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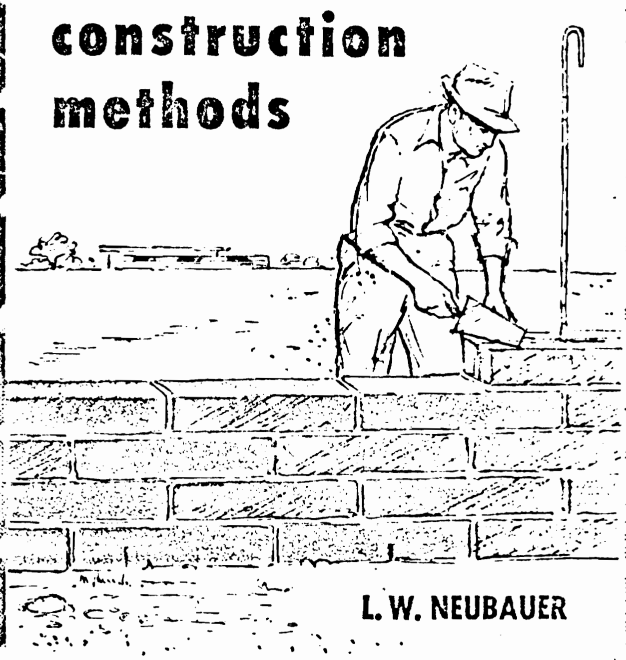
ADOBE construction methods



L. W. NEUBAUER

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Adobe Construction Methods

USING ADOBE BRICK OR RAMMED EARTH (MONOLITHIC CONSTRUCTION) FOR HOMES

L. W. NEUBAUER

UNIVERSITY OF CALIFORNIA · COLLEGE OF AGRICULTURE
Agricultural Experiment Station and Extension Service

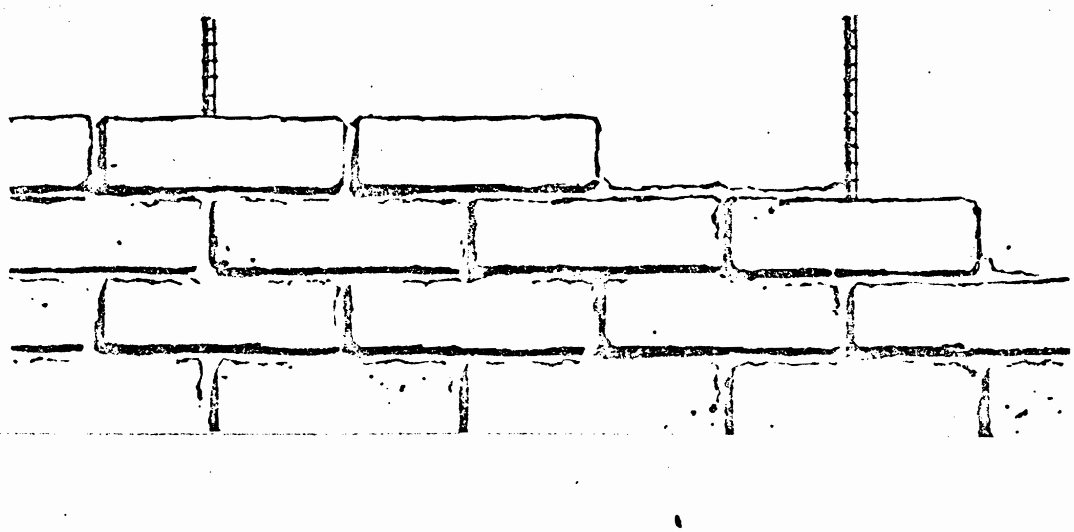
Adobe . . .

is the soil material—usually a combination of sand, clay, and silt—used in the construction of adobe bricks or of rammed-earth walls. Bricks made from this soil are also called "adobes." The best adobe soil is a stable, uniform mixture of good strength, and much different from the so-called adobe clay found in some regions, which heaves and expands when wet, and shrinks badly when drying, forming large cracks.

Natural earth has been used for centuries to build houses, and probably will be used for centuries to come. In spite of certain obvious weaknesses it has often proved satisfactory. This manual discusses methods that will make adobe still more serviceable and permanent. Certain stabilizers will harden the earthy material or make it water-resistant, and will give the natural soil the additional strength and durability that is necessary for building homes.

THE AUTHOR:

Loren W. Neubauer is Associate Professor of Agricultural Engineering and Associate Agricultural Engineer, Experiment Station, Davis.



How good is it?

It's available—you may find it near or even on your construction site.

It's economical—you may secure soil without cost or at a very low price.

Labor is cheap—no special skills are needed.

It requires very little trim—and still looks satisfactory.

It's durable—will last for generations, especially when stabilized.

Walls are solid and strong.

It's fireproof.

It's decay- and termite-proof.

Total insulation is excellent.

Heat capacity is high—retarding temperature changes.

It's popular—people appreciate its rustic appearance.

What's wrong with it?

It's hard work—you and your family have to do it yourself, or hire help at extra cost.

It's not water-resistant—unless stabilized.

It's low in strength—weaker than wood, concrete, or steel, unless reinforced or used in very large masses.

Earthquake hazard is high—unless special features are included.

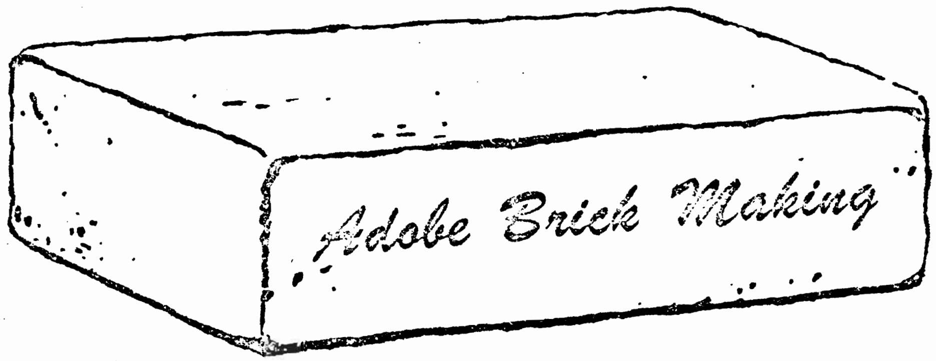
Heavy weight—large tonnages must be handled during construction. Foundations are subject to high loadings.

Little lateral strength—do not use adobe for water tanks or grain storage.

Also remember: while cost of walls is low in adobe houses, the expense for walls is only a fraction of total house cost.

Here is information on:

This manual replaces Bulletin 472



You can construct walls from earth either by pouring or molding the entire mass of soil into a single unit (monolithic methods) or by forming bricks from which to build the walls.

In both types you have to handle damp or wet soil to puddle it. In the puddled state the soil grains are brought close together, so that there is a mechanical binding or locking between the soil particles, and so that the surfaces in contact can be cemented by the clay in the soil. Thus the material often becomes much harder and stronger than you would expect.

Several monolithic methods are discussed on pages 22–25. In recent years (especially in the Southwest) the use of adobe bricks has become more popular.

What are adobe bricks?

Adobe bricks are rectangular mud bricks, shaped in forms, dried in the sun, and then laid up in courses in the wall with mud or cement mortar. This method has two advantages:

1. The exact amount of shrinkage in the brick is relatively unimportant as long as the unit remains intact. That means you can use heavier soils than with monolithic methods. All shrinkage takes place before the bricks are laid in the wall.

