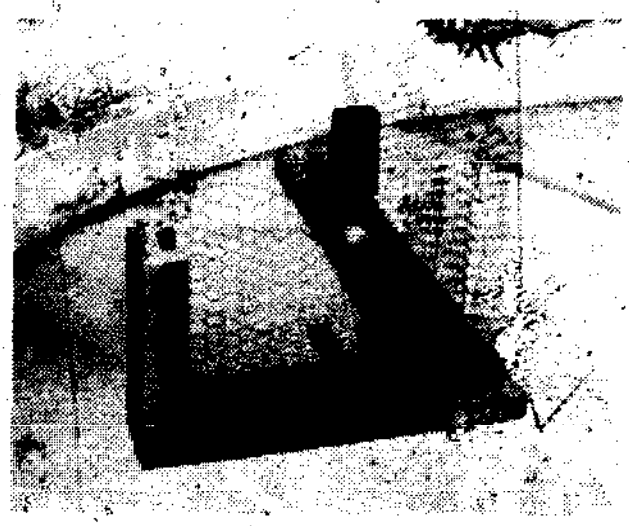


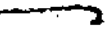
Woven. Alternate widths of wire or mesh placed inside and outside the posts as the wall progresses from foundation to roof.



Sandwiched. A modification of either of the above methods in which a filler or blanket of insulation material is added with or between the supporting wire or mesh.



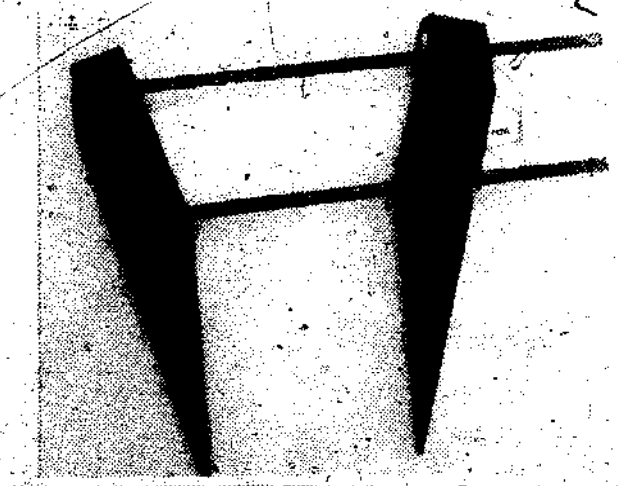


Sections of wire mesh may be mounted about one and a half to two inches from what is to be the outside finished wall surface. The parallel strips of wire should be reasonably stable during the pouring process. This can be done by double-ended wire hooks,  and/or putting temporary spacers between the outside form and the wire.

Wire reinforcing may be used horizontally instead of vertically. Wire mesh or heavier concrete-reinforcement (e.g., with 6 x 16 inch grid) may be laid every ten to twenty inches. Reinforcing is especially helpful in corners and around window or door frames. Rod may also be used as reinforcement. For example, it may run diagonally from foundation to roof plate. If rods are to be cinched down with washer and nuts, care should be taken that the rod does not sag while the adobe is poured around it; otherwise, when tension straightens it out, it can crack the adobe wall.

Poured adobe walls are made one layer at a time. As the lower layer dries, it supports the next layer. For best bonding between layers, the lower layer should still be damp when the next layer is poured on top of it. The height limit of each layer will depend upon how thick the wall is, whether there are any internal supports (such as wire mesh) built into the wall, whether an external form is used to support the mix as it is being laid up, and how wet the adobe mix is when it is poured. About six inches to a foot is the approximate height for each layer without it slumping out of shape.

Movable forms can increase the speed of erecting poured walls. Two methods of supporting such forms are shown in the pictures. One method is to place parallel 2 x 4s on edge on either side of the wall. Another method is to use clamps. The one pictured was made by shaping a piece of 2 x 4, drilling



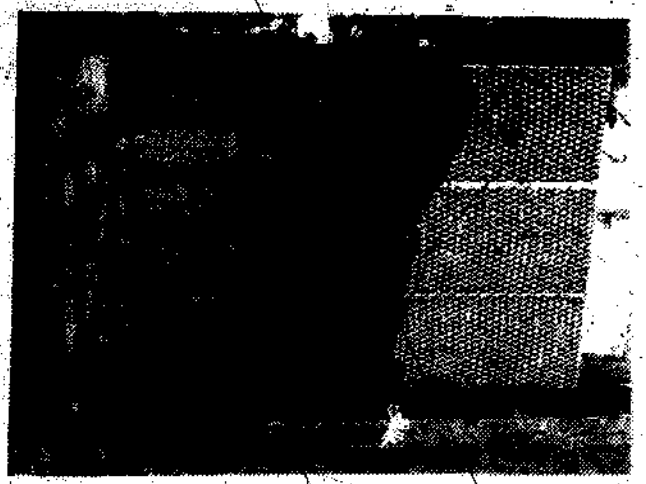
half-inch holes, and inserting half-inch aluminum pipe. Width is adjusted by holes one inch apart in which wire pins are placed to lock in position. The forms should be sprayed with water or brushed with oil to prevent the adobe from adhering to them. As each layer of adobe wall is completed, the forms are removed, cleaned, and moved to the next section.

The forms may be flat wood or a material with a mold design such as a section of vinyl siding, corrugated sheet of metal or fiber glass roofing, etc. Interior and exterior wall surfaces should be finished while still wet to the desired shape and texture.

Another advantage of poured adobe walls is that a "sandwich-type" wall can be built. A different type of mix may be used for the inner section of the wall than the outer section. For example, the inner section may use recycled scrap, a mix with sawdust or other filler, or a mix with a different color soil than the outer layer.

Notice the pictures of different ways of joining wood, adobe, and wire. Such joints are common to any type of adobe construction, but most frequently in poured post-adobe type building. Common to the three designs is to provide for verticle stabilization of the adobe by a lip or recess in the post, and to mount the wire so adobe can flow all around it.

Veneer is another application of poured adobe. Such veneer may be used for exterior or interior surfaces. Exterior plywood, chipboard, particle board, or other similar material may be used as a backing or base. It may be waterproofed, if necessary, by brushing on undiluted emulsified asphalt, using a layer of felt paper or plastic film. The base is laid on the ground and wire mesh, 3/4", 1", or 1 1/2" is attached by furring nails. The adobe mix is poured on and trowled through the wire and built up to the desired thickness, one to three inches.



To facilitate mounting, a one-inch lip may be left exposed around the base. This panel can then be slipped into a groove with mastic to make a simple, effective waterproof joint with load-bearing sides, base, and top.

Sample estimate of emulsified asphalt cost for post adobe and solid-wall home construction:

1. Post adobe construction with 8" x 8" posts on five foot centers (either poured adobe or block construction 8" thick).

   = 100' x 8' wall surface = 800 sq ft less 1/3 for doors, windows, and posts = 280 sq. ft.

   = 520 sq ft x 8" thick = 347 cu.ft adobe

   = 347 cu ft x .6 gal emulsified asphalt per cu.ft

   = 208 gallons emulsified asphalt at approximately .30¢ per gallon

   = $62.40

2. Bearing wall construction, 16 inches thick, no posts

   = approximately 2 1/6 times above estimate

   = 445 gallons emulsified asphalt at approximately .30¢ per gallon

   = $133.50

Note: February 1974 prices quoted for SS 1h per gallon
= .40 in 55-gallon drums
= .229 gallon in 500-gallon bulk
= .208 gallon in 1200-gallon bulk or more

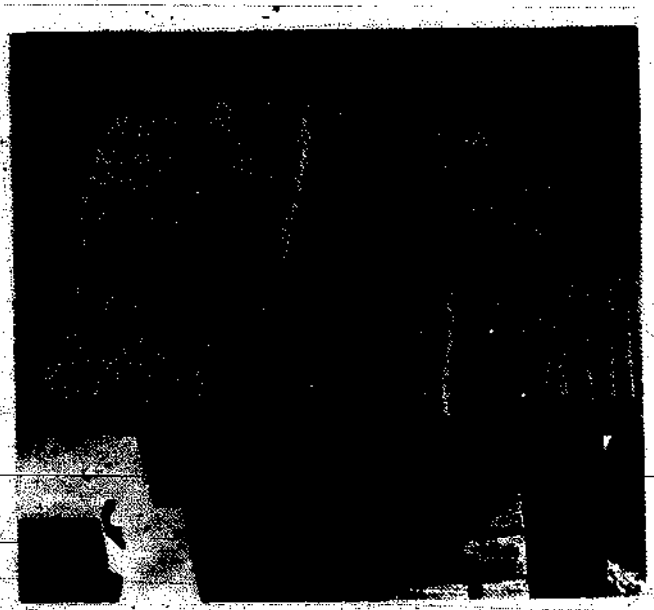
D. Roofs and Floors

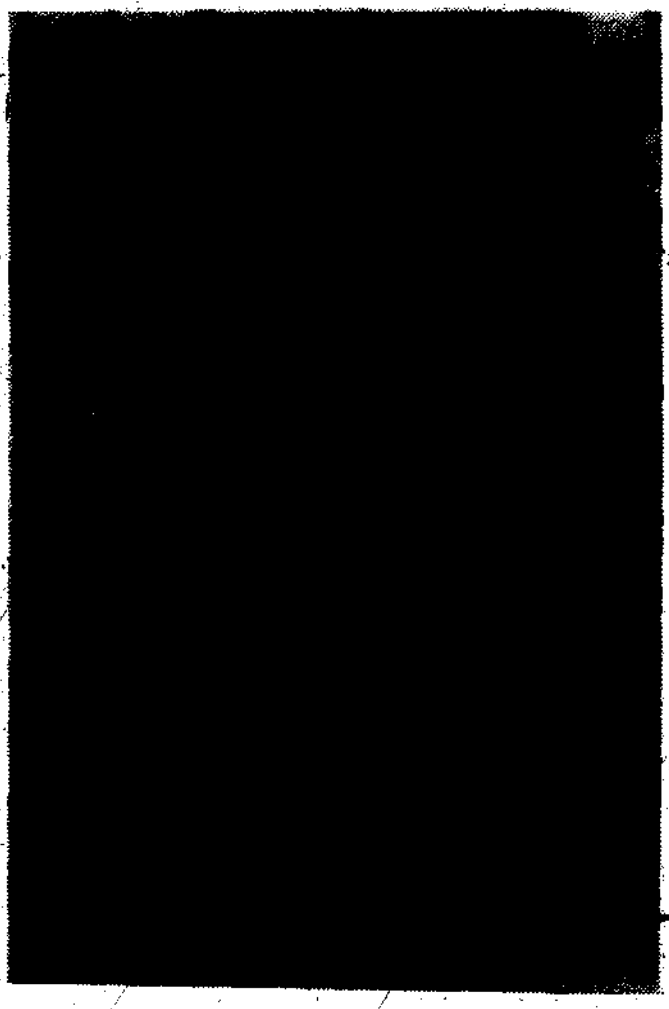
A number of experimental roof and floor adobe applications are reported in the literature.

A forty percent reduction in adobe mix for roof use has been reported (4). An experimental roof is shown in the pictures to the left.

The first picture shows the roof immediately after molding. The second picture is the same roof about two and a half years later, with constant exposure to the cycles of rain, frost, and sun. Note the minimal erosion shown in the slightly enlarged crack, lower left "shingle." The roof was constructed in the following manner:

1. A piece of exterior plywood was sprayed lightly with water to dampen the surface.
2. This plywood was then brushed with asphalt emulsion to seal and waterproof the surface and allowed to dry about twenty minutes.
3. Chicken wire was mounted on the plywood with furring nails. A tuck in the wire was made at the point where the simulated shingle would be the thickest. This would probably not have been necessary.
4. Adobe mix, about fifty percent soil and fifty percent redwood sawdust, was troweled firmly through the wire and built up, about half an inch thick at the top and about one inch thick at the bottom of the "shake shingle." This was allowed to dry about one day. (When an absorbant filler such as sawdust is used, the final color is quite dark.)
5. To give a more natural color and adobe texture, a thin (about one-half inch layer of adobe without the





filler) layer was trowled over the first layer. If the picture is examined carefully, this two-layer effect can be noted where the light top coat feathers off to show the underneath filler layer.

Cracks which may appear in the drying process may be filled with an adobe slip.

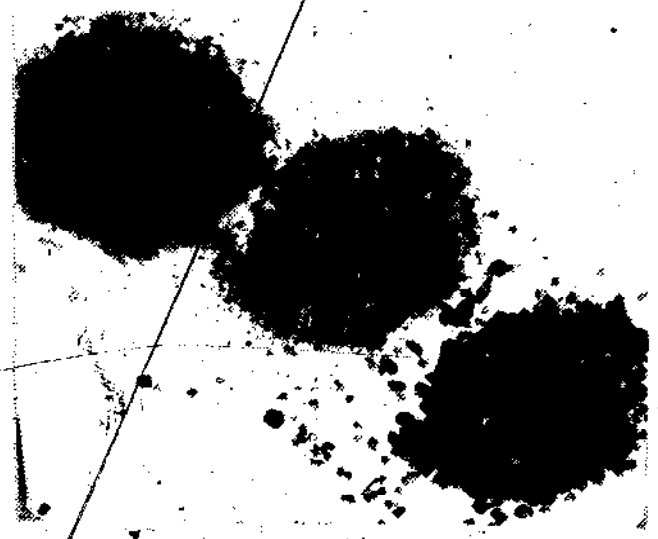
Poured adobe floors have distinctive and varied possibilities. Construction would follow basic principles used in pouring concrete floors, compacted red rock type base and moisture barrier. This approach was followed in making the exterior hillside step shown in the picture to the left. (See chapter on landscaping.) It has served very well for nearly three years, light foot traffic, without any surface treatment.

Adobe floor tile, 16" x 16", or adobe slab floors, up to 4" x 6' x 6', without cracking have been reported using Portland cement with basic adobe mix (4). Another method of making durable, attractive adobe floors has been reported. The adobe mix is poured. The mix may produce random cracks in drying. The natural mosaic is completed by filling these cracks with either blending or contrasting slip made of very thin adobe mix. After thorough drying, the surface is sealed with several coats of turpentine/linseed oil mix, allowing about a week of drying time between coats. The floor surface is finally finished with wax and polished (17, page 108).

More contemporary types of floor finishes should be satisfactory. Preliminary experimentation, upon the recommendation of a local paint dealer, used a resin sealer and then, at approximately one day or more intervals, brushing on thin (about 1 mil.) coats of urathane or verathane. These are available in "satin" or "gloss" finish. To assist the bonding, the surfaces should be rubbed with steel wool. This gives a smooth, hard abrasion-resisting surface.

Although no reports have been found, it would appear that a poured adobe floor would be ideal for radient heating.

E. Fillers, Joint Mortar, and Finishes



Experimental work and reports in the literature suggests that a considerable variety of "fillers" or "additives" may be used in adapting the basic adobe-making process to special local circumstances and end uses or effects. Eucalyptus pods, walnut shells, and sawdust (wood chips) have been used experimentally. Nut or seed shells, chopped fibers, shredded cardboard, mine tailings, etc., should have possibilities. Use of such fillers could be dictated by availability, desire for weight reduction, or for aesthetic effect.

Joint Mortar. Proper mortar for firm and waterproof joints is important in working with adobe. Adobe blocks should be moistened with water before mortar is applied. The commercial producer of adobe bricks has recommended a joint mortar formula of 1 cu.ft. soil, 1 bag cement, 1 gallon emulsified asphalt, and water as needed (5). A slightly different formula has also been recommended: $2\frac{1}{2}$ cu.ft. sand, 1 bag Portland cement, $1\frac{1}{2}$ gallons emulsified asphalt, and water as needed for right consistency (8).

Finishes. The addition of emulsified asphalt to soil produces a block slightly, but almost unnoticeably, darker than the original soil. Color is importantly affected by the soil used--browns, reds and maroons, tan and yellows, and greys. Soils may be blended. Contrasts may be obtained by using, for example, a yellowish decomposed granite with a dark red or brown clay. When the adobe is partially dry, it can be lightly sprayed or brushed with water to wash away some of the clay particles exposing the larger yellow-tan aggregate. Pigment powders as used in concrete may also be used.

Final interior and exterior surface finish is optional. Clear sealers and finishes such as described in the section on floors may be used, or surfaces may be painted.

IV. LANDSCAPING WITH ADOBE

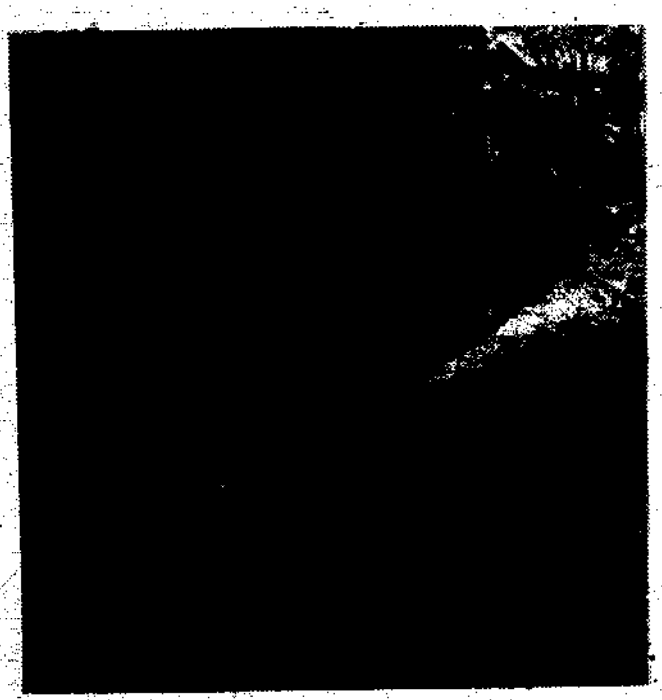
The average home setting presents an amazing number of landscaping applications for adobe blocks or adobe mix. Only a few are mentioned and illustrated on the left.