2. Labor requirements are extremely flexible. One man or several men may be put to work with a minimum of equipment. One person, working alone, may accomplish a great deal, over a period of time. A three- to five-man crew will usually work most efficiently.

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.

How to make bricks

You may want to make your bricks by hand or with simple equipment, or you can buy them commercially.

Manual labor is, of course, the historical method of brick making. It is still used in adapted forms, often with the help of small tools or light machines to puddle the soil completely.

Make rectangular forms of wood or metal. Lay them on the ground, on a smooth area, and place mud in the forms by shovel or bucket. Spade the adobe carefully and tamp it into all corners of the forms, to insure well-shaped bricks. Strike the top off level, then lift the forms, leaving the bricks in place.

Do not make the mixture too wet, or the mud will slump or run after you remove the forms, or it may shrink and crack excessively upon drying. A slight slump or settlement may be all right, as many people prefer the somewhat irregular and rustic appearance.

Cover the bricks with paper to slow down the initial drying which prevents severe cracking. (See photos below).

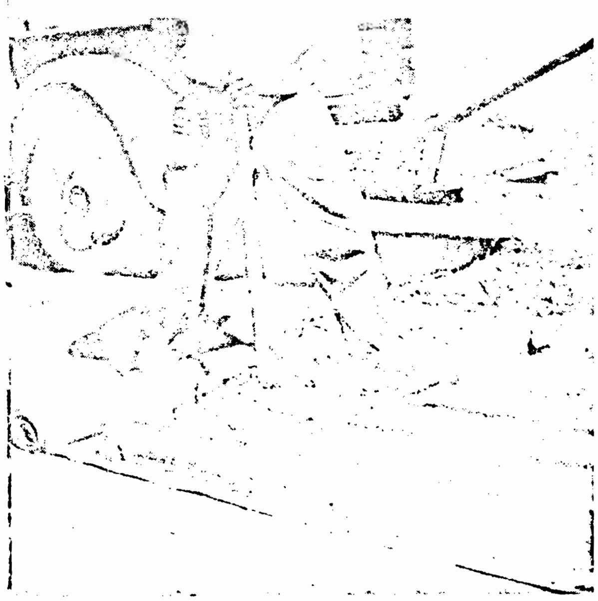
After lifting the form, wash excess mud off its inner faces with water, and repeat the molding process.

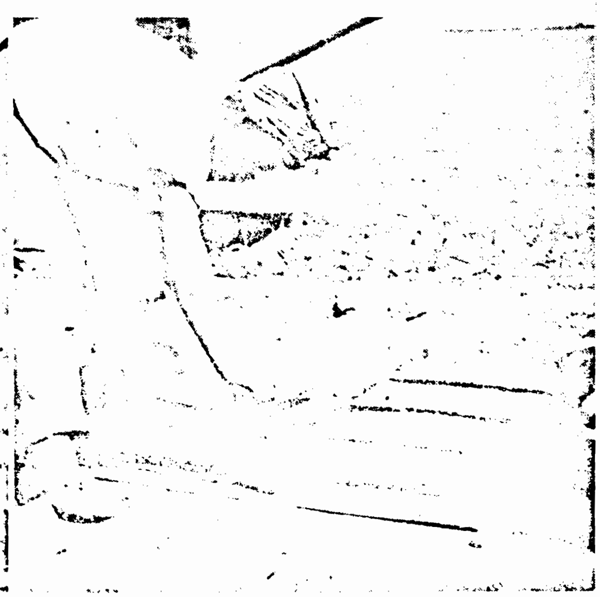
ALL-METAL FORM for shaping adobe bricks, strong and smooth, and very convenient for small operations.

Allow the bricks to lie flat for one to three days, until they are sufficiently strong to hold their shapes when turned. At that time, set the bricks on edge, so the air may circulate freely on both sides. This will promote uniform drying and help prevent warping and cracking. After a few more days of drying in this position, stack the bricks in loose piles for a few weeks, to complete their drying and curing. They will often dry down to a 3 per cent moisture content during a hot, dry summer.

Small-scale mechanical method of brick making involves home-made mixers (see photo, page 4, left), or other

MAKING ADOBE BRICKS, using a wooden form making three bricks at one time. Paper is rolled down, the form is filled with wet mud, and tamped (left). After finishing the surface right), form is lifted, paper unrolled on top of the bricks, and form set down for next bricks.





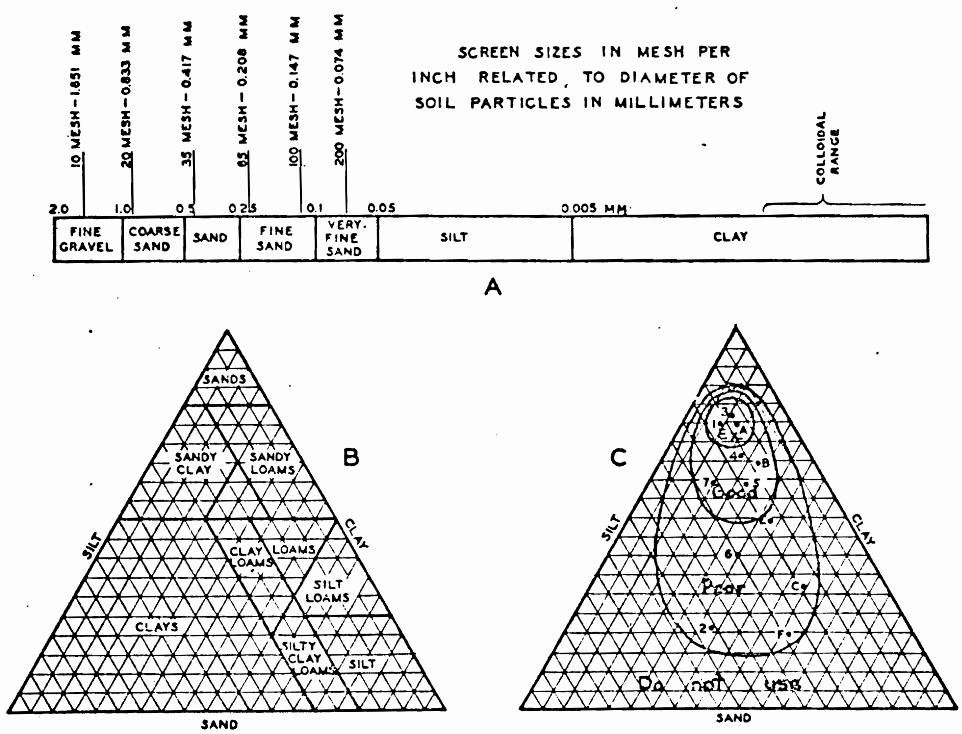
types of pug-mills, dough, or plaster mixers (see photo, page 4, right). These mixers can be placed near the drying yard and building location. Concrete mixers are not suitable for this purpose.

If you use wooden forms for the brick making, line them with thin sheet metal, to provide smoother surfaces and make cleaning easier. Some people prefer all-metal forms, either for one brick at a time (see photo on top of page 5) or for a group of bricks. Metal forms will yield a fine type of brick.

Commercial or large-scale brick making. If you dislike the dust, dirt, and mud that goes with making the adobe bricks, but don't mind the labor and limited amount of dirt involved in laying the bricks, you may buy adobe bricks, already dried and cured. They are being manufactured on a large scale in some regions.