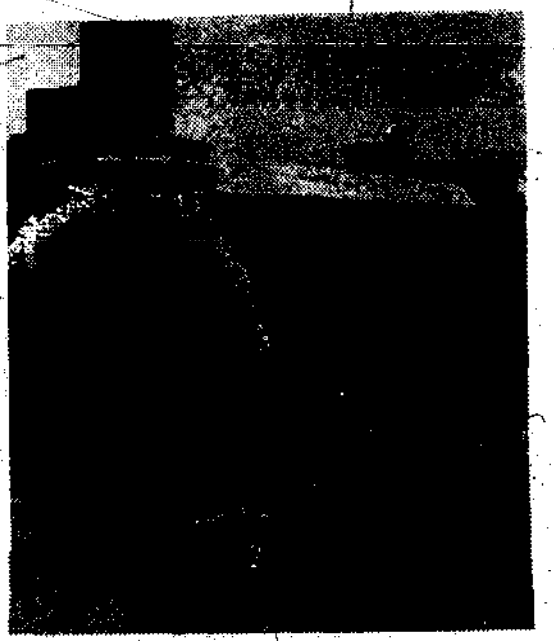
Adobe mix has a wide variety of applications. It may be used as a waterproofing agent for fence posts or wooden steps--brush on or soak in a bucket or trough made by putting a sheet of plastic in a ditch. It can be used for setting fence posts. Dig the hole, fill it partially with the asphalt-water mix, mix with soil in the hole; pour more asphalt-water mix, and add soil until post is set. It has also been used successfully for stabilizing hill areas. Make a shallow ditch with hoe or shovel following the contour of the slope. Pour the water-asphalt mix into the ditch and mix with existing soil, adding clay or sand as necessary. Let dry for several days and continue building up the contour to desired height.

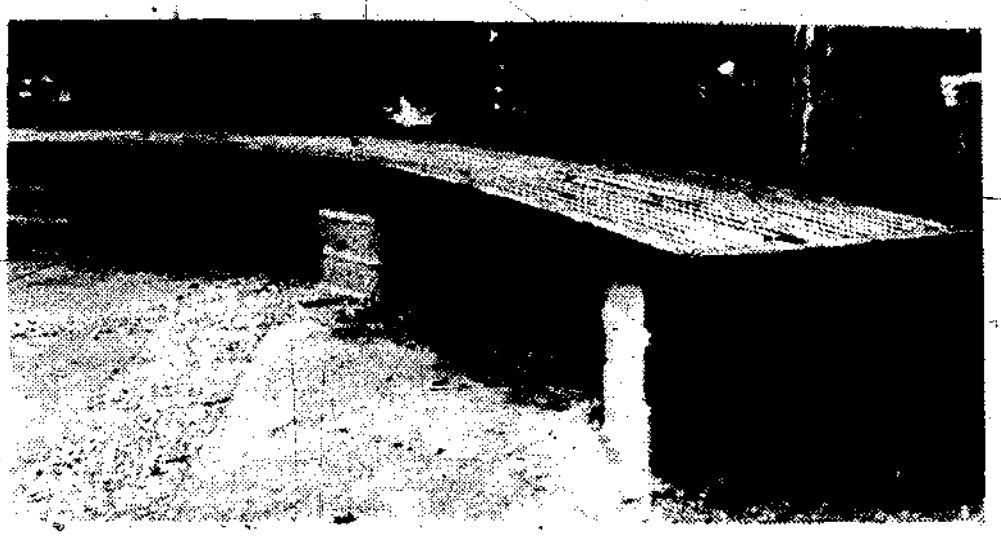
Adobe mortar--asphalt, water, soil, and cement also has many applications as a bonding filler for rock retaining walls, joining bricks, base for setting rock or tile in patio type area, etc.

Adobe may be used as a mortar mix, for making steps or patio area type mosaics. In the pictures shown, the area was first prepared by clearing out a base area about six inches below finished surface. Soil and gravel-sized rock was mixed with five parts water and one part emulsified asphalt. This was spread about one and a half inches thick over the base area and left to dry for a day or two. Then adobe mix was poured in to desired height and smoothed off. After several hours of drying, the

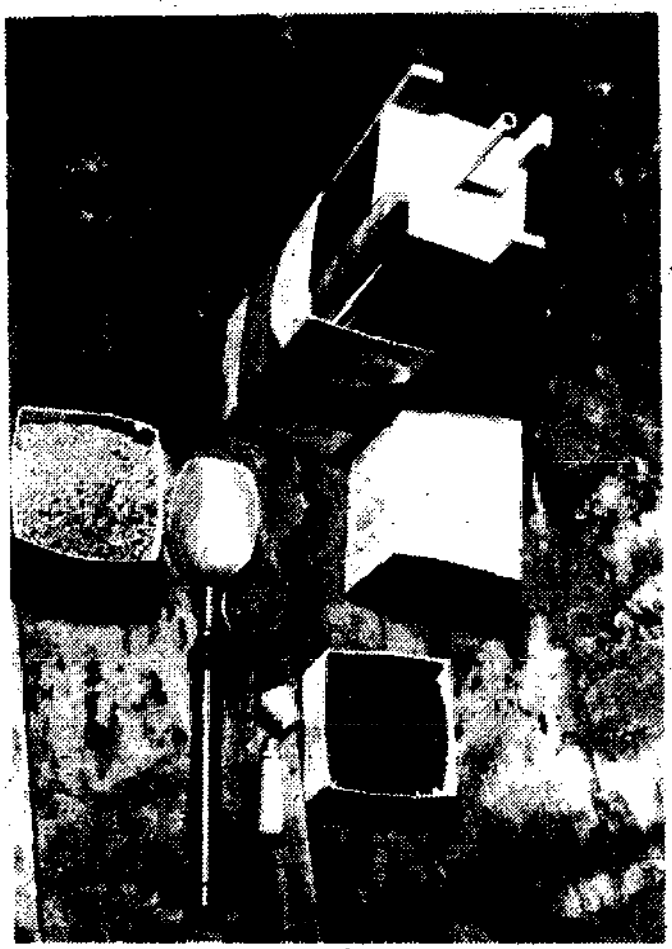
random simulated brick mosaic design was cut in with putty knife and spatula. After about a day of further drying, the cuts were repeated and the "brick" edges smoothed off. If weather is warm, keep partially covered or spray with water every three or four hours.







V. ADOBE ART-SCULPTURE

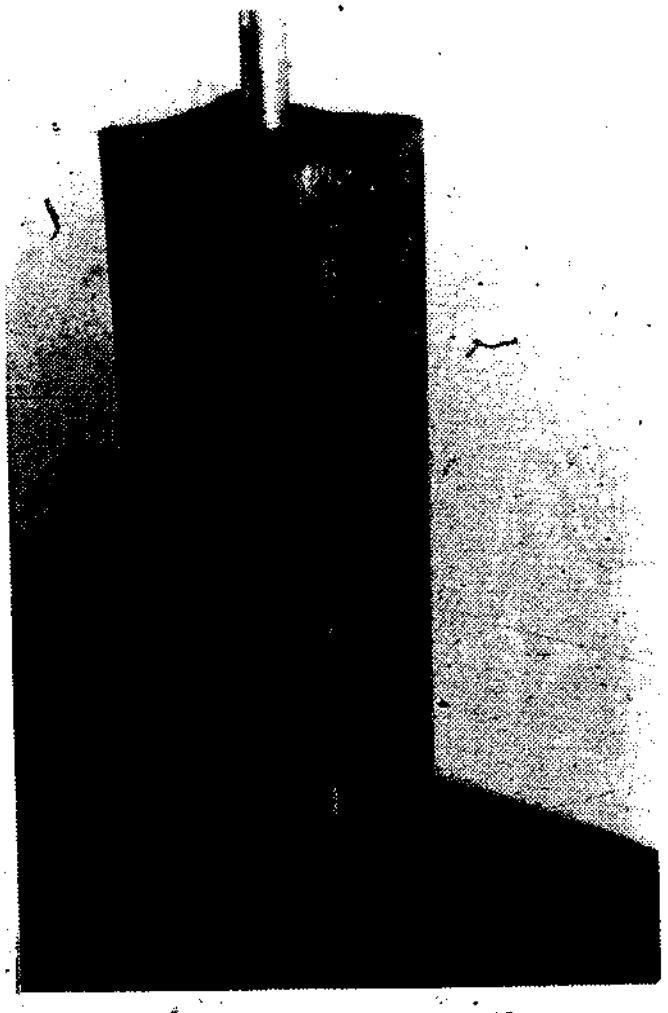


Art-sculpture applications of adobe are almost limitless. Soil technology is similar to that in ceramics. The molding process is much the same as with clay, but adobe does not hold a hollow shape unsupported. No firing is needed as in ceramics. Low plasticity is particularly important in making objects with large, flat surfaces. As with clay, large pieces may require rod and wire type supporting framework over which the adobe is molded. Cracks which may occur in drying may be filled in before drying is complete, or left untouched to add a random "cracked" effect.

The basic steps in most art-sculpture work involves rough molding, design application, drying, and final design refinement.

Mold forms of all sizes and shapes may be found in throw-away supermarket containers such as milk cartons, cottage cheese containers, egg cartons, ice cream containers, etc. Other mold shapes may be custom made for a specific end product. It helps release the adobe if the mold is dampened first. Or, a film of plastic (like one gets from a dry cleaner) may be inserted in the mold.

The adobe is pressed into the mold. Initial or final design work may be done in this wet stage. It is allowed to dry until firm enough to remove. At this partially dried stage, additional design work may be done or it may be left to dry completely. Different effects are possible at each of the three stages, and somewhat different tools are needed at each stage. When wet, the trowel or spatula-type tool may be most effective.

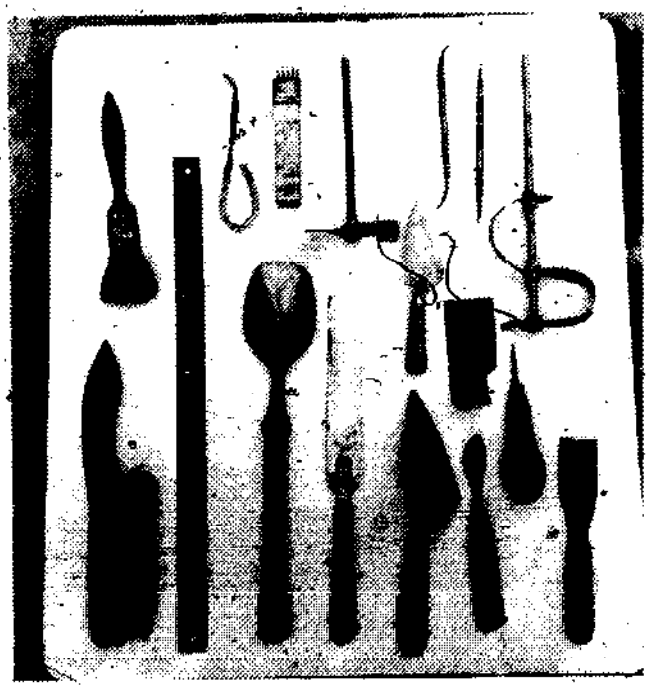


If the adobe mix has contrasting color or texture materials, e. g., larger light tan "decayed granite" and dark brown or maroon clay, an exposed aggregate effect can be obtained by brushing or spraying the surface with water after partial drying. The finer clay particles are washed away exposing the lighter larger particles. When partially dry, a fish scaler or multi-tined cake cutter may be used. When completely dry, a hacksaw blade, cold chisel, or masonry bit may be most useful.

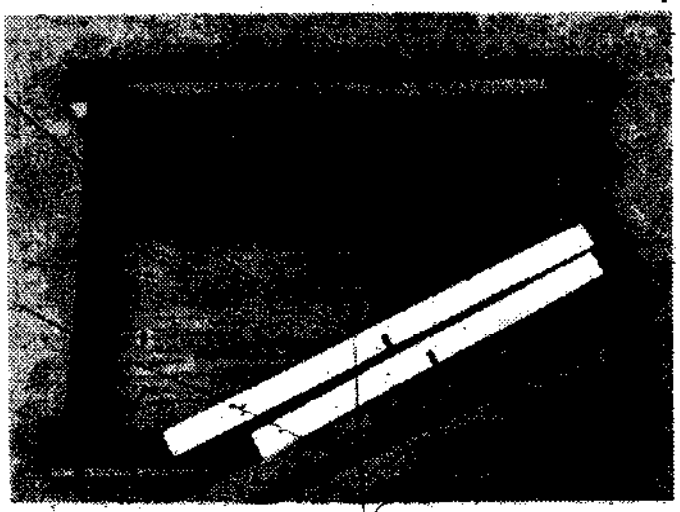
A wide variety of color, texture, and weight effects may be obtained with different kinds of fillers and surface applications. Sawdust, pulverized cork, wood chips, crushed eucalyptus pods, broken walnut shells, etc., are a few of the experimental additives which have been used. These color texturing materials may be mixed into the basic soil-base adobe. After the block has dried, a light pass with a masonry saw or rasp will bring out the color and texture of the material which was added. Another way to produce special effects is to press the wood chips, broken shells, or similar material into the adobe surface while it is still in the mold and still wet.

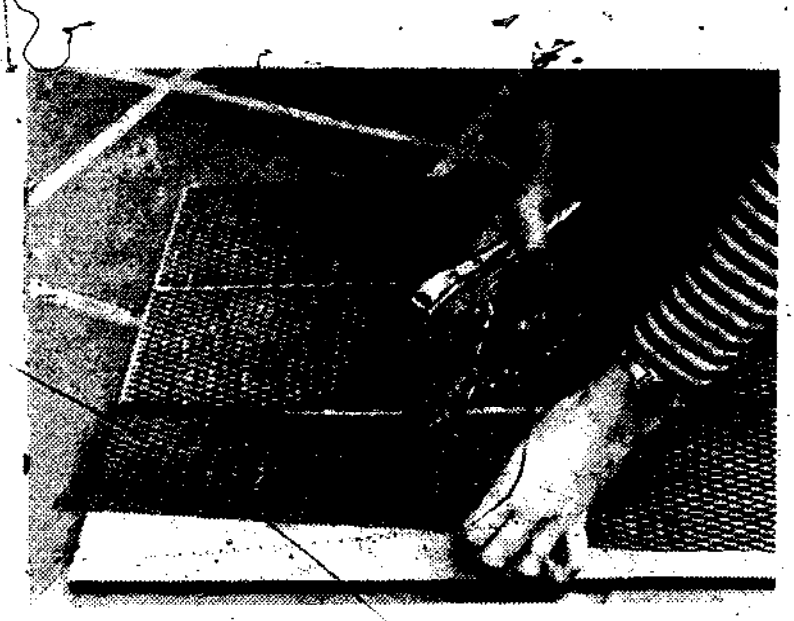
Fine, gritty particles tend to rub off from adobe surfaces. Experimenting has been done with a number of different sealers which are useful for such things as bookshelf spacer, lamp bases, wall mosaics, pieces of sculpture, etc. Aerosol epoxy or similar spray sealer is useful for some purposes. Thimed out, powdered resin glue mixed with water gives a hard, almost transparent, dull gloss surface. Urathane or Verathane gives a more glossy, hard surface.

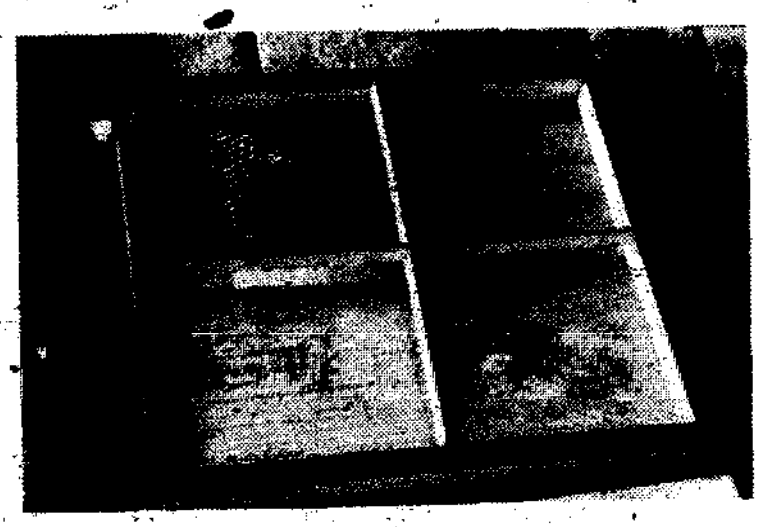
For a flat sculpture or mosaic-type wall hanging, a solid backing is necessary. This is necessary for molding and hanging. The simplest and most effective is a chipboard-type base the size of the finished hanging. The top

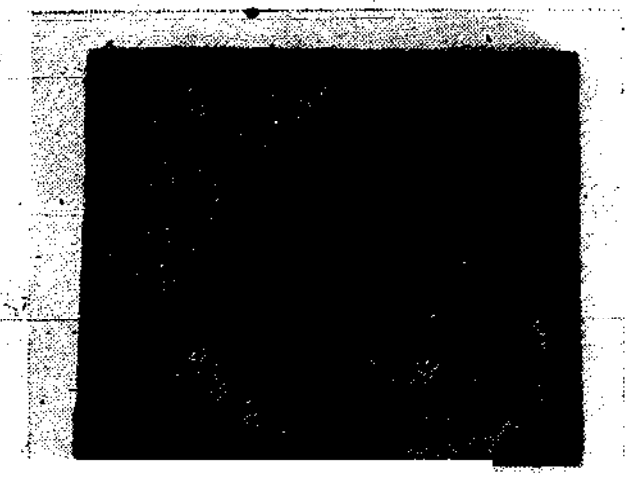


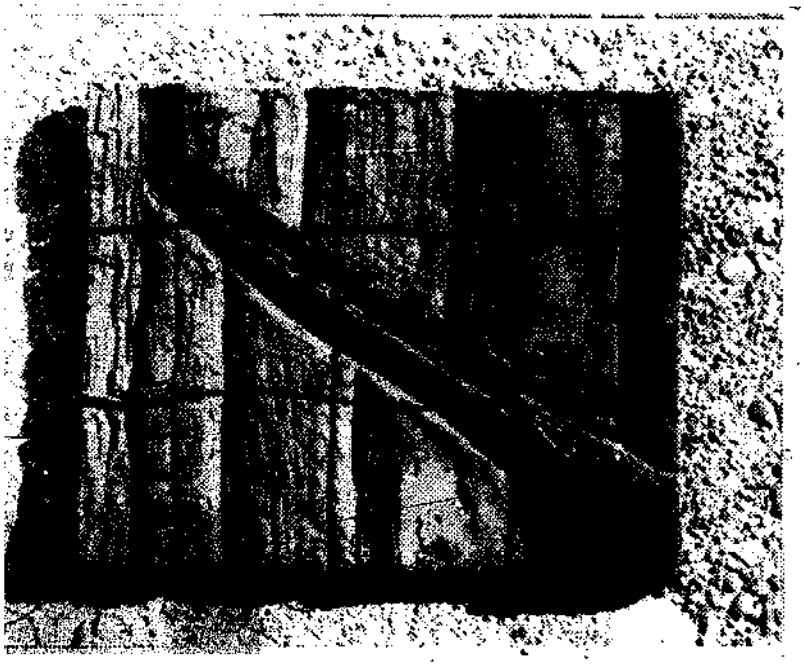
of this piece is painted or made waterproof with a film of plastic or asphalt emulsifier. A piece of metal lath or chicken wire slightly smaller than the base is cut and stapled to the chipboard so the adobe will bond to the backing. An open top and open bottom mold frame is now made to slip around the edges of the backing and extend 1 or $1\frac{1}{2}$ inches above it. The adobe is now trowelled into the expanded metal, and the mold filled to the desired depth. The desired design is made in the wet adobe. A knife or spatula is slipped around the mold between the frame and the adobe, the mold frame is lifted off, and the art object is gently moved to a storage spot for slow drying.