THE SOIL TO USE

Not all soils can be used for brick making. Many will not form bricks of adequate strength. A very sandy soil is weak, and so is a loamy or organic soil. Most suitable soils contain some clay or silt, but too much of it will cause too much shrinkage and will result in warping and cracking. As a rule of thumb, the soil should contain less than 45 per cent of material passing a number 200



A, Bar graph illustrating the soil texture classification as used by the USDA Bureau of Soils. B, Soil classes based on the relative amounts of clay, silt, and sand. C, Results of certain soil tests. The contours indicate suitability for earth construction. Note that the best mixes contain large percentages of sand.

Adobe Testing Laboratories

	Type of test
Abbot A. Hanks, Inc., 624 Sacramento Street, San Francisco 11	Soil or Bricks
American Bitumuls and Asphalt Company, 1520 Powell Street, Emeryville	Soil
Edward S. Babcock and Sons, P. O. Box 432, Riverside	Soil
California Testing Labs., Inc., 619 E. Washington Blvd., Los Angeles 15	Bricks
A. F. Janes, 220 East Ortega Street, Santa Barbara	Bricks
Los Angeles Testing Lab., 1500 South Los Angeles Street, Los Angeles 15	Bricks
Morse Laboratories, 316 16th Street, Sacramento 14	Bricks
Nelson Laboratories, 1145 West Fremont Street, Stockton	Soil
San Diego Testing Lab., 3467 Kurtz Street, San Diego 10	Soil
Smith-Emery Company, 781 East Washington Blvd., Los Angeles 21	Bricks
South Dakota State College Experiment Station, Department of Agricultural Engineering, Brookings, S.D.	Soil
The Twining Laboratories, P. O. Box 1472, 2527 Fresno Street, Fresno	Soil or Bricks
The Twining Laboratories, 321 19th Street, Bakersfield	Soil or Bricks

screen. The diagram on page 6 shows these relations, indicating which combinations will provide best results.

Looking at the soil—even a careful examination—will not tell you enough to predict its value for brick making. Preliminary tests can be made by handmolding. Make small bricks to check cracking and strength for handling. If you are in doubt, seek expert advice. You will find a list of adobe-testing laboratories above.

Recent experiments with agricultural soils have shown no correlation between soil type and strength of bricks. However, good agricultural soil generally is not desirable for adobe bricks. A mixture stronger in clay and sand, which is frequently poor for crop production, is usually more satisfactory.

STABILIZATION AND WATERPROOFING

You often can improve soils that are unsatisfactory for brick-making by mixing them with other soils and materials. Two or three different soils may be combined in various proportions, or any one soil may gain by the addition of a certain amount of sand or clay. Coarse sand, or even some types of gravel, may often be added to good advantage. Generally, clay in the soil adds strength, while sand and gravel aid in reducing shrinkage.

Example: In one soil test we found that the natural soil had sufficient strength (over 500 pounds per square inch in compression) but linear shrinkage was excessive (over 8 per cent). To reduce shrinkage and cracking, we added sand in various proportions. This resulted in a weaker brick in every instance, although the strength remained satisfactory for admixtures up to 50 and 60 per cent of sand. This mix, however, reduced shrinkage to half, and, having decreased warping and cracking, made a much more suitable brick.

Stabilizers

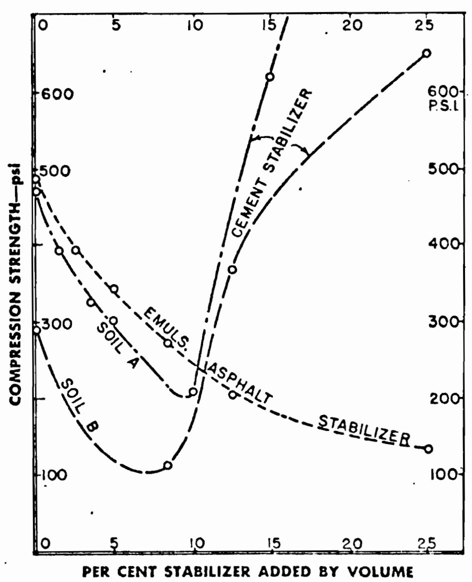
Portland Cement. Portland cement increases the strength of soil that by itself would be too weak for building, and makes it water resistant. It reduces the absorption of water (seldom stopping it completely) and prevents softening or weakening of bricks exposed to water, thus avoiding serious harm.

Earth composed chiefly of fine-grained particles, such as clay and silt, may require a considerable proportion of cement for an appreciable gain in strength. A mix of 10 to 20 per cent is sometimes used, although a 5 or 6 per cent mix will often provide enough increase in strength—especially in sandy loams, composed of less-fine material. In order to get satisfactory results with cement admixtures, keep the bricks damp for several days while the cement hardens.

Large proportions of Portland cement will, of course, increase costs considerably, which limits its use for stabilizing. Each soil has its peculiarities, and it is impossible to predict how much cement is needed to raise the soil strength to a required level. Only by making a few test samples or large blocks can you determine how the structural features have been improved.

In some cases you may want to add cement not to increase strength but purely to provide resistance to moisture—so that earth walls subjected to rains and especially damp conditions will not soften or decompose, but will retain their normal shape and strength. Some soils are badly weakened by small amounts of cement but become very strong as more is added.

The graph on this page indicates how greatly compression strength is weakened when small amounts of stabilizers are added to the cement, and how steeply strength increases with more additions. To determine the most satisfactory and economical combination, test your bricks for strength and water resistance.



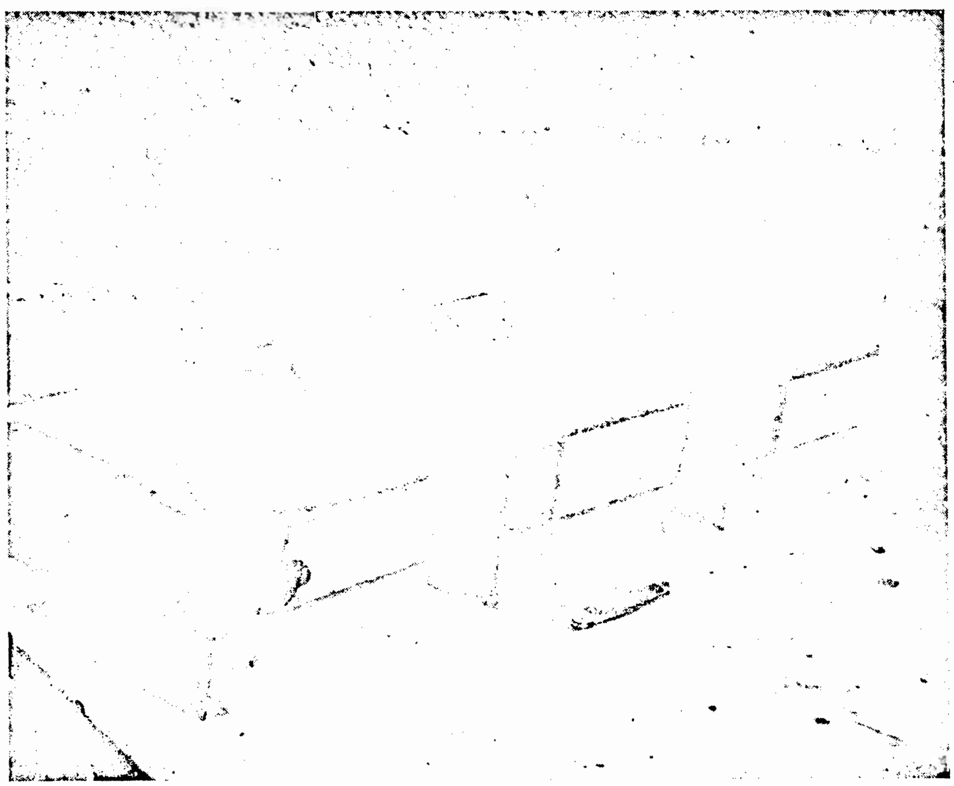
This graph explains what happens if you add various amounts of emulsified asphalt stabilizer or cement to the soil.