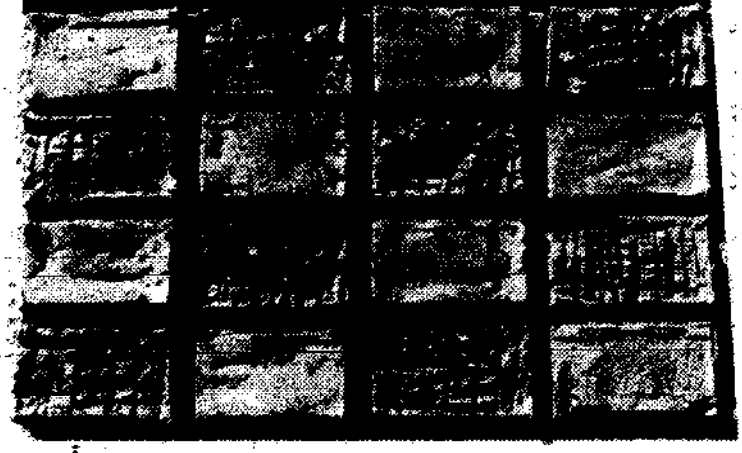


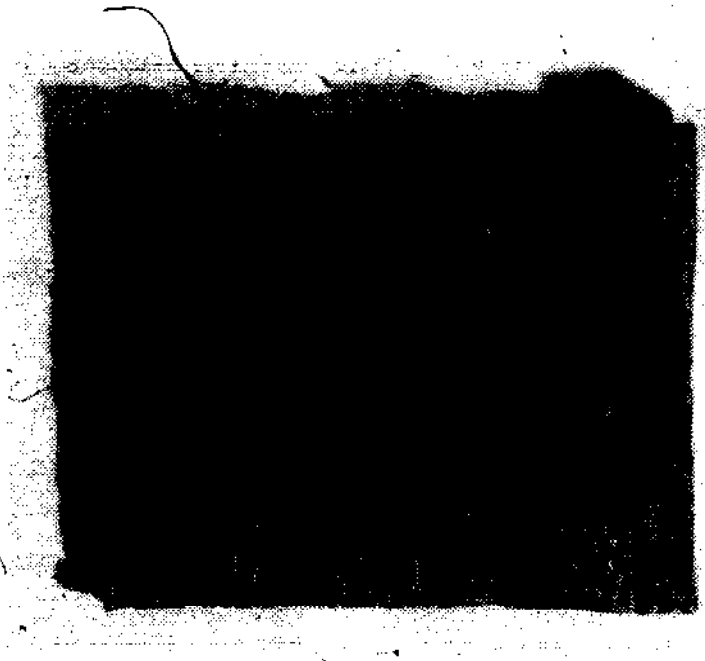


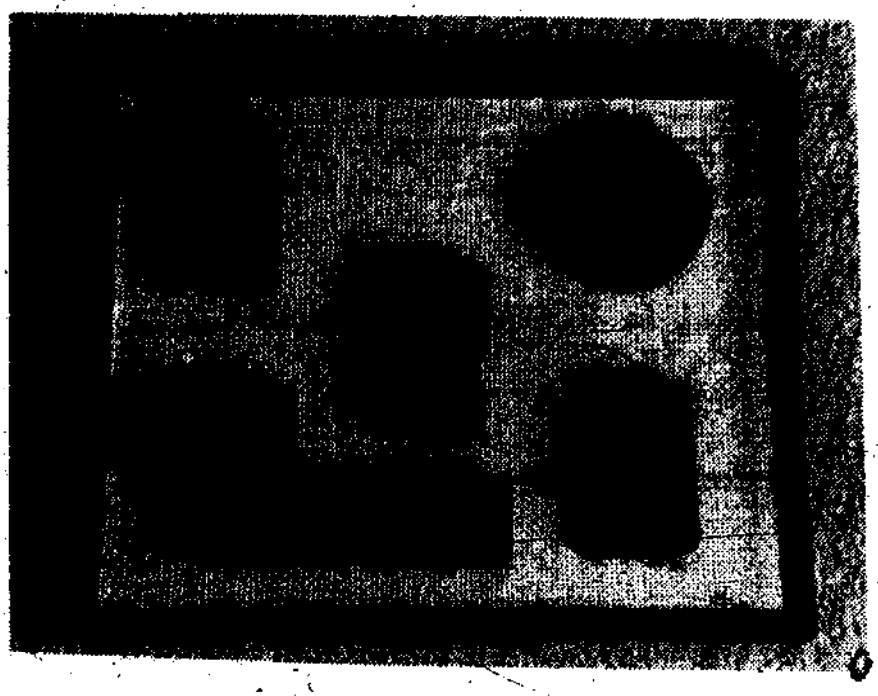


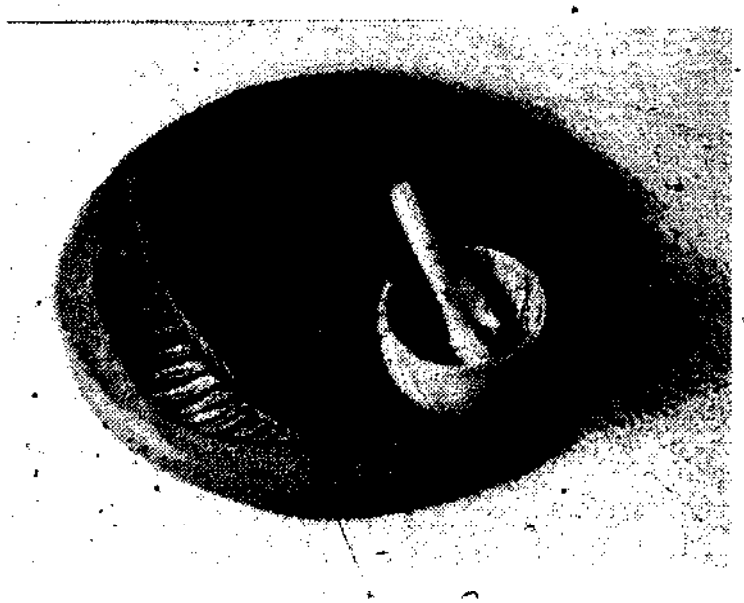


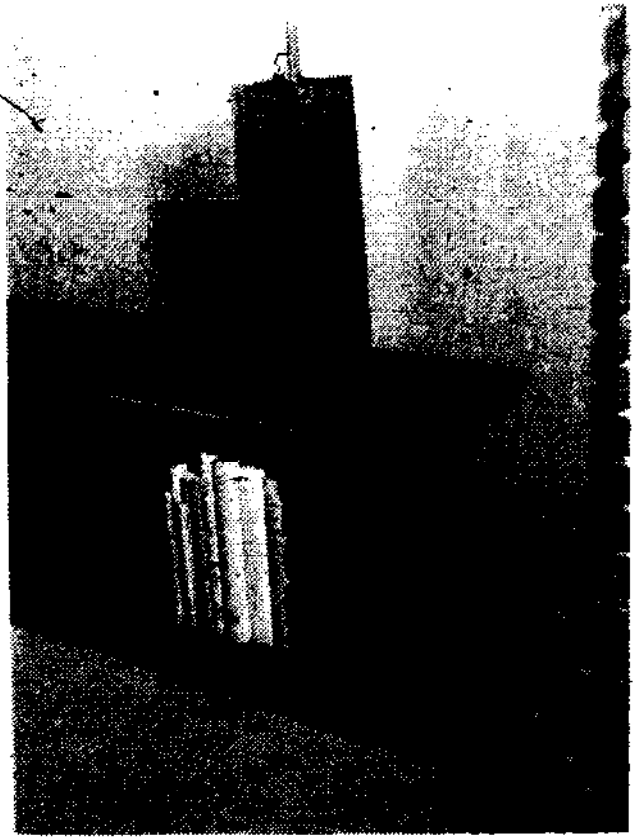


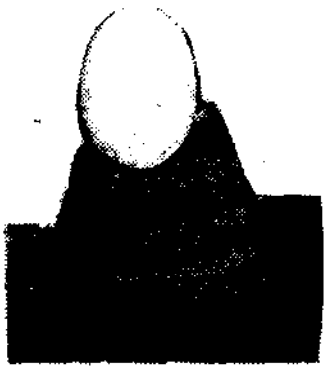


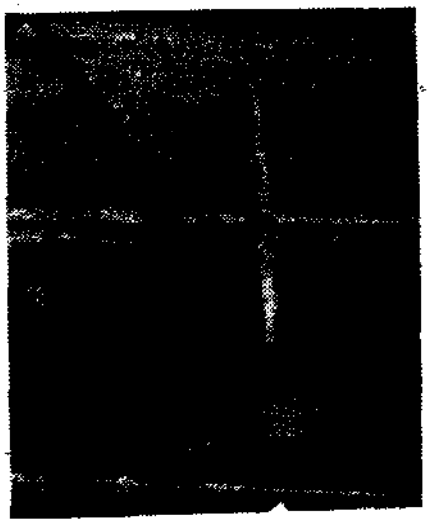


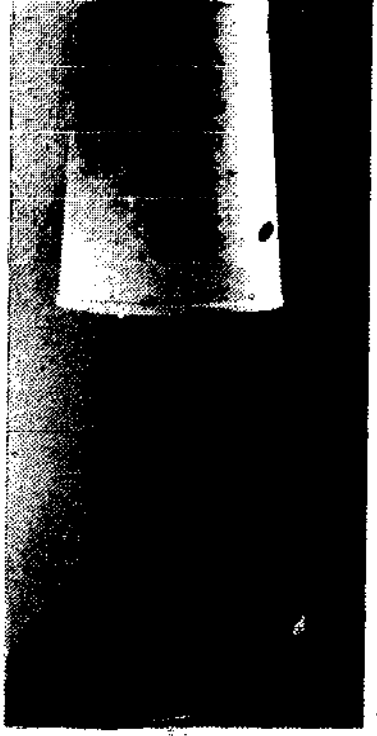


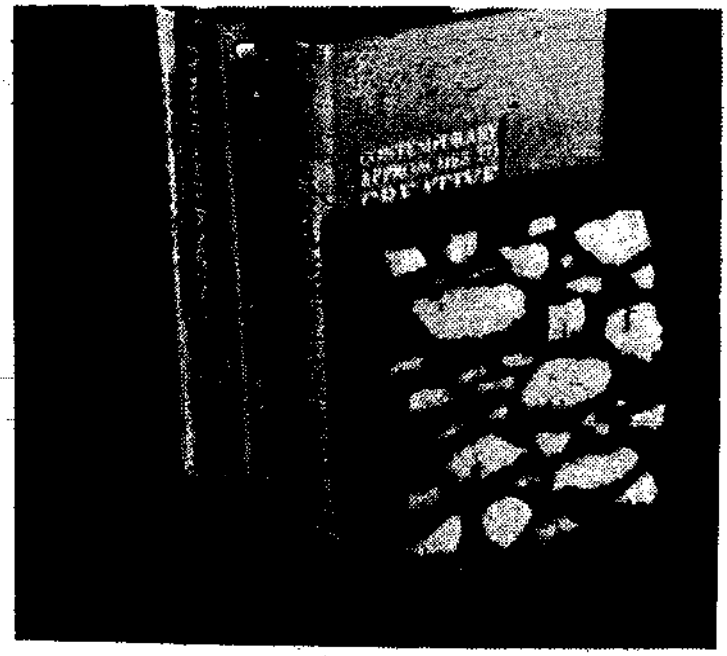


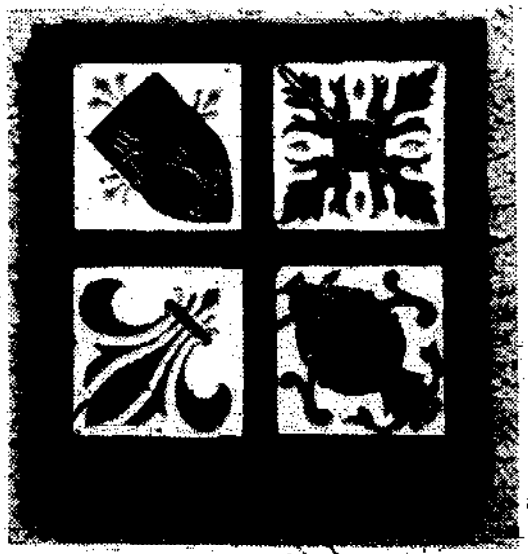


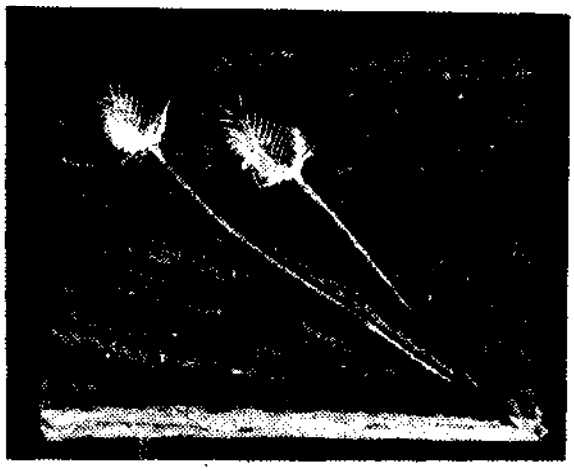


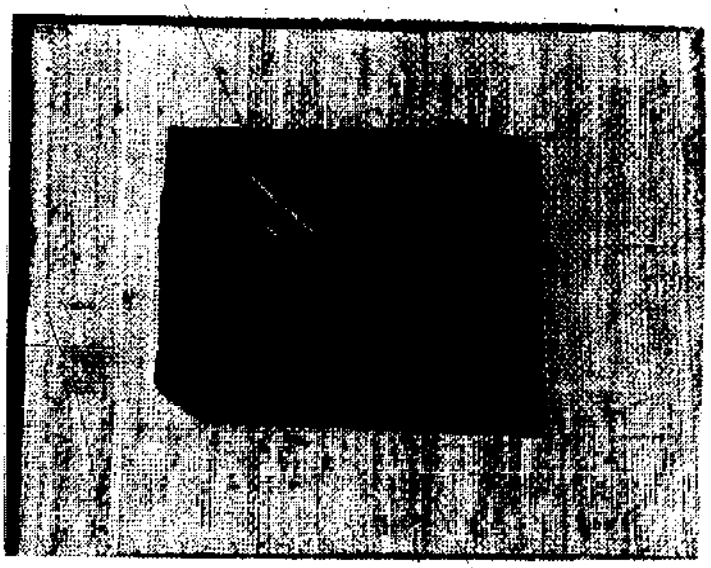


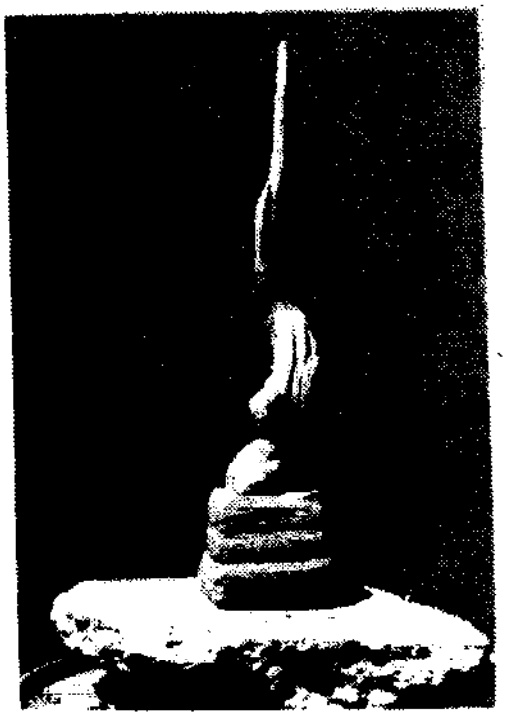


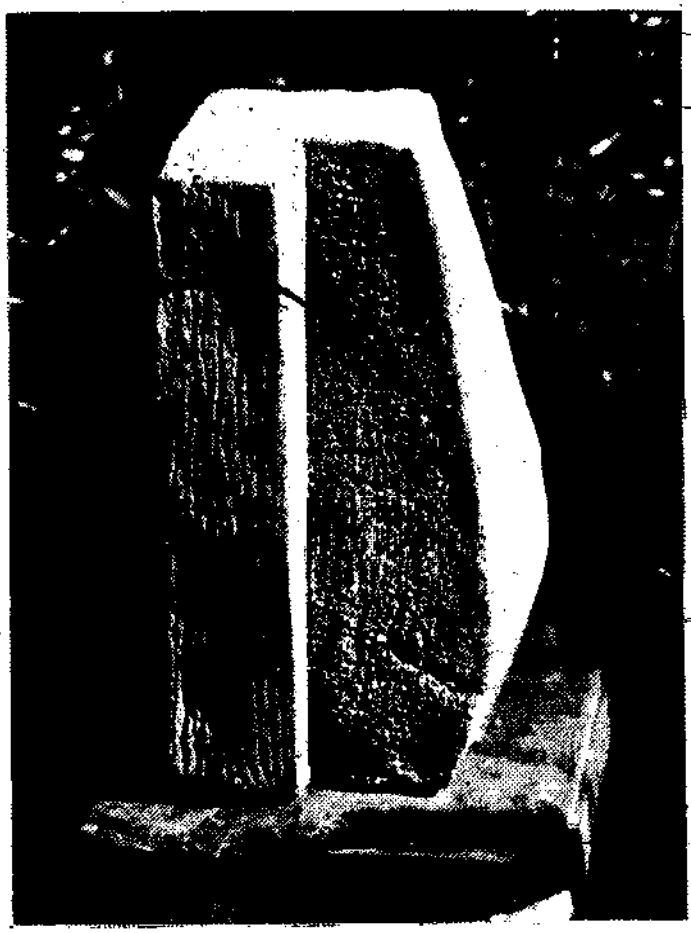










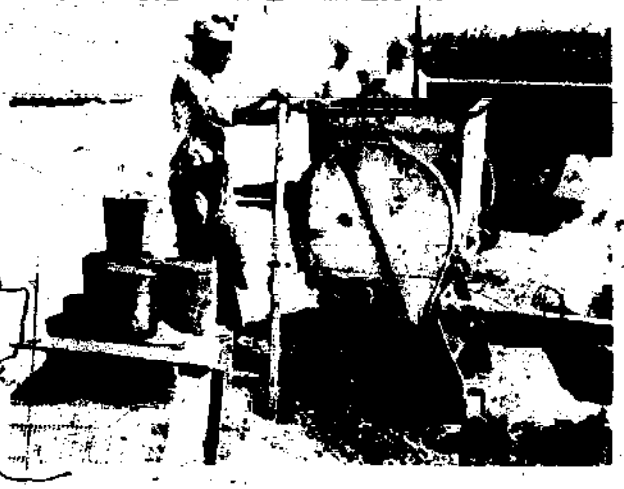


APPENDIX A

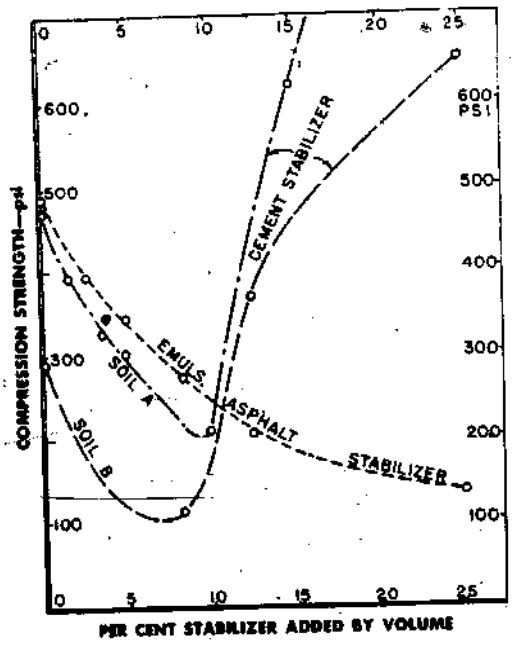
ADOBE CONSTRUCTION METHODS
(L. W. Neubauer, 1964 reprint)

Author's Note: Two of the most complete references for building with adobe are Long and Neubauer, Adobe Construction, Bulletin #472, 1946; and L. W. Neubauer, Adobe Construction Methods, Manual #19, Revised 1964, College of Agriculture Publications, University of California, Berkeley, California. The latter is an updated but smaller revision of the first publication. Both of the above are out of print. The University Publications Office advised the author that there are no plans for reprinting. Copies are only available in libraries. Since these publications are in the "public domain" a number of selected sections from Adobe Construction Methods are reproduced as a reader service.

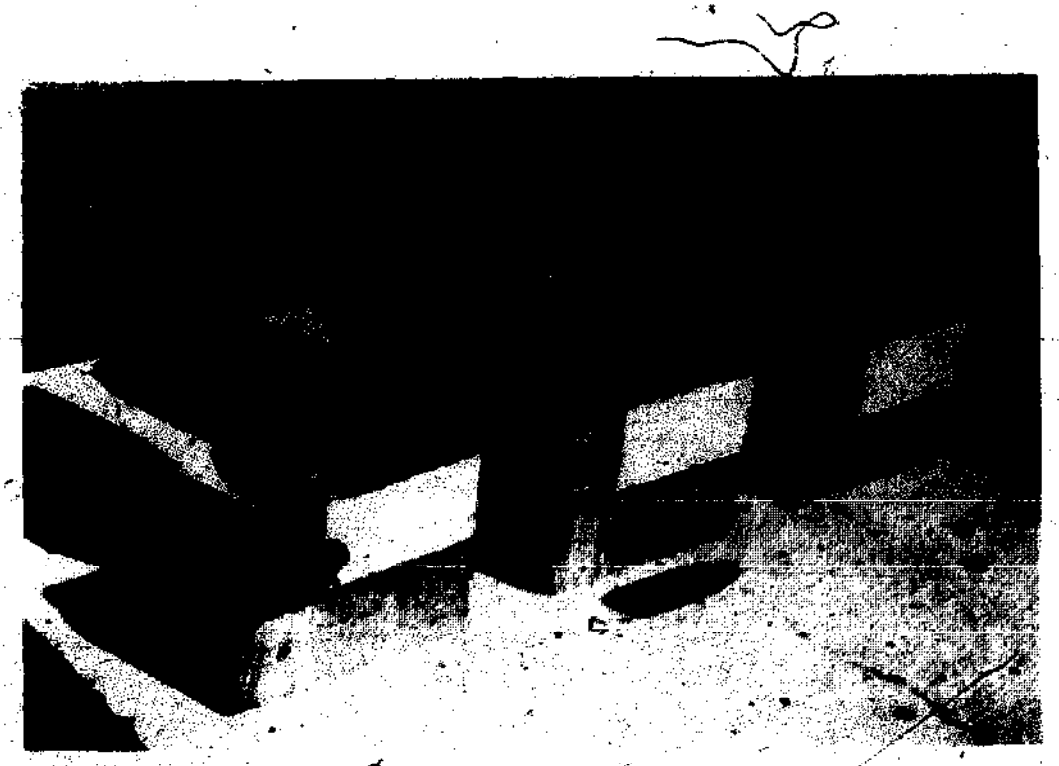
A HOME-BUILT ADOBE MIXER constructed with metal paddles on iron pipe. It is turned by a motor belted to the large pulley at the right.



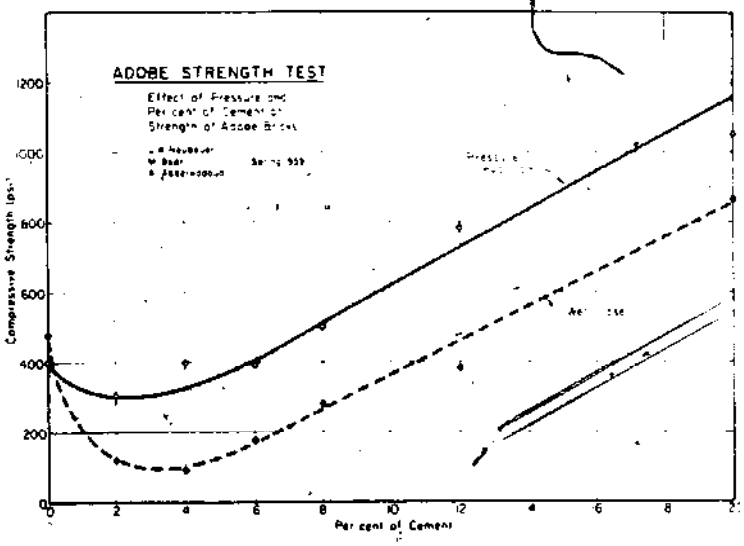
A DOUGH-MIXER used for adobe brick making. The interior blades are rotated by means of a gasoline engine.



This graph explains what happens if you add various amounts of emulsified asphalt stabilizer or cement to the soil.



Water-Resistance Tests. The bricks on the left are of plain soil, those in the middle are half sand, those on the right contain 10 per cent emulsified asphalt. The top bricks in each stack have no surface coating, the second (black) bricks were painted with asphalt, the third (white) bricks were painted with white house-paint, the bottom bricks with a patent masonry paint. Note that the stack on the right held up well although it had been tested in water for 1,000 hours.



Left: A high-pressure machine such as the "Cinva-Ram" can be used to produce bricks of greater strength. Right: Pressurized bricks can often be made doubly strong, or 200 to 300 psi stronger than common adobe bricks.

STRUCTURAL REQUIREMENTS . . .

To build a strong and stable construction that will last at least a generation or two, you must meet certain structural requirements.

Strength of Bricks. Common strength requirements for adobe bricks are: 300 to 350 pounds per square inch (psi) in compression, and 50 pounds per square inch in tension or shear. These are obviously much less than concrete or tile, but are normally adequate for safe construction. In the technical design of walls, a factor of safety of 10 is often used. That means that a compressive stress of only 30 or 35 pounds per square inch is permitted, and the tension stress is held down to 5 pounds per square inch, or zero. In designing for zero strength in tension or shear, you must build your walls very thick, or use some steel wire or rods for reinforcement.

Stabilization. It is often required that bricks be stabilized, either with some type of oil (to waterproof them) or with a hydraulic cement (to strengthen them and make them more durable). Any such treatment is very desirable: it may easily make permanent, dependable, and durable a wall that otherwise would be temporary, undependable, and absorbent.

Special stabilization of the bricks may not always be necessary, however. Some soils are relatively durable and resistant and may do very well without special treatments. Or, in well-drained locations, walls protected by protruding roofs may never become wet enough to warrant treatments, and may stand up in good condition for many years. Or waterproof paint, applied to exterior surfaces, may be sufficient to protect the walls from ordinary rainfall.

Size of Bricks. Common brick size is 4" × 12" × 18", having a volume of one-half cubic foot. This is about as heavy as you can conveniently handle, weighing about 50 pounds. The 4" height provides a good appearance in the wall, and you can lay the bricks so they can form a wall either 12" or 18" thick.

Sometimes bricks are made in other

sizes, such as 4″ × 8″ × 16″, or 4″ × 8″ × 12″, or 4″ × 16″ × 24″. You may prefer special sizes for corner details, window sills, jambs, or interior walls. When you use vertical reinforcing, half-sized bricks may leave room for vertical rods in the center of the wall, with the narrow bricks on each side. Some people make special units, having holes, grooves, or cavities, through which they project the vertical reinforcements. But special shapes complicate the brick making and are expensive. That's why many people simply saw and chip down standard sizes to the desired proportions.

Wall Height. Codes often require that you limit walls to one story in height. The second story imposes many complications and the need for much greater strength. When you build a two-story structure, make the first-story walls about 50 per cent thicker than those of the upper story.

Another code requirement calls for wall thickness to be ⅛ to ⅒ of wall height. An 8′ or 10′ wall might be 12″ thick; or a 12′ wall may have a thickness of 16″ to 18″. Many one-story walls are relatively thick, ranging up to 24″ or more, although some—particularly when reinforced with steel—are only 8″ thick. Generally, 8″ walls are not desirable because they are weak and do not insulate well.

Earthquake Proofing. In earthquake regions, hazard with all types of soil and masonry structure is rather serious. Adobe construction, being weaker than other masonry, is especially susceptible. But you need not fear ordinary earth temblors if you employ sound construction practices, use some reinforcement, and build lintels and plates of heavy wood timbers, or reinforced concrete.

Codes. Follow carefully all city, county, state, and national building codes; they are usually required for good reasons. In most cases they will include requirements very similar to the recommendations made in this section; such features are desirable even where no specific codes prevail.

The Uniform Building Code is a standard in many areas and should be heeded by incorporating accepted methods or following a design by a registered engineer or architect. Follow the "Riley Act" for earthquakes, that requires (when applicable) a horizontal resistance strength of 3 per cent of the building weight, but this is usually less critical than a design for resistance against strong winds.

. . . AND PRACTICES

In many respects, construction details for adobe houses are similar to those used for common wood-frame constructions. Foundations, plumbing, hardware, wiring, and roofing may require only small changes.

Foundations. Construct footings, piers, and foundations somewhat larger and stronger than usual because they have to support walls heavier than usual. Such practice is not always imperative, but a sound, stable foundation will protect you best against earthquakes and other unusual forces.

Preferably make foundations of concrete. Include three or four longitudinal reinforcing rods of adequate size the entire length around the building. On common clay or loamy soils that often get wet, limit the allowable soil-bearing pressure to about one ton per square foot.

On sandy or gravelly soils which are not subject to severe wetting, you can permit much greater bearing pressures—often up to two or three tons per square foot.

For footings and piers you may use brick, stone, or concrete block, built up to standard size or larger. These materials are never as good as reinforced concrete but they serve the purpose very well, especially for small houses and temporary types of buildings.

Common adobe blocks are rarely suitable for footings, for they will not stand up when wet. If stabilized carefully with asphalt or cement, however, they will resist moisture adequately and may do under light loadings and for temporary structures.

Walls. As mentioned before, walls may vary from 8″ to 24″ in thickness, depending upon the size of the blocks. Wall height is usually 8′ or 9′, or eight to ten times the wall thickness. You may lay bricks in various patterns, with random or staggered joints requiring a definite overlap.

Mortars can be made in two ways. Use either a mix identical with that used in bricks, but without coarse sand or gravel, to secure as uniform a wall as possible; or a high-grade masonry mortar with cement and sand proportioned 1:2½ or 1:3, often including a waterproofing agent, such as 10 per cent emulsified asphalt or vinsol resin.

Steel reinforcement is always recommended. The simplest method is this: Place heavy wires or rods in the horizontal mortar joints between the bricks, continuously around the wall. Space them 2′ to 4′ vertically. Also put the horizontal reinforcements just below and above windows. Use rods in pairs and lap them 2′ or 3′ at joints, as shown in the photo below left.