Emulsified Asphalt. Oily waterproofing agents, especially emulsified asphalt, are being widely and successfully used as stabilizers. A fractional volume of a water emulsion of asphalt, added to the earth-and-water mix, provides an internal waterproofing that permanently protects the adobe bricks. Such mixes may require 5 to 15 per cent of emulsion to give adequate protection to various soils. See graph on this page. Emulsified asphalt often weakens the brick in direct proportion to the amount used, but it may make the brick tougher, more elastic and durable. Some 5 per cent of asphalt may be sufficient to provide waterproofing. Test your bricks by standing them up in shallow water. Once you have established the minimum amount that is satisfactory for waterproofing, adding further asphalt will only weaken brick strength and increase cost. The amount of asphalt that will provide waterproofing and strength at economical cost can usually be determined only by experiment. Make several small test bricks containing various amounts of asphalt. You can get an approximate idea of brick strength by rough handling or by dropping the test bricks on a hard surface. How much asphalt you need, depends primarily upon the amount of fine silt and clay contained in your soil. These waterproofing agents, however, often cause some weakening of the adobe, so you should aim to use the least possible amount that will provide the waterproofing.

Treated bricks, when set in water, will usually suffer no damage for many days, while plain adobe bricks may be entirely ruined within one hour. This is illustrated in the photo on this page. You may buy emulsified asphalt from several of the well-known oil companies.

Other Stabilizers. Other materials have been used as stabilizers to a limited extent. Among them are resin emulsions, lime, pozzolan, stearates, soaps, water glass, and other silicates. Each contributes certain valuable features—such as waterproofing, strength, transparency, or light color—but are uneconomical.

In the past, straw or manure has often been used as a stabilizer or strengthener, but recent tests revealed that in most cases these materials often hinder rather than help the hardening of adobe. At present they are used very little.



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.

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 1/8 to 1/10 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.

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.

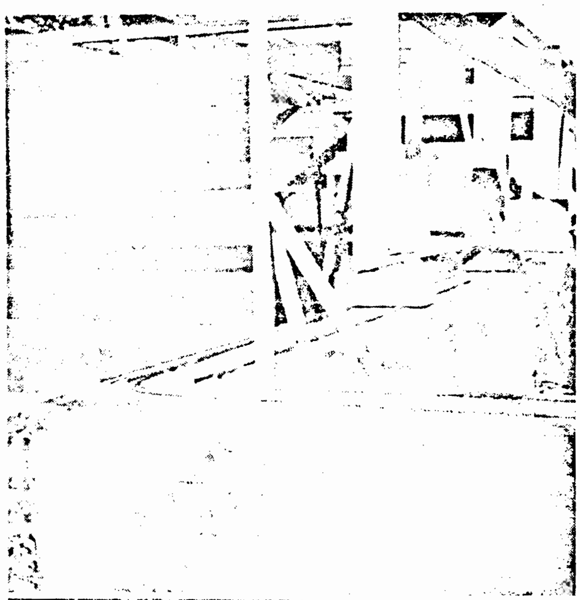
For footings and piers you may use brick, stone, or concrete block, built up to standard size or larger. These materials are never as good as reinforced concrete but they serve the purpose very well, especially for small houses and temporary types of buildings.

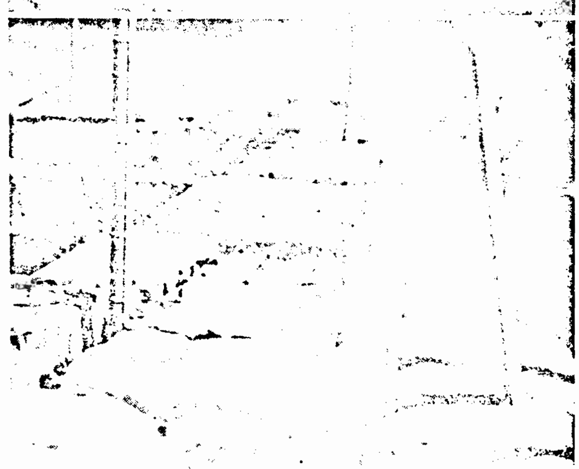
Common adobe blocks are rarely suitable for footings, for they will not stand up when wet. If stabilized carefully with asphalt or cement, however, they will resist moisture adequately and may do under light loadings and for temporary structures.

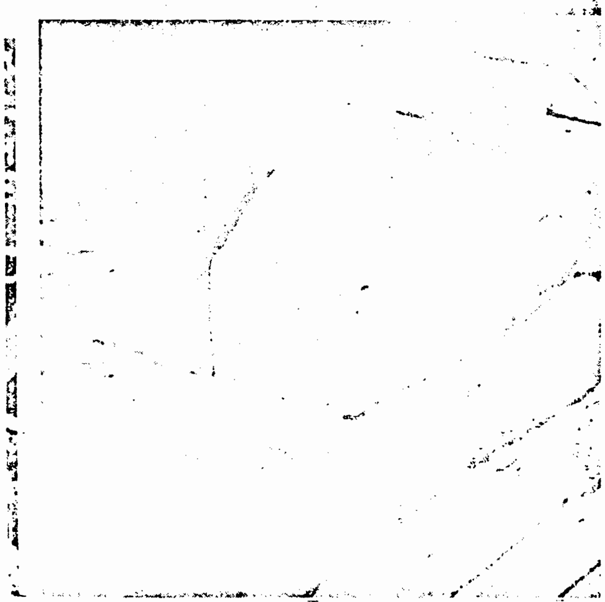
Walls. As mentioned before, walls may vary from 8″ to 24″ in thickness, depending upon the size of the blocks. Wall height is usually 8′ or 9′, or eight to ten times the wall thickness. You may lay bricks in various patterns, with random or staggered joints requiring a definite overlap.

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 $1:2\frac{1}{2}$ 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:

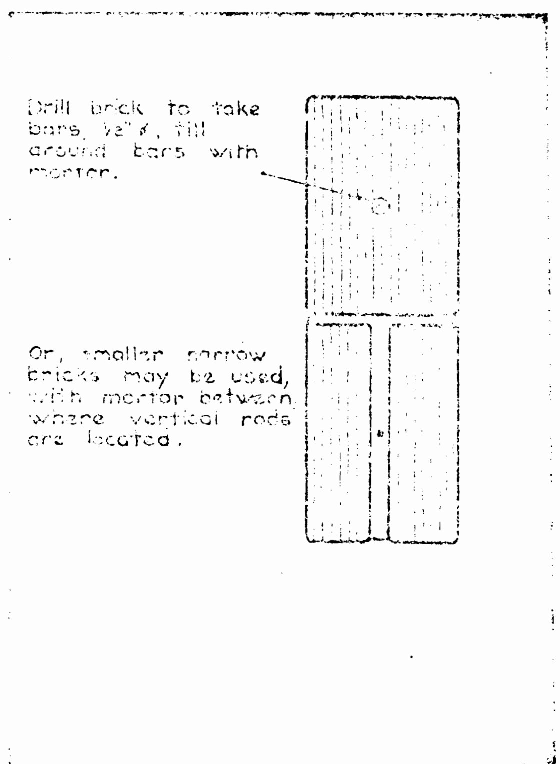


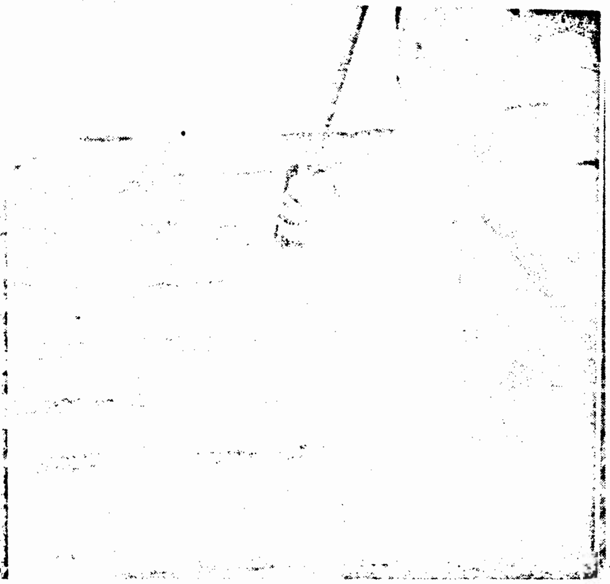




Place heavy wires or rods in the horizontal mortar joints between the bricks, continuously around the wall. Space them 2′ to 4′ vertically. Also put the horizontal reinforcements just below and above windows. Use rods in pairs and lap them 2′ or 3′ at joints, as shown in the upper photo on this page.

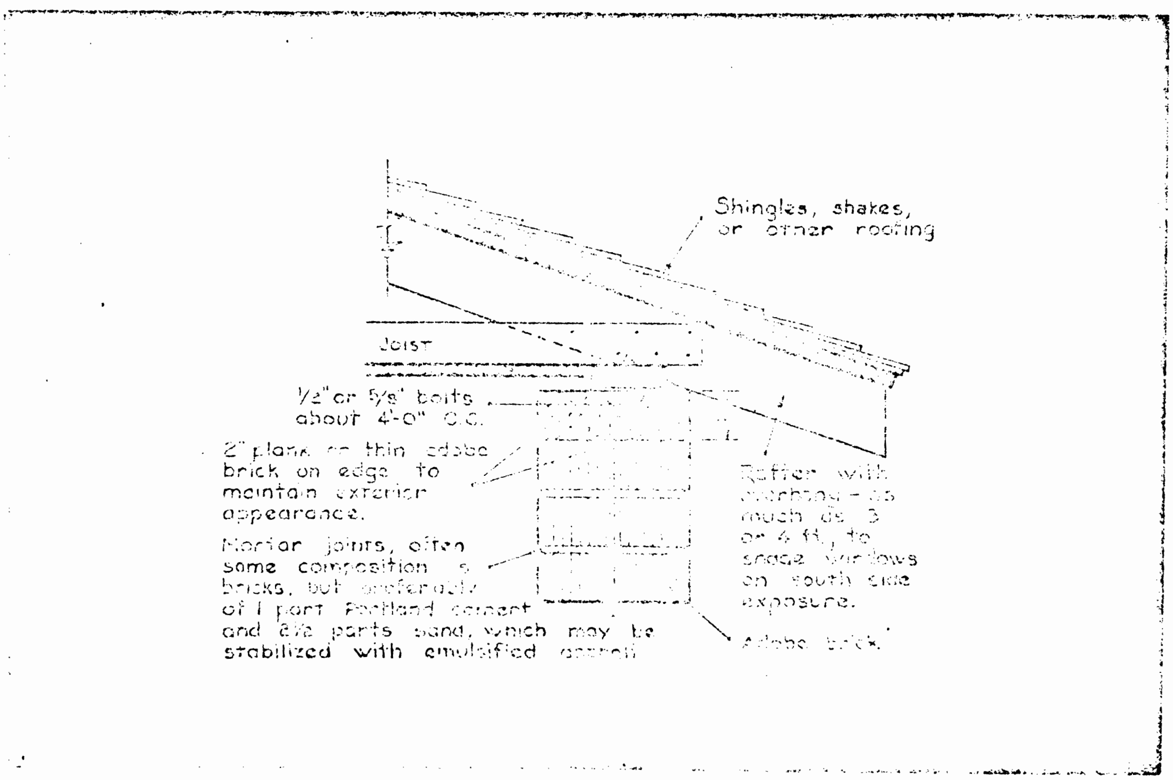
Vertical steel reinforcements are superior, and required by certain codes, but more difficult to place. You can either put the rods in the center of the wall, or stagger them from side to side. There are several ways to place them in the wall: you may split bricks, use narrow half-sized bricks (see center photo on this page), or drill holes vertically through bricks in alternate courses, and fill the holes around the rods firmly with mortar. The sketch on page 13 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.

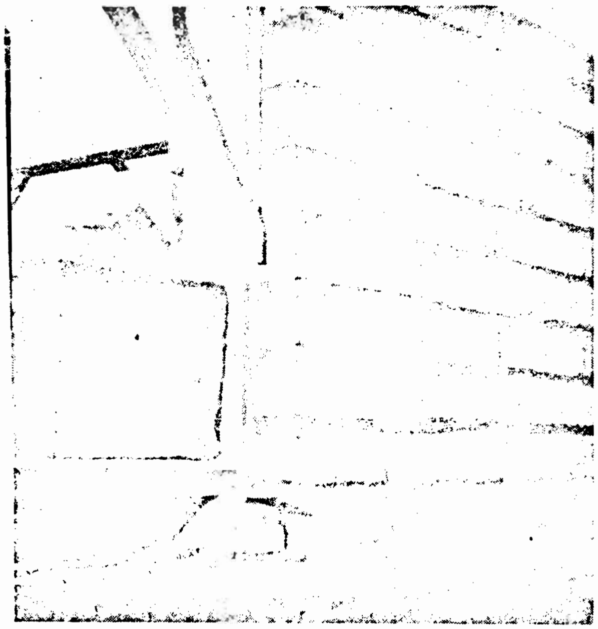




WALL REINFORCEMENT METHODS are shown on page 12. In the left column the top picture presents a wall detail with a double row of horizontal reinforcement rods. Rods are lapped two or three feet at joints. The other two photos on page 12 show vertical reinforcement rods, set between split bricks in one row (center) and at the end of standard bricks in the next row (bottom). Steel extends from foundation up through bond-beam or plate. The sketch on page 12 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). Sketch below gives cross-section details of roof and wall for typical adobe construction.