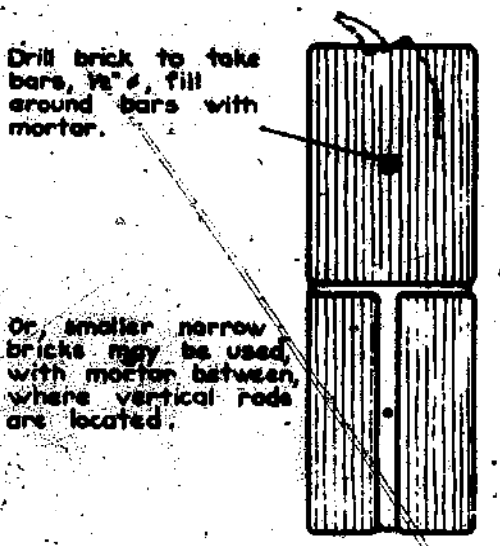
Vertical steel reinforcements are superior, and required by certain codes, but more difficult to place. You can either put the rods in the center of the wall, or stagger them from side to side. There are several ways to place them in the wall: you may split bricks, use narrow half-sized bricks (see photo on this page right), or drill holes vertically through bricks in alternate courses, and fill the holes around the rods firmly with mortar. The sketch on page 17 illustrates this method, and also shows details for a bond beam as well as joists and overhanging rafters. The bond beam, at the top of the wall, may be solid reinforced concrete 6″ or 8″ high, or may be faced with wood or adobe as shown in the sketch. The thin adobe brick facing provides the best natural appearance.

WALL REINFORCEMENT METHODS are shown in the sketch below. The picture on page 14 left presents a wall detail with a double row of horizontal reinforcement rods. Rods are lapped two or three feet at joints. The other two photos below show vertical reinforcement rods, set between split bricks in one row (center) and at the end of standard bricks in the next row (right). Steel extends from foundation up through band-beam or plate. The sketch below shows two methods of using vertical reinforcing steel.

BUILDING THE WALL can be done by unskilled labor. Photos on top of this page show how mortar joints are finished by hand, using a rubber glove (left) and how finished section of wall is broomed to remove loose mortar and dirt (right).

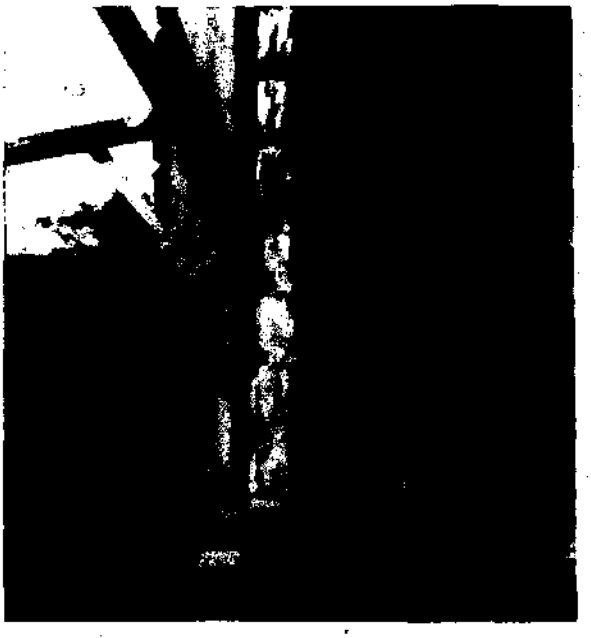
Windows. You may use any standard type of wood or metal sash. Set wood frames in place, and build up the adobe walls around them. Shape or groove adjacent bricks at the ends, to allow for mortar to hold metal ties, which are then nailed to the wooden window frame.

Iron or aluminum window sash are handled similarly. Brace them in position while you build adjacent walls. Groove brick ends for projecting flanges or metal frame. Use mortar or mastic to



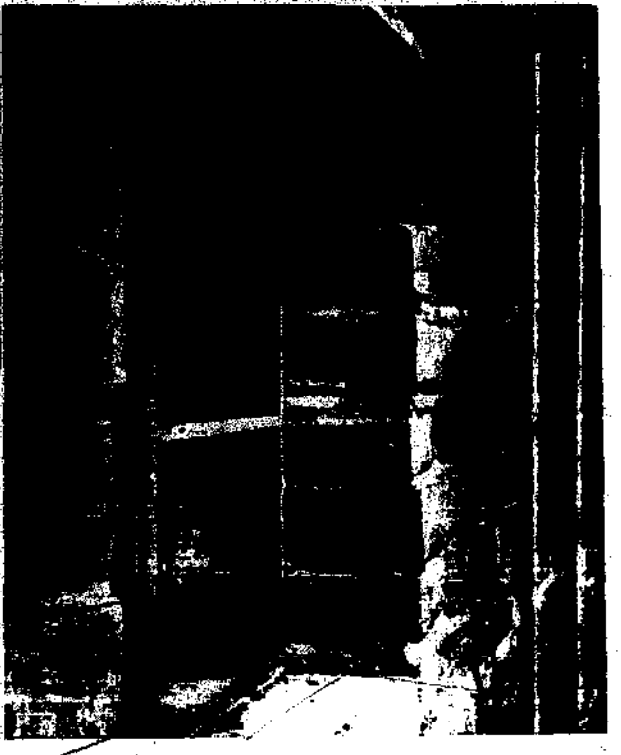
make a tight fit. See photos and sketches on these two pages for details.

Lintels. Use lumber or reinforced concrete for lintels over windows and doors. They must be strong enough to support the weight of bricks and to help support the bond beam, plate, and rafters. Details for a reinforced concrete lintel are shown in the sketch on page 17, indicating approximate dimensions and reinforcing steel required.

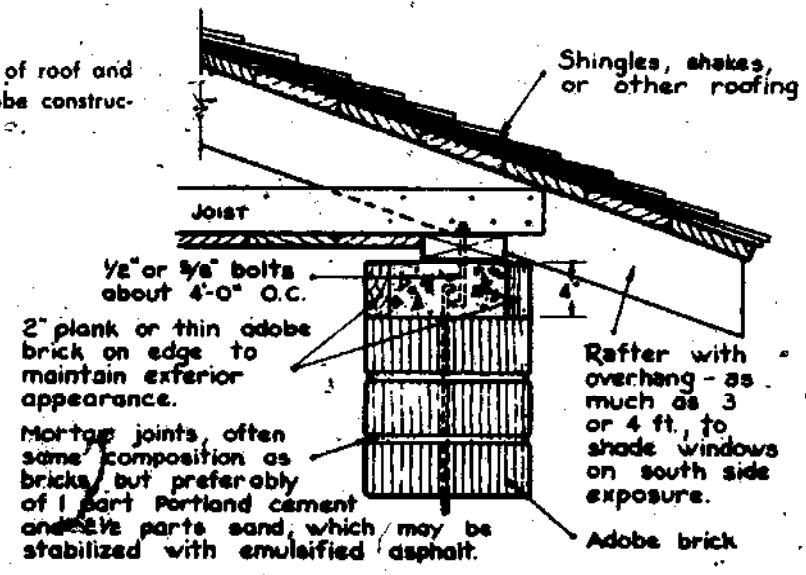


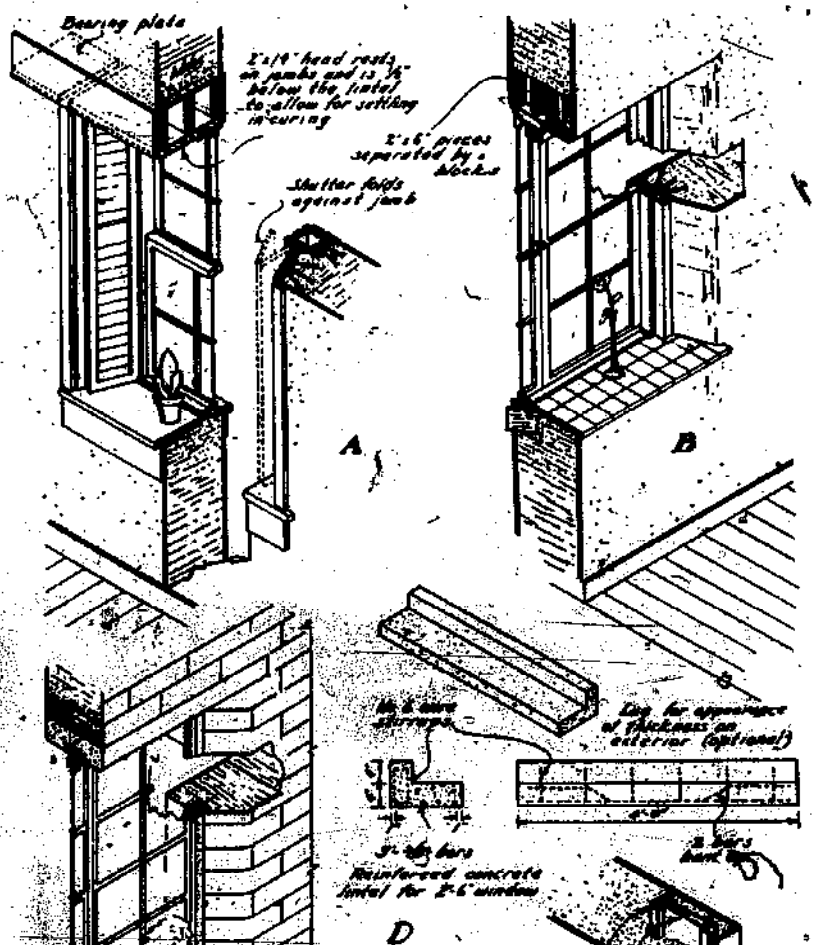
WOODEN WINDOW FRAME set in place, the adobe wall being built around it. One brick is used as a weight to steady the frame. Space below frame will be finished later with a concrete window sill, or one made of adobe or burned-clay bricks.

METAL WINDOW SASH (left). Edges are set in mortar and mastic. Window sill is of stabilized adobe bricks, set at an angle for drainage, and projecting a few inches beyond the wall. Right: Window in a finished adobe wall. The lintel is a heavy wooden beam. The sill is solid concrete.

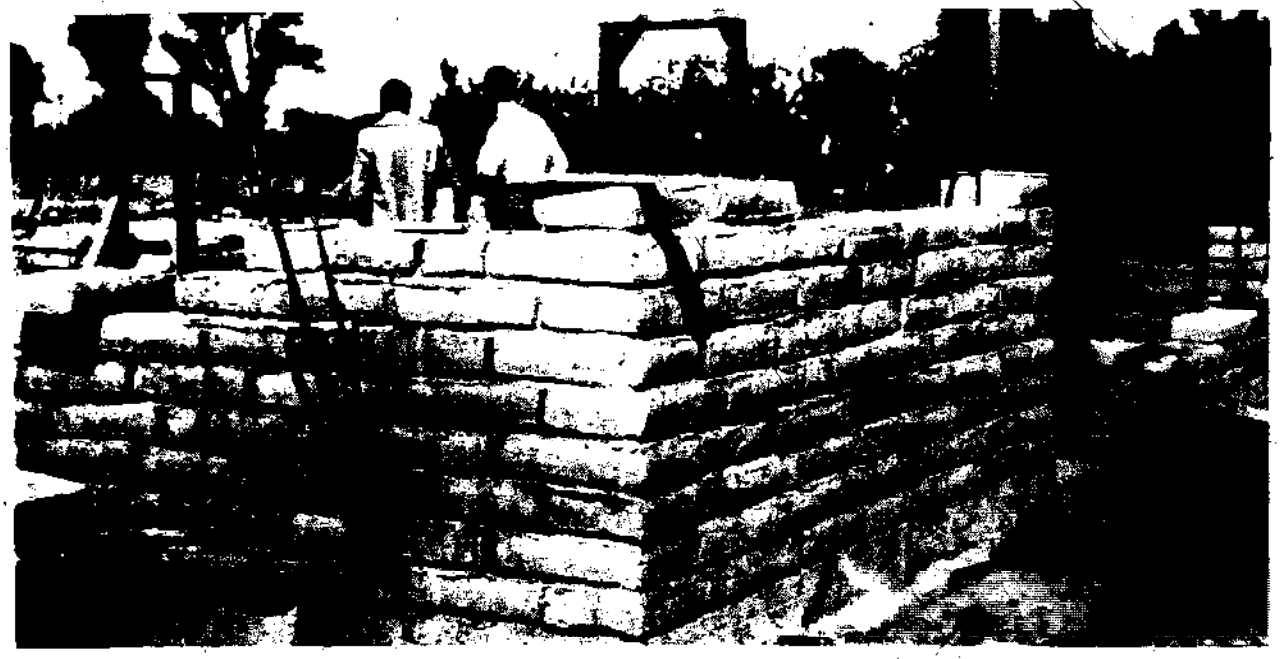


Cross-section details of roof and wall for typical adobe construction.





TYPICAL WINDOW DETAILS: A, Double-hung window, with standard sash adapted to splayed plank frame. B, Out-swinging wood casement, rabbeted 2 × 6-inch jamb, laminated lintel, "bull-nosed" plaster jamb, tile window ledge, brick sill, and roll screen. C, Steel casement window set in precast, reinforced concrete lintel. D, Reinforcing details for a precast concrete lintel. E, Steel sash on wooden T-shaped buck set in place in monolithic walls.



ADOBE-HOUSE CONSTRUCTION, showing brick arrangement, vertical reinforcing steel, and door frames in place.

Doors. You probably will use lumber frames around doors. Set them in place like windows, build the walls around them, and attach them with metal strips or nails 1" in the mortar joints. Use concrete or timber lintels over doors. Allow a total of ½" to 1" in height for vertical shrinkage in the mortar joints. Jamb anchorage is shown in the sketch on page 19.

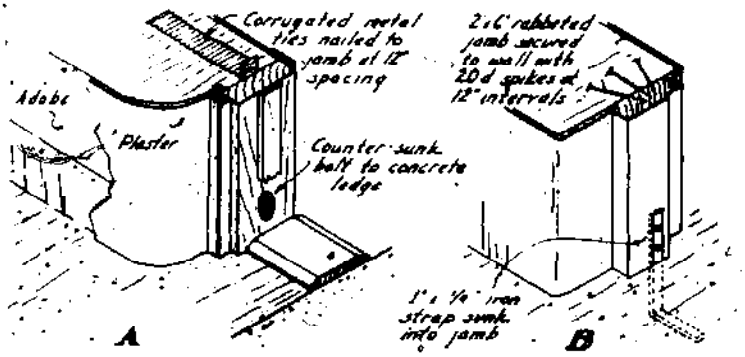
Bond Beam. A continuous reinforced concrete bond beam should extend around the top of the wall. This is an excellent stabilizing influence against strong winds or earthquakes. The beam may be as thin as 4" but it is better to make it 6" or 8". Two or more reinforcing rods should be included. These details are shown in the sketches on pages 17 (top), 20, and 21.

Interior Partitions. Walls or partitions within the house may be of thinner adobe sections or of wood frame. In either case, attach them firmly to the exterior walls with nails, integral masonry, or metal strips, as shown in the photo on page 19. Here the exterior wall was laid in anticipation of a subsequent interior partition. The metal strips may be laid in new mortar joints or nailed to wood studding.

Plumbing and electric wiring

In planning the adobe house you have to consider the needs for running rough plumbing and wiring through foundations and concrete floors. Most of the plumbing pipes can be fixed in place before pouring concrete for the footings, foundation walls, and concrete floors. Finish plumbing can be done later. Expert help is usually required.

Wiring also is sometimes located in the concrete of the floor and foundation. Protective pipes or conduit can be laid in place where desired or required, and the concrete poured around them. Be sure to have adequate wiring and outlets available wherever you may possibly need them. Wiring can also be placed between joists in floors or ceilings. Vertical chases or grooves are frequently left in adobe walls for wires or conduit, but this may weaken the walls or may require thicker walls to allow for the chases. Small vertical boxes or tubes may



Inside doors can be carried on simple jambs of stock dimension material. A. Where the concrete foundation extends above the door sill the lower portion of the jamb may be bolted to it. B. On a concrete floor an anchor plate accurately set in the green concrete may be screwed to the jamb.

also be used in corners, to carry wiring up or down. An especially convenient arrangement consists of a horizontal plug-in strip completely around the room, in a horizontal mortar joint on the inside about a foot above the floor.

Floors. Usually, the floor for an adobe house is made of masonry. Reinforced concrete is best, although you may use plain concrete, adobe bricks, or clay tile. These are placed on a sand or gravel fill, a few inches above the exterior gradeline. See sketches, pages 20 and 21.

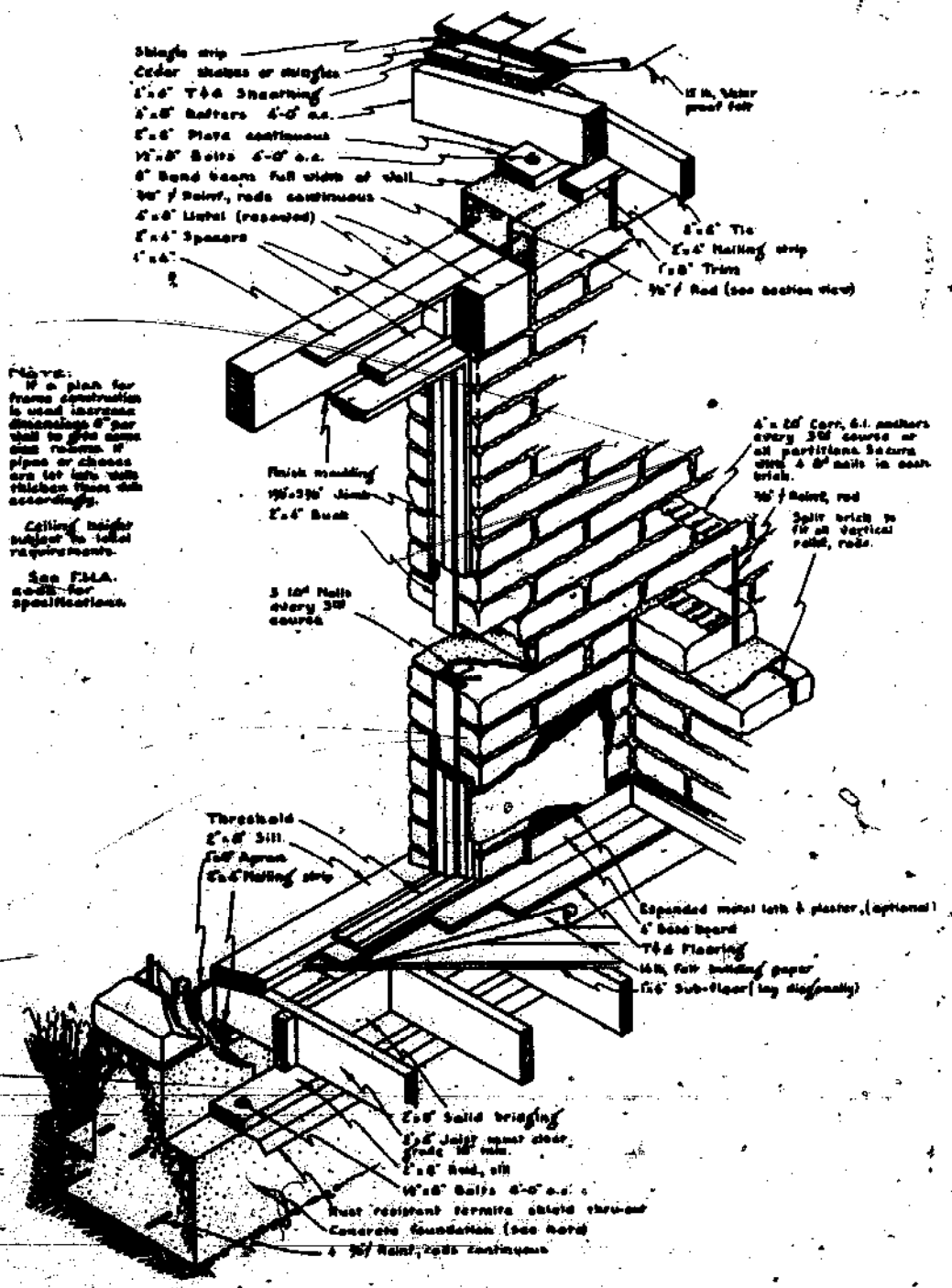
You may prefer a finish floor of wood or asphalt tile over the concrete; or you may want to construct a common wood floor on joists at 18" or more above the interior ground level. This is usually more expensive. A lumber floor is shown in the sketch on page 20.

Roofs. An adobe house can take any standard type of roof. Especially suitable are cedar shingles, redwood shakes, or clay tile. The latter is durable and attractive but relatively expensive. You can use cedar shingles or shakes on a pitched roof; on a flat roof you may try built-up roofing of a few plies of paper treated with hot tar, pitch, or asphalt. Details for both types are shown in the sketches on pages 17 (top), 20, and 21. Be sure to nail gable roof rafters especially well to ceiling joists, plates, and walls.

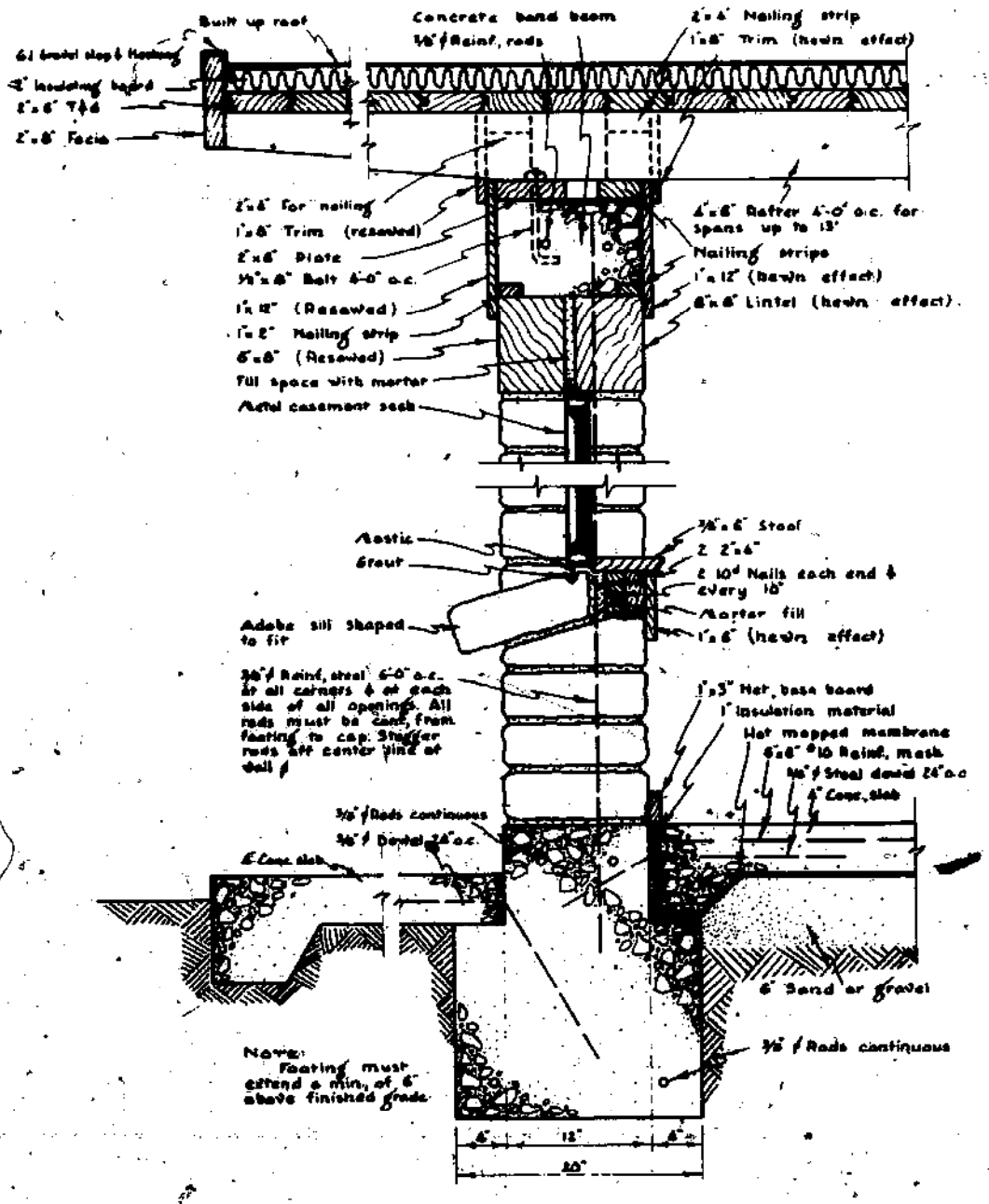
Many roofs are now being constructed with an overhang of two, three, or four feet, to help protect the walls from rain and provide shade for windows and walks. An overhang of about three feet on the south exposure will completely shade large windows from the summer sun but permit the low winter sun to enter all day long, greatly increasing heat and comfort in the house.

CORRUGATED METAL STRIPS are often used to attach an interior partition to the exterior wall. The attached partition may be of adobe or wood frame. Similar attachments are often used for door and window frames.

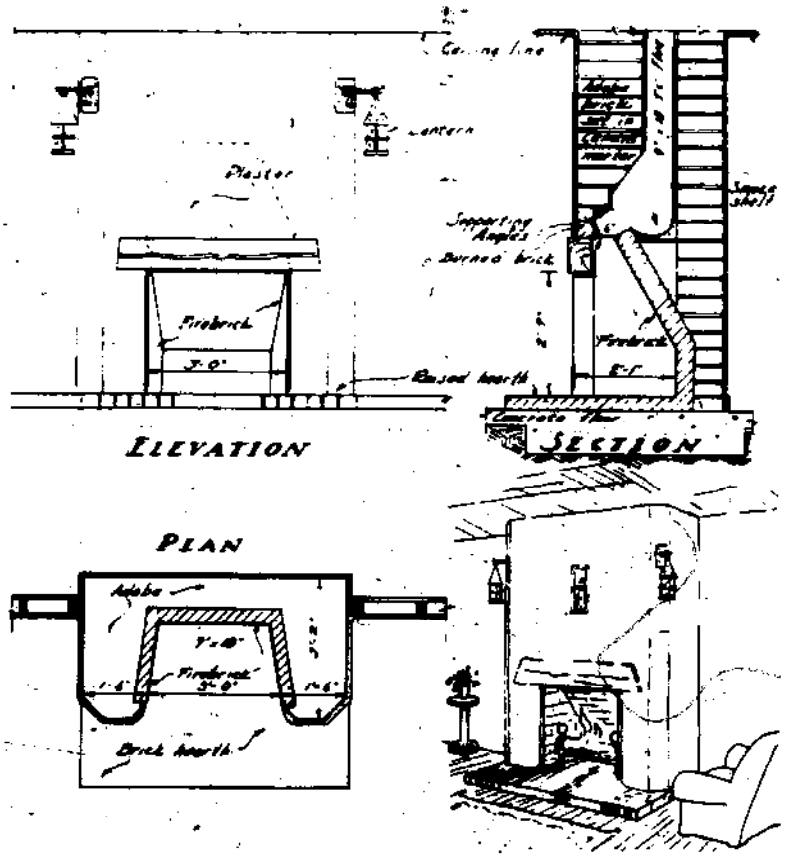
TYPICAL ADOBE CONSTRUCTION DETAILS



PICTORIAL VIEW showing construction details, including wooden floor.



CROSS-SECTION DETAILS of roof, wall, floor, and foundation for typical adobe construction.



FIREPLACES can be built of adobe. Sun-dried bricks lend themselves to intricate designs more readily than the monolithic adobe. Fire-brick lining is usually placed in the more ambitious designs. Adherence to the fundamental principles of fireplace design is essential to successful operation.

Chimneys and Fireplaces. Follow the usual practices for chimneys and fireplaces. Put terra cotta, asbestos, or metal flues within the walls and surround them with adobe bricks; or run the flues through the walls, attaching and supporting them in the usual way. You need no special protection around fireplaces, as adobe is fireproof and stands high temperatures without difficulty. Use firebrick for the fireplace lining, however, to secure the best permanent construction, as shown in the sketch on this page. Or you may use patent metal fireplaces, such as shown in the photo on page 23, with ventilating and heating flues. This type actually provides considerable heat for the house, while ordinary fireplaces give very little heat but serve mainly as ventilators.

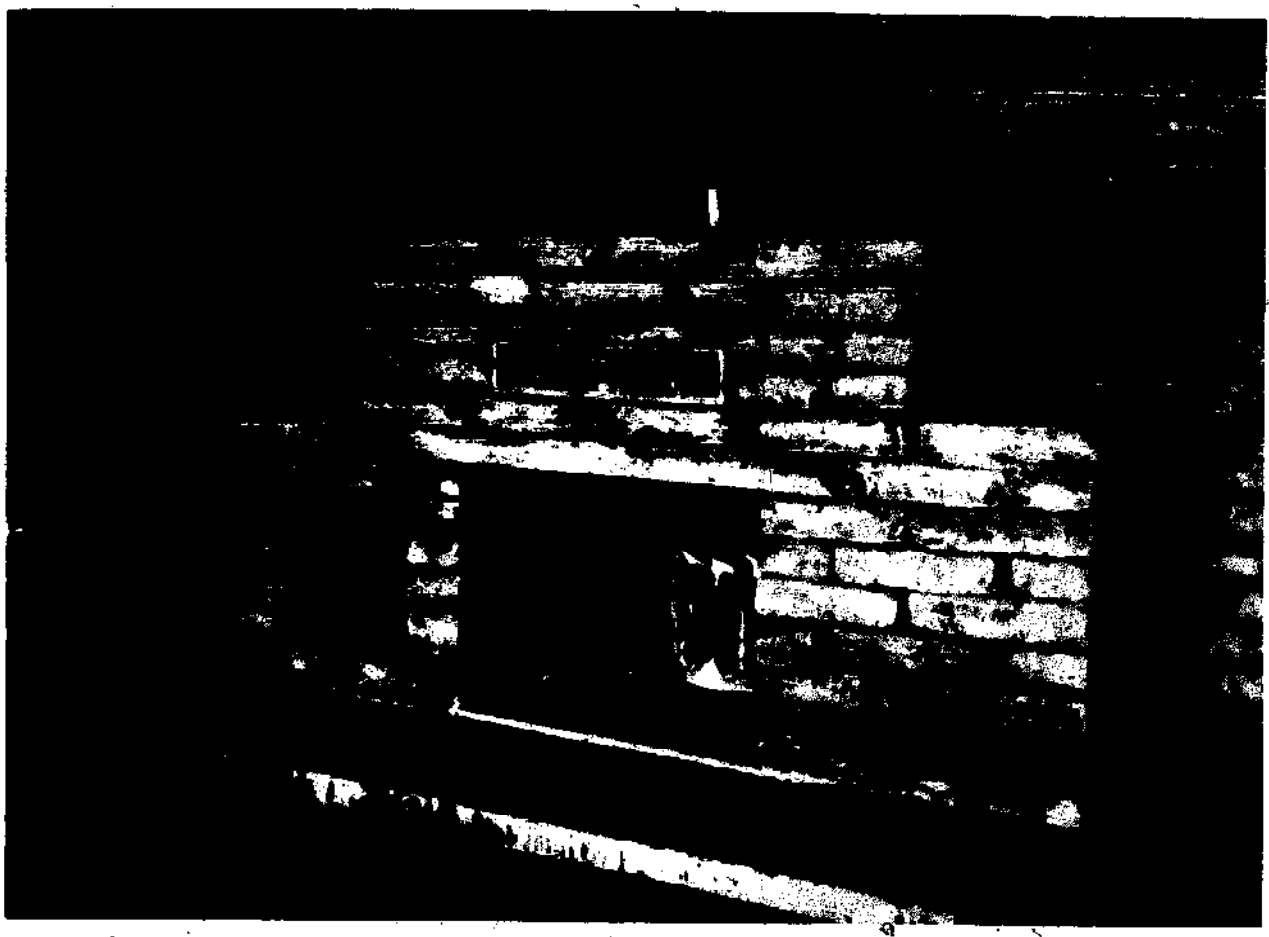
If you have a wooden floor, the usual insulation and precautions are necessary. With a concrete or masonry floor the details are much simpler, and the hearth may actually be integral with the floor, or can be raised or lowered a few inches.

A wooden beam or lintel over the fireplace opening as shown on the sketch above, is usually safe from fire when protected by sheet asbestos and angle irons, although reinforced concrete or steel channels are often preferred.

Finishing and Painting. Stabilized adobe walls do not need any surface treatment and often are left in their natural condition.

If you prefer a lighter color, you can use almost any type of paint. One of the cheapest types is a water-cement paint, made of natural gray Portland cement, or white Portland cement, and water, with possible admixtures of calcium chloride, soap, or stearates, for increased waterproofing. You can buy this paint, already prepared, in various colors.

Common lead-and-oil paint is often used. Two coats will occasionally permit



ADOBE-BRICK FIREPLACES may be very attractive. This one is built around a patent metal form having circulating ducts, for better heating.

some asphalt to bleed through, but three coats usually provide complete protection.