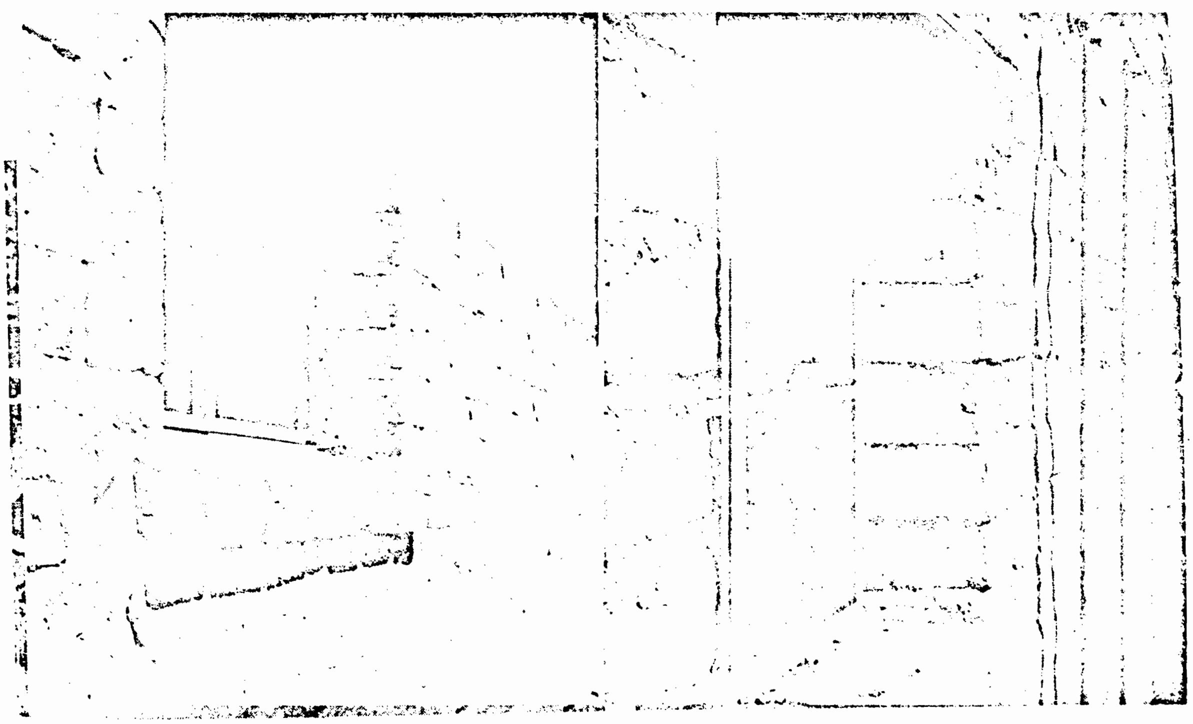
WOODEN WINDOW FRAME set in place, the adobe wall being built around it. One brick is used as a weight to steady the frame. Space below frame will be finished later with a concrete window sill, or one made of adobe or burned-clay bricks.

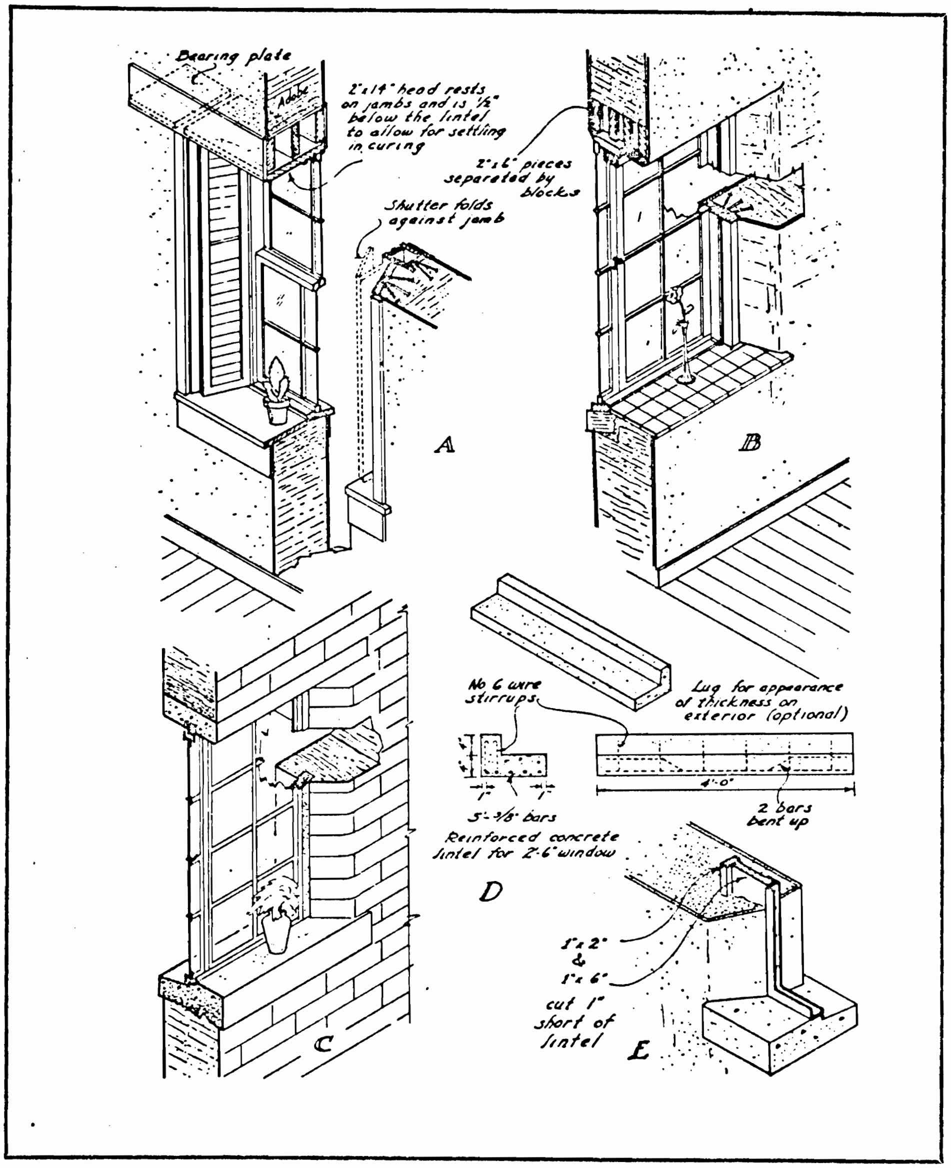
Windows. You may use any standard type of wood or metal sash. Set wood frames in place, and build up the adobe walls around them. Shape or groove adjacent bricks at the ends, to allow for mortar to hold metal ties, which are nailed to the wooden frame.

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 photo 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 15, indicating approximate dimensions and reinforcing steel required.

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.



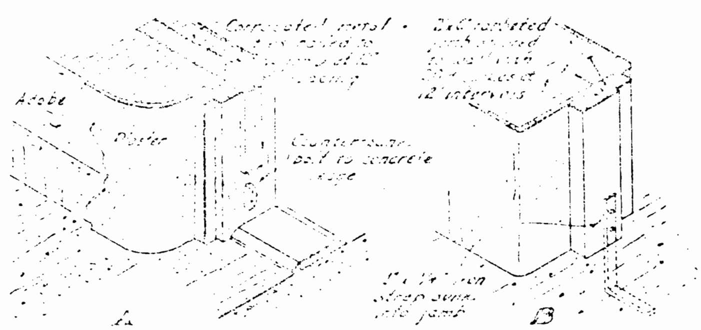


TYPICAL WINDOW DETAILS: A, Double-hung window, with standard sash adapted to splayed plank frame. B, Out-swinging wood casement, rabbeted 2 × 6-inch jamb, laminated lintel, "bull-nosed" plaster jamb, tile window ledge, brick sill, and roll screen. C, Steel casement window set in precast, reinforced concrete 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 this page.

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 13, 18, and 19.



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.

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 this page. 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.

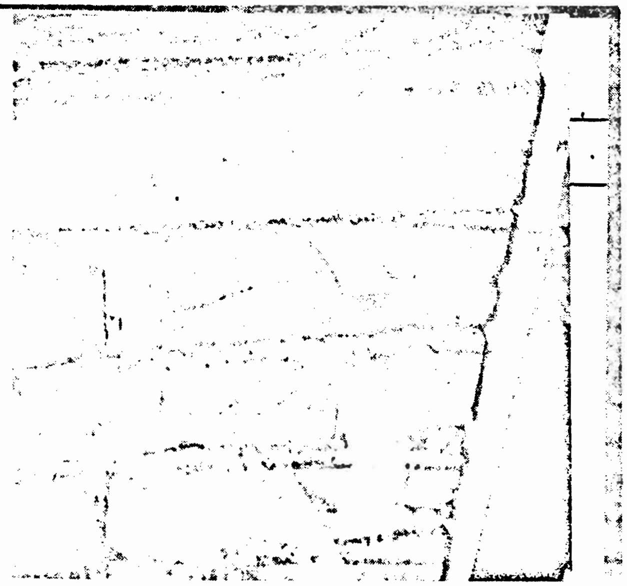
Plumbing and electric wiring

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 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 18 and 19.

You may prefer a finish floor of wood or asphalt tile over the concrete; or you



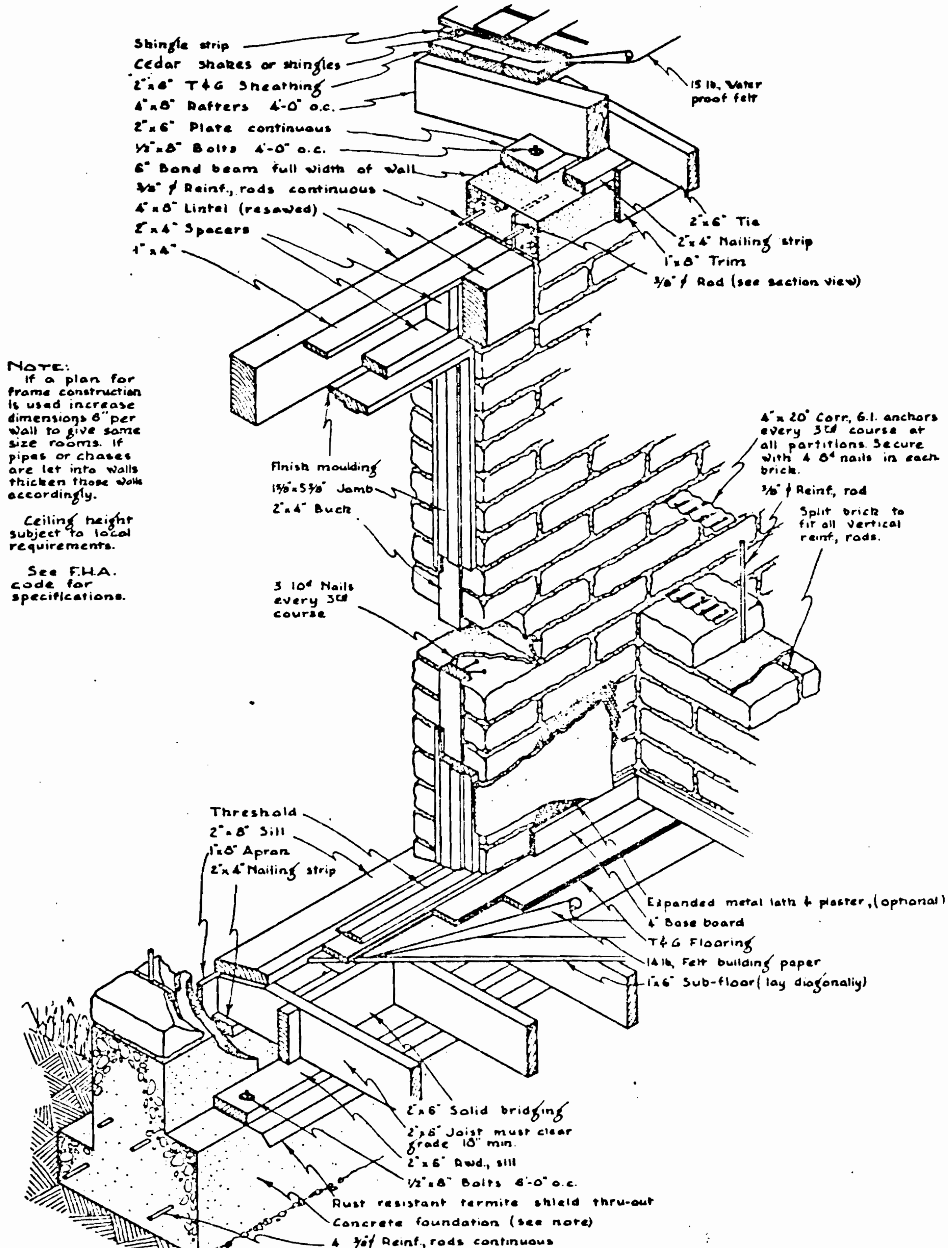
CORRUGATED METAL STRIPS are often used to attach an interior partition to the exterior wall. The attached partition may be of adobe or wood frame. Similar attachments are often used for door and window frames.

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 18.

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 13, 18, and 19. Be sure to nail gable roof rafters especially well to ceiling joists, plates, and walls.

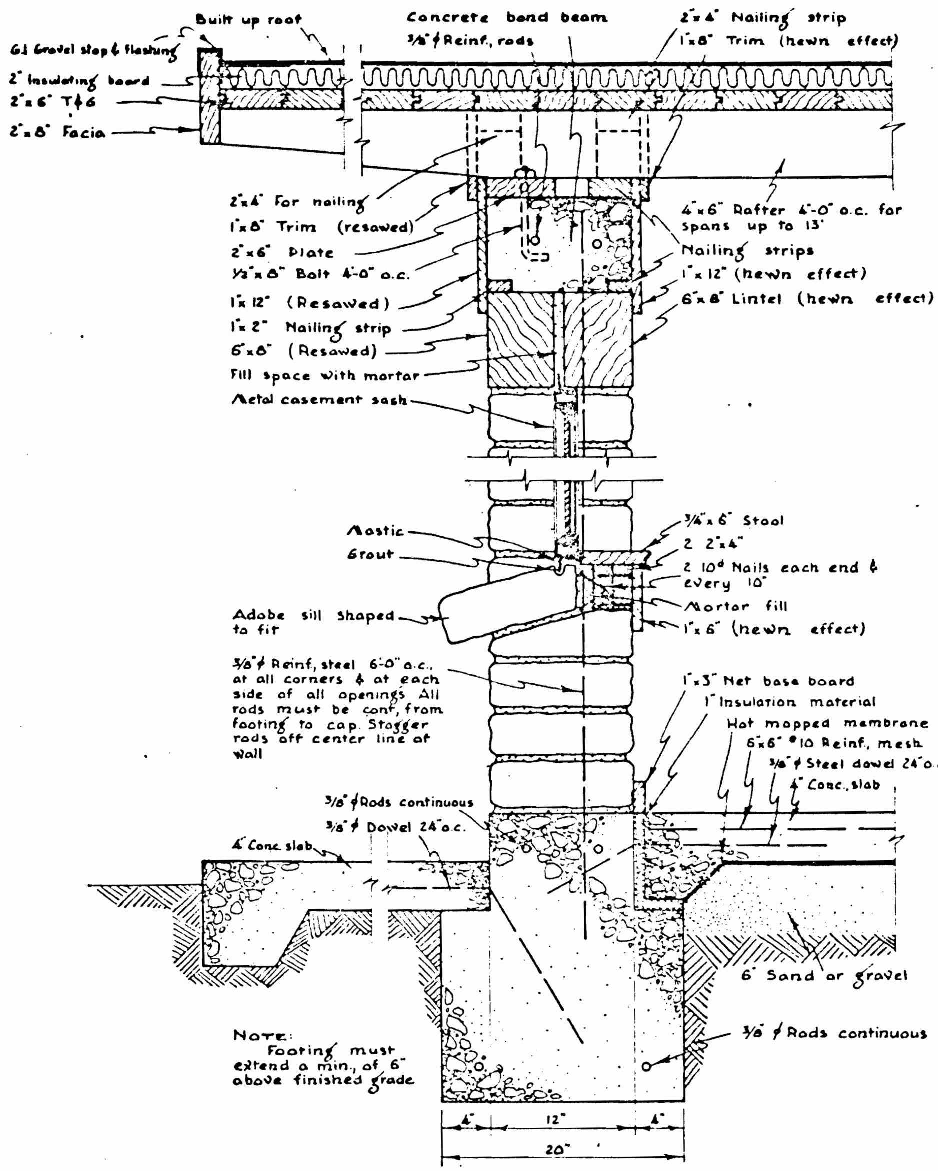
Many roofs are now being constructed with an overhang of two, three, or four feet, to help protect the walls from rain and provide shade for windows and walks. An overhang of about three feet on the south exposure will completely shade large windows from the summer sun but permit the low winter sun to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