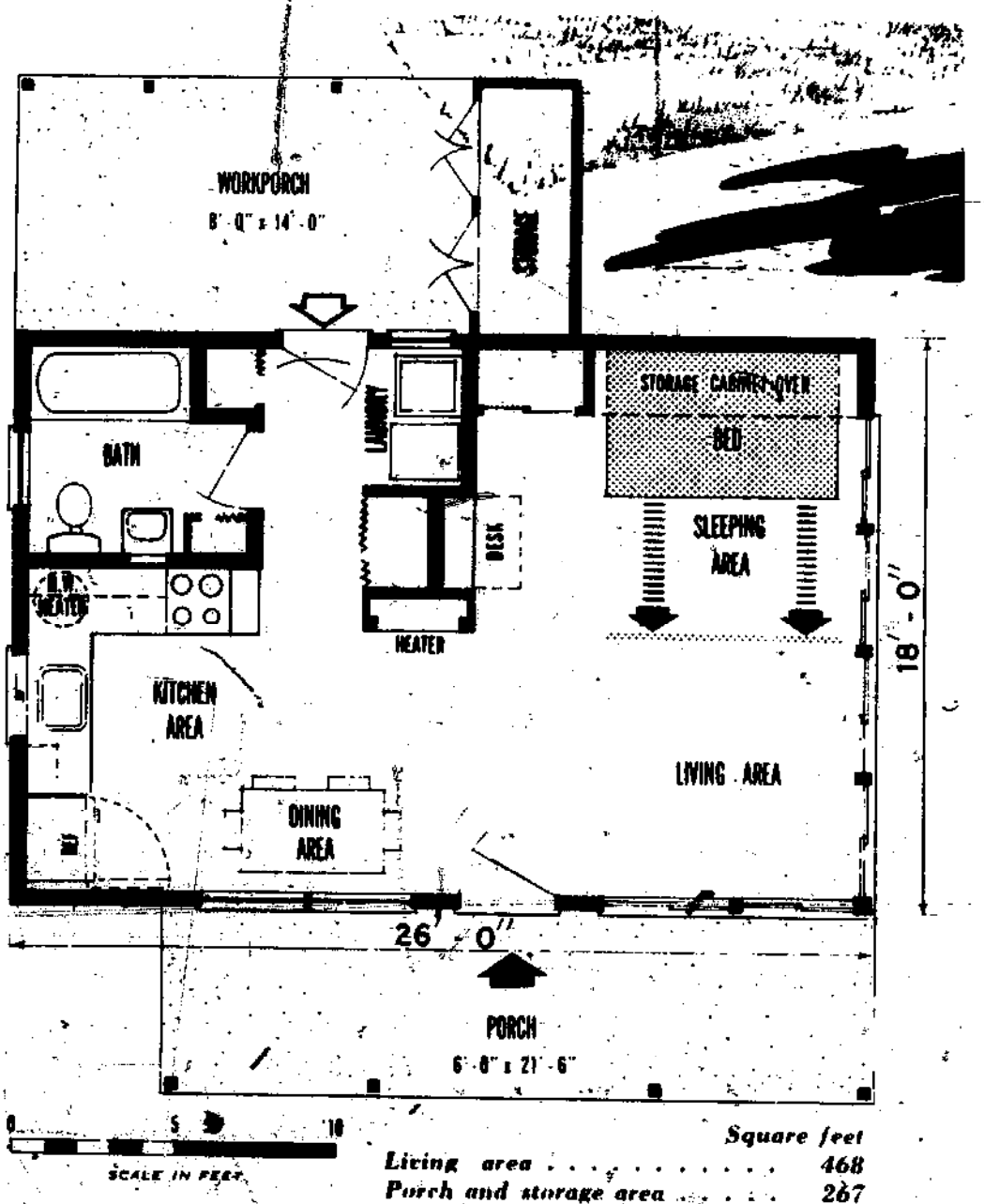
Aluminum paint with an asphaltic base is very satisfactory but usually more expensive. Two or three coats are recommended.

Special masonry paints, made to cover concrete, brick, and earthen surfaces, are exceptionally good for protection and waterproofing. These may be more expensive, but they will often last long enough to prove economical. Two of the newer protective coatings are the silicone masonry water repellents, and the latex primers and conditioners, which assist in hardening and stabilizing the adobe surface, as well as preparing it for a finish coat. Epoxy paints are also among the very best, but are relatively expensive.

Plaster and stucco are used in some cases. Metal lath or wire provides the best attachment. These conceal the mortar joints and obscure the natural brick appearance. The cost also may be higher than paint.

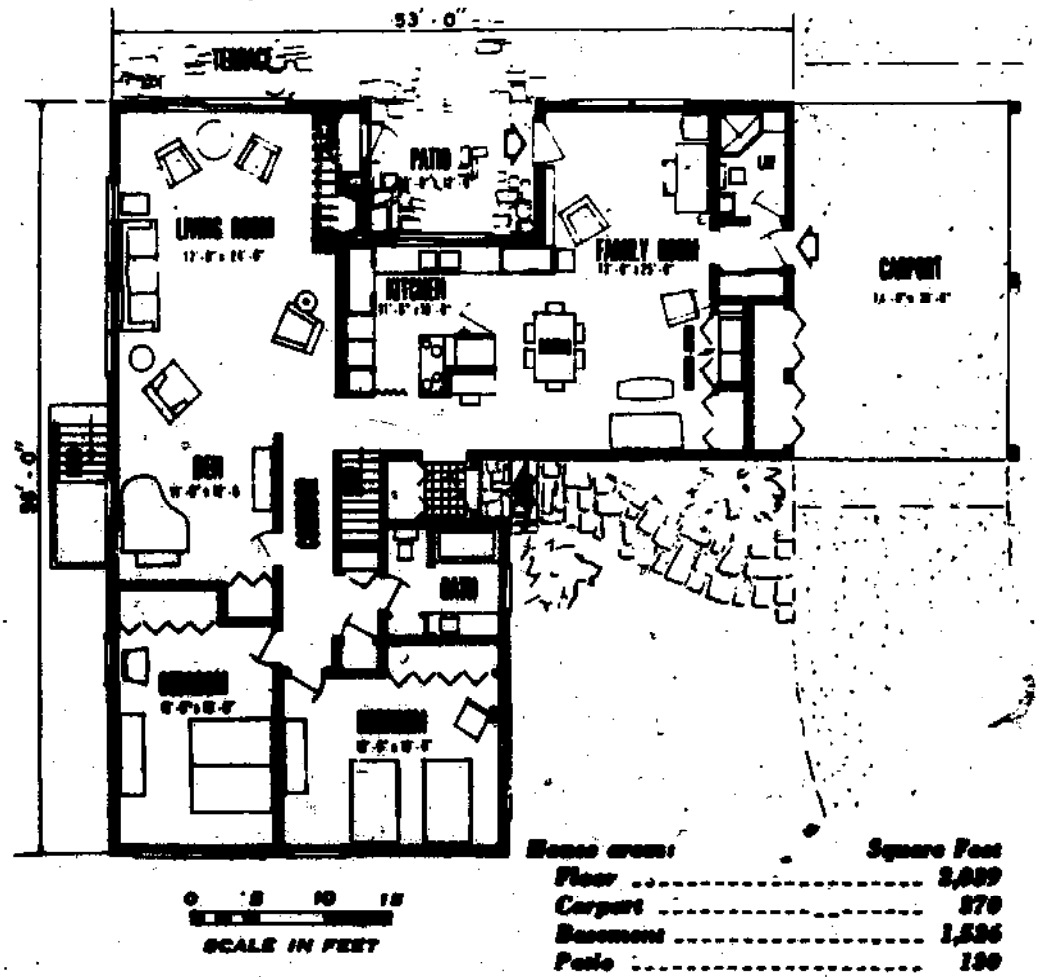
The floor plans shown on the following pages, while not available in detail, may give you some ideas.

A small but useful and convenient farm cottage which can be built primarily with adobe brick wall construction.



	Square feet
Living area	468
Porch and storage area	267

A spacious and attractive farmhouse, with two bedrooms, energy-saving kitchen, and masonry and frame construction.



House areas:	Square Feet
Floor	2,809
Carport	570
Basement	1,526
Patio	130

ADOBE BRICK TESTING LABORATORIES

Abbot A. Hanks, Inc., 1300 Sansome St., San Francisco, California 94111.
California Testing Labs., Inc., 619 E. Washington Blvd., Los Angeles, California 90015.
Hales Testing Labs., 646 Hegenberger Rd., Oakland, California 94600.
A. F. Janes, 220 East Ortega St., Santa Barbara, California 93100.
Los Angeles Testing Lab., 1300 South Los Angeles St., Los Angeles, California 90015.
Morse Laboratories, 316 - 16th St., Sacramento, California 95801.
Nelson Laboratories, 1145 West Fremont St., Stockton, California 95203.
Pittsburgh Testing Lab., 651 Howard, San Francisco, California 94100.
San Diego Testing Lab., 3467 Kurtz St., San Diego, California 92110.
Smith-Emery Co., 781 East Washington Blvd., Los Angeles, California 90021.
Sonoma Testing & Exploration, 2630 Mendocino Ave., Santa Rosa, California 95401.
Testing Engineers, Inc., 2811 Adeline, Oakland, California 94600.
The Twining Laboratories, Inc., P.O. Box 1472, 2527 Fresno St., Fresno, California 93700.
The Twining Laboratories, Inc., 1502 Coldwell Ave., Modesto, California 95350.

FOR FURTHER READING

you will find detailed information in the following publications:

Aller, Paul and Doris. Build Your Own Adobe. Stanford University Press, 1947. Stanford University, California 94300. $3.00.

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Betts, M. C. and Miller, T. A. H., Rammed Earth Walls for Building, Farmers' Bulletin 1500, U.S.D.A., Supt. of Documents, Washington, D.C., 20402. 24 pp. 1937. 10c.

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California Division of Mines, "Adobe Brick" Mineral Information Service, V. 12, No. 7, July, 1959, Ferry Building, San Francisco, California 94111.

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Cullimore, Clarence, "Santa Barbara Adobes," Santa Barbara Book Publishing Co., Santa Barbara, California 93100. 1948, 225 pp.

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Fenton, F. C., The Use of Earth as a Building Material. Bulletin No. 41, Kansas State College, Manhattan, Kansas 66502. 34 pp., 1941.

Glenn, H. E., Rammed Earth Building Construction. Bulletin No. 3. Engineering Experiment Station. Clemson Agricultural College. Clemson, South Carolina 29631. 18 pp., 1943.

Groben, W. Ellis. Adobe Architecture. Its Design and Construction. U.S.D.A., Forest Service. U. S. Government Printing Office. Washington, D.C. 20402. 36 pp., 1911.

Hansen, Edwin L., The Suitability of Stabilized Soil for Building Construction. Bulletin No. 333. University of Illinois. Engineering Experiment Station. Urbana, Illinois 61801. 80 pp., 1911. 45c.

Harrington, Edwin Lincoln. Adobe as a Construction Material in Texas. Bulletin No. 90, School of Engineering. Texas Engineering Experiment Station. College Station, Texas 77840. 36 pp., 1915.

Hubbell, Elbert. "Earth Brick Construction." Haskell Institute, Lawrence, Kansas 66044. 110 pp., 1943. 50c.

Kirkham, John Edward. How to Build Your Own Home of Earth. Publication No. 54, Engineering Experiment Station. Oklahoma A and M College. Stillwater, Oklahoma 74074. 36 pp., 1943.

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Miller, T. A. H., "Adobe or Sun-Dried Brick for Farm Buildings." Farmers' Bulletin 1720. U.S.D.A., Supt. of Documents, Washington, D.C. 20402. 18 pp., 1934. 5c.

Patty, Ralph L., The Relation of Colloids in Soil to Its Favorable Use in Pise or Rammed Earth Walls. Bulletin 298. Agricultural Experiment Station. South Dakota State College, Brookings, South Dakota 57006. 24 pp., 1936.

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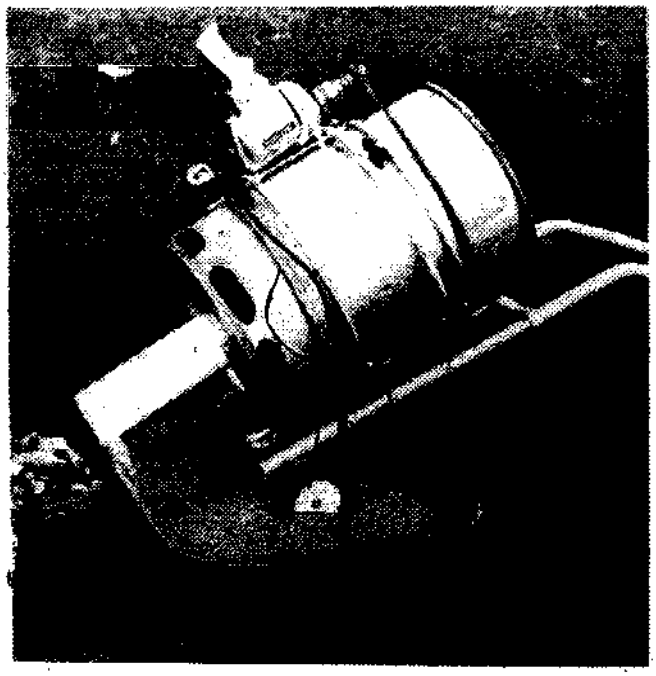
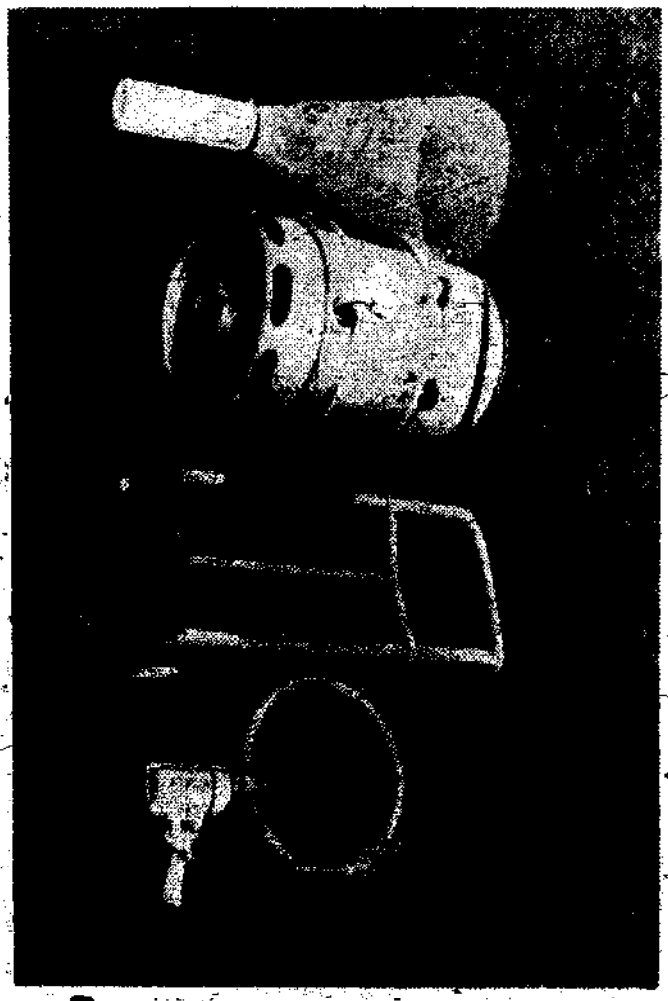
Wolfskill, Lyle A., Wayne A. Dunlap, and Robert M. Gallaway, Earthen Home Construction. Bull. 18. Texas Transportation Institute. A. and M. College of Texas. College Station, Texas 77840. March, 1962.

APPENDIX B

SOIL SIFTER

Parts and Assembly





1 hand truck = sifter chassis

1 barrel, preferably with removable cover (20, 30, or 55-gallon size) Cut out hole, about 3 1/2" and then cut and bend out to allow 4 1/2" plastic drain pipe to fit in bottom of barrel.

Cut out oval holes around circumference of bottom of barrel for discharge of fine soil.

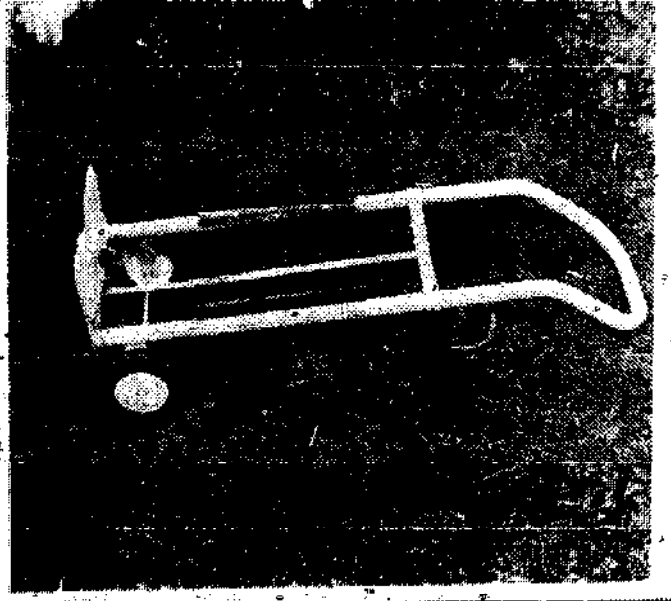
Cut hole in barrel cover, about 2" from rim. Cover exposed edge with horizontally cut section of garden hose.

1 pc. 1/4" hardware cloth to make sifter cone-screen. (A 3' x 4' pc. will make a cone for barrel 16" x 24".) Lace with wire and attach to drain pipe with band clamp. Insert into barrel and with second clamp, attach drain pipe to barrel.

10 ft. length of 1/2" flexible electrical conduit or aluminum tubing. For a smooth bend, make two continuous circles around barrel and then cut into two hoops.

8 skate wheels: one mounted on hand truck base, three around bottom hoop, and four around top hoop. A 2" diameter section of discarded automobile water hose cut in 3/4" widths bonded to skate wheels with Barge or equivalent rubber cement. Threaded rod, 1/4", lock washers and nuts to mount skate wheels.

1 pc. 3/4" threaded rod, approx. 24"; 18" pc. of 1/4" plastic tubing; 8 nuts and 4 washers for motor mount.



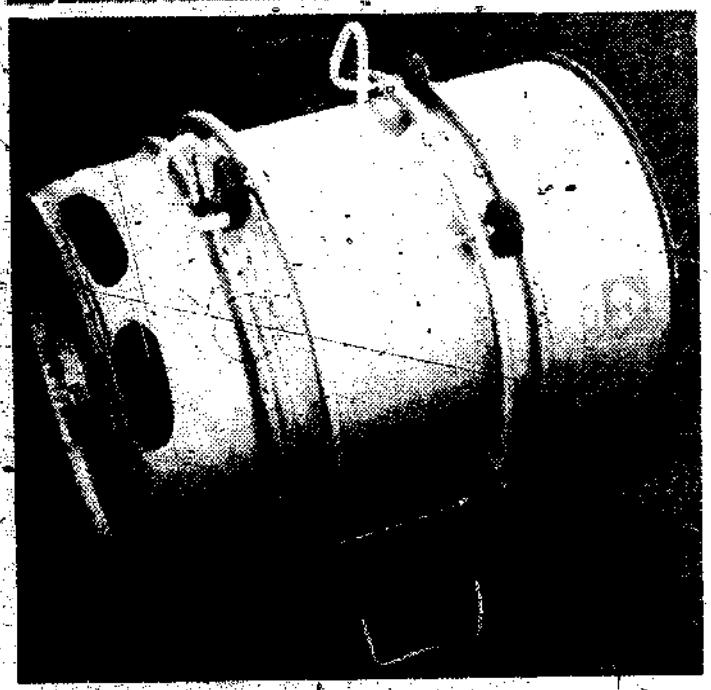
3 pcs. heavy wire covered with plastic tubing--1 pc. to stabilize motor handle, and 2 pcs. to stabilize barrel on hand truc..

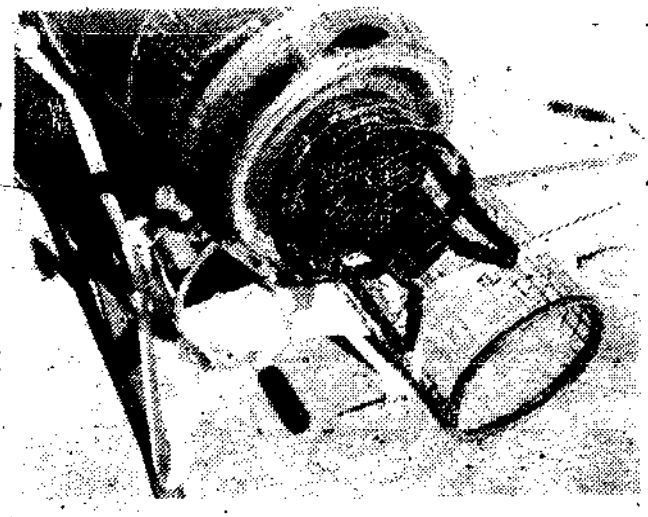
1" pulley, 1/2" x 3" threaded rod, lock washer and 2 nuts.

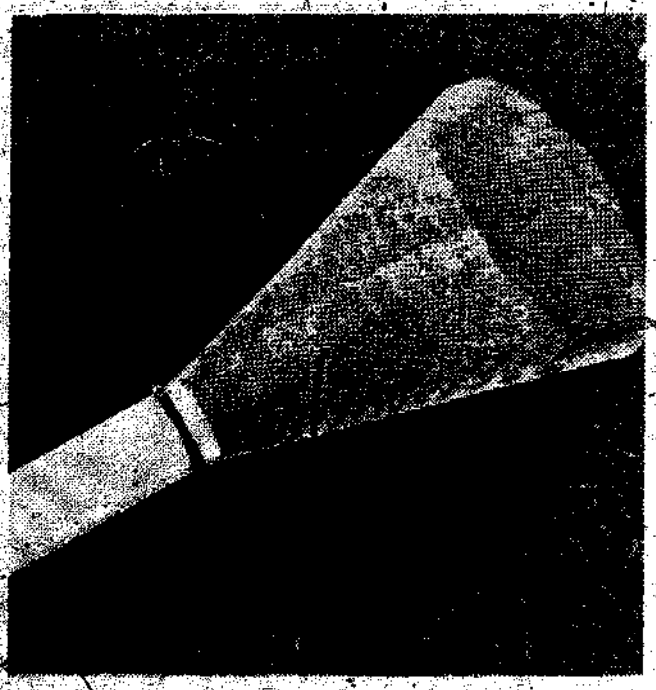
V-belt.

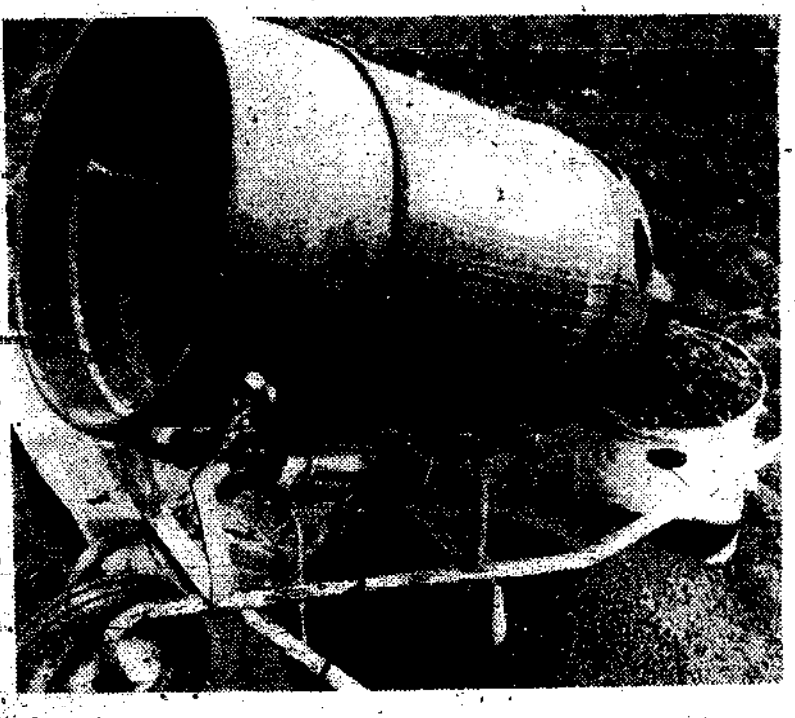
Hand drill motor, 3/4 hp, heavy duty, variable speed preferred.

Fabrication time about four to six hours. Parts cost $20 - $25, without motor.





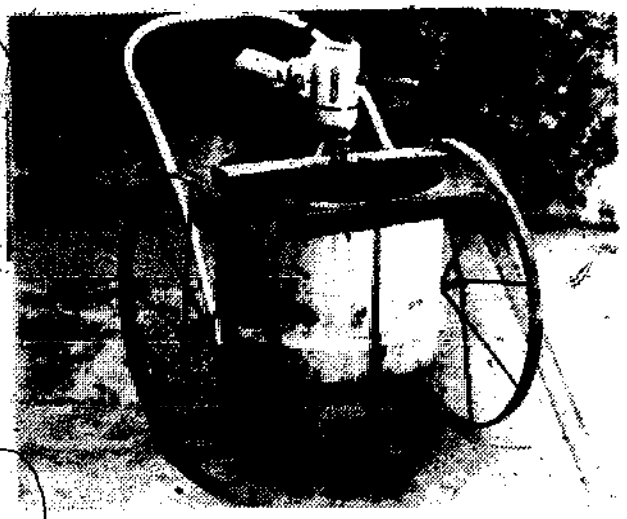


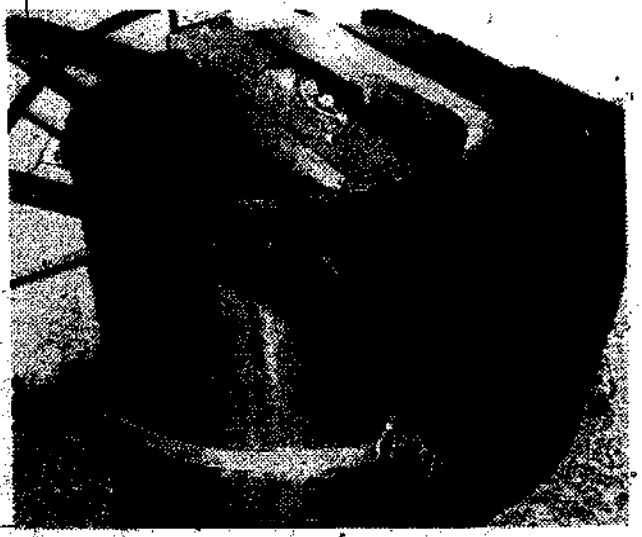


APPENDIX C

ADOBE MIXER

Parts and Assembly Instructions
(Modify Design as Desired)





Mixing Container

18" diameter x 20" deep section of tank, curved bottom. (If other than above size is used, adjust other parts specifications. A 16", 18", or 22" barrel section may be used if wok or gold pan is inserted in bottom to give curved surface.) Mount 4" to 6" from ground, if possible, to clear mold when pouring.

Power Mount (optional)

2 pcs. coat hanger wire 10" long (stabilize ends of mount)
1 pc. plywood, 1" x 3"
Mixer lock pin (to keep propeller in socket): Wire 1/8" x 4"; 6" mounting cord; one wood screw.
Mounting lock pin (to keep mounting board on mixing container): 1/8" wire or nail; mounting cord; wood screw.

Discharge Bumper (to stabilize mixing container as adobe mix is poured into mold)

1 pc. wood, 1 3/4" x 1 3/4" x 18" (round ends and cut to fit mixing container circumference curve)
1 pc. packing band, 3/4" x 60"
2 wood screws, flat head, 3/4" to attach discharge bumper to band.
1 hose clamp, cut, attached to packing band so it can be tightened around mixing container.

Handle and Wheel Mounting Assembly

Handle: 1 pc. flexible conduit, 3/4" x 76" (bend with a "pipe bender" per picture on left).
Two wheels (wheels in model are 24" diameter x 3/16" axle holes.) If available, a larger diameter wheel with an half inch or larger axle would be preferable, especially for an 18" diameter or larger mixing container.

Two axle bolts (model in picture has 5/16" x 4 1/2" axles, 4 nuts, 6 flat washers, and 2 lock washers) to mount wheels on mixing container. Greater stability is given to the wheels if the axle bolts go through the walls of the mixing container, through the strap iron and handle and then to the wheels.

One piece galvanized iron, 1" x 1/8" x 80" (to add strength in mounting the handle and wheels on the mixing container.) In the model shown, the ends of this band are fastened with two bolts, 1/4" x 3/4", and two nuts. A simpler method would be to drill holes in the two ends of the strap iron, bend them at right angles, and cinch them together with a 3/8" x 1 1/2" bolt ( ).

Power Mixing Unit

Hand drill motor, 3/4 to 1 1/2 hp, heavy duty, variable speed preferred (300 to 600 rpm), 1/2" chuck. (A verticle drive gasoline powered unit such as used in post hole digger would be adaptable to this mixing unit design where electricity is not available.)

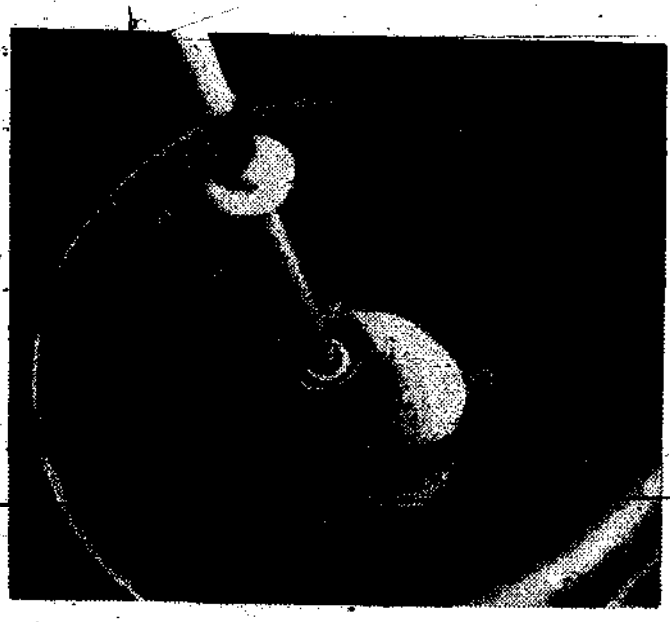
Mixing shaft and blade:

- 1 pc. threaded rod, 1/2", approx. 25" long.
- 6 nuts, 3 lock washers.
- 1 pc. flexible spring steel packing band, 1 1/2" x 24" (marine propeller may also be used).
- 3 pcs. 1/2" garden hose, 5", 3" and 9" long (to cover exposed shaft threads and thus help clean up).
- 1 brass lipstick tube (end cut off) to cover top of shaft and serve as brushing to reduce friction against wood shaft holder.

Mixing Unit Holder

Plastic or metal pail with handle.

One section plastic pipe, 3" x 15", custom shaped and slotted (see picture on left).



APPENDIX D

EQUIPMENT SALES--ADOBE CRAFT ASSOCIATES

Inquiries received from previous editions of this manual have suggested a market for ready-made equipment and perhaps a place for local sales and demonstration centers.

Working relationships might be developed in different geographical locations with individuals or organizations/firms to produce the equipment to meet Adobe Craft standards and be sold through Adobe Craft and/or serve as local sales/community demonstration centers. We are using this announcement as a means of exploring the interest and feasibility of such a step.

Inquiries should include brief statements of:

1. Interest and related experience.
2. Proposed plan in terms of personal-local resources-setting. Include a suggested method-formula for the compensation of all involved (production, sales, administration, development, etc.).
3. References--persons who could comment on your integrity, competence, and personality.

(If interested, use back of this sheet.)

APPENDIX E

MATERIAL AND SUPPLY SOURCES
(Also see local suppliers)

Compost Maker (new pulley and screen replacements needed to make soil pulverizer):

David Bradley, Model 950-7404
Sears Roebuck
Chicago, Illinois

Pulleys:

Congress Drives Division (Mfr)
ACME Precision Products, Inc.
Detroit, Michigan 48234

Power Supply (variable-speed, heavy-duty electric drill, 3/4 or 1 hp):

Power Tool Distributors

Emulsified Asphalt, SS lh:

Chevron Asphalt Company
4525 San Leandro Blvd.
Oakland, California
(or other local-regional distributors)

Perforated Steel (screen for pulverizing soil)

California Perforating Screen Co.
655 Bryant Street
San Francisco, California 94107

Mixing Blades, Propellers:

Outboard Marine Supply Outlets
Strap Steel Bands (used in shipping lumber or other bulk materials)
Threaded Steel Shafts (hardware stores)

Mixing Containers:

Steel Drums, Barrels, or Tanks

"Gold Pans" or Woks (12" to 30" diameter steel, to use in bottom of mixing containers):

Atlas Metal Spinning Company (Mfr)
183 Beacon Street
So. San Francisco, California

Mold Material Possibilities (or adjunctive building materials):

Vinyl House Siding
Masonite Corporation (Mfr)
Dept. M-3, 131 S. Taylor St.
South Bend, Indiana 46601

Conduit Bender (for bending 1/2" and 3/4" flexible conduit):
Catalog No. 222
LEW Electric Fittings Co.
627 W. Lake Street
Chicago, Illinois 60606
(Purchased from Sears Roebuck)

Plastics, Fiber Glass, etc:
Taylor and Art Plastics
3011 Alvarado
San Leandro, California

Vinyl Siding (to complement the adobe or to be used for making molds):
Mastic Corporation
131 S. Taylor Street
South Bend, Indiana

Bird & Son
2555 Flores
San Mateo, Calif.

Lightweight, Waterproof Sheeting (Unikraft Board):
Universal Papertech Corp. (Mfr)
Hatfield Industrial Park
Hatfield, Pennsylvania 19440

Wood Preservative (Pentachlorophenol, 5% Technical, Federal Specification TT-W-570):
Admiralty Manufacturing Co.
3030 Bridgeway
Sausalito, California

Post-Beam Alternatives:
Local Telephone Company, or
McCormick and Baxter
P. O. Box 1728
Stockton, California, or
Drain pipe, plastic, or asbestos-concrete (Fill with adobe or concrete if added strength is needed)

Gate Valve for Emulsified Asphalt Barrel:
#74 Gate Valve
Sargent & Company
Hand Tool Division
New Haven, Connecticut 06509

Mixer Wheels:
Sears Roebuck Suburban Catalogue
Wheel for Hand Cultivator
#71KF1843N, or
Empire Plow Company
3140 East 65th Street
Cleveland, Ohio 44127
#800-17A Boy Scout Wheel, 24"

Anchors, Connectors and Hangers:
Local hardware, building materials, or lumber dealers
For address of nearest Strong Tie distributor or dealer contact: Simpson Company, 1470 Doolittle Drive, San Leandro, California 94577

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7. "How to Design and Install Plumbing," Sears & Roebuck, Catalog No. 3A1309.

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19. Uniform Building Code. Vol. 1. International Conference of Building Officials, Whittier, California.

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21. Village Technology Center Catalog (Tools for Development). New York: VITA, Inc., College Campus.

22. Wolskill, L. A., W. A. Dunlap and B. M. Gallaway. Handbook for Building Homes of Earth. Washington, D. C.: Housing Advisor, Division of International Affairs, Department of Housing and Urban Development.

23. World Housing Conditions and Estimated Housing Requirements. New York: United Nations Publication, Sales No. 65.IV.8, 1965.