TYPICAL ADOBE



PICTORIAL VIEW showing construction details, including wooden floor.

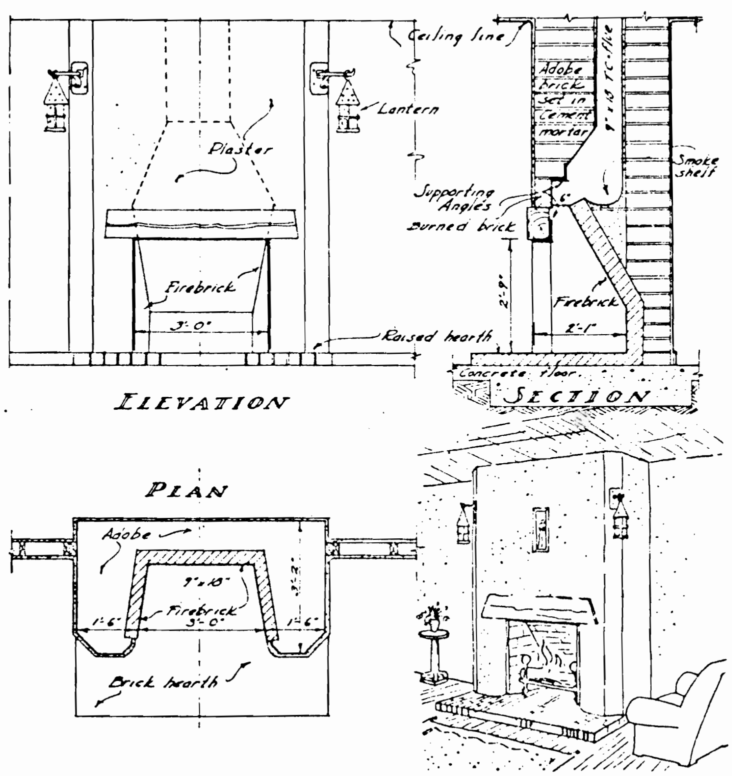
CONSTRUCTION DETAILS



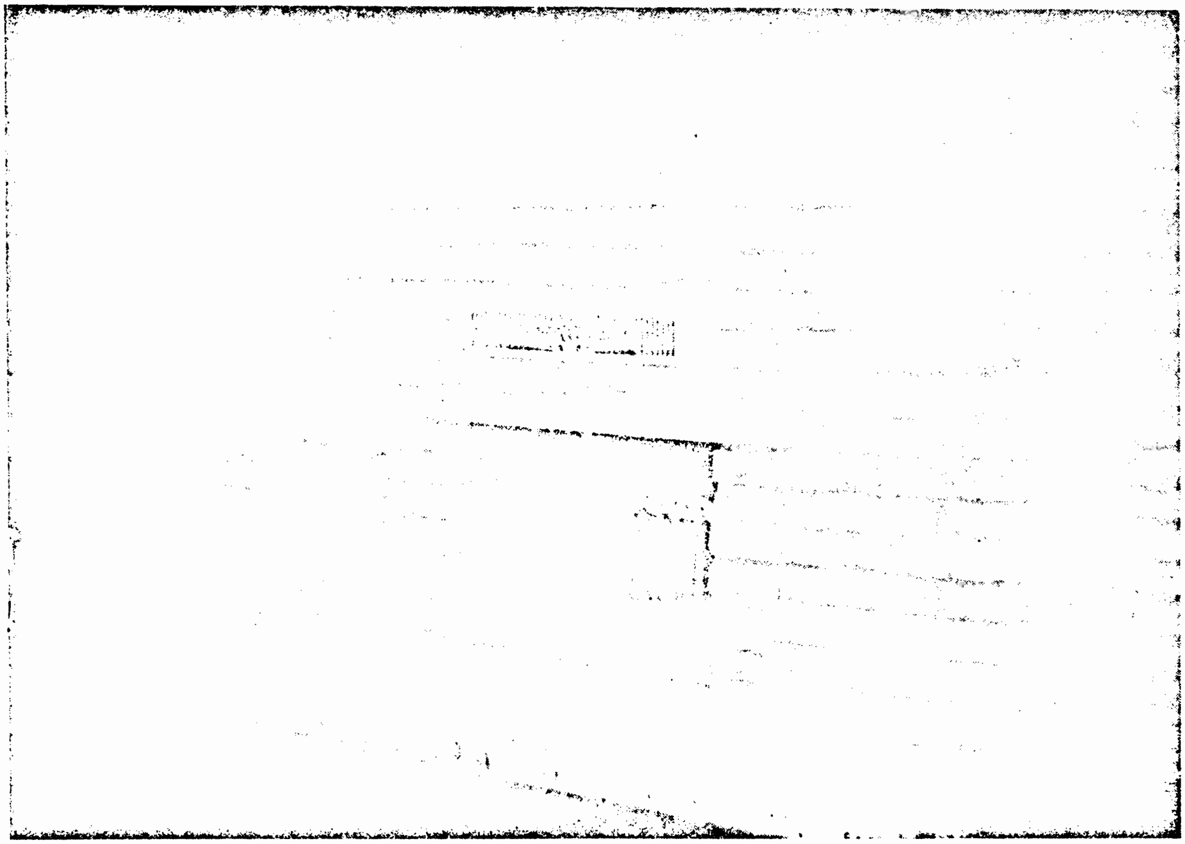
CROSS-SECTION DETAILS of roof, wall, floor, and foundation for typical adobe construction.

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 21, 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.



FIREPLACES can be built of adobe. Sun-dried brick 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.



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

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 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. The photo on page 9 shows test blocks and paint experiments.

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.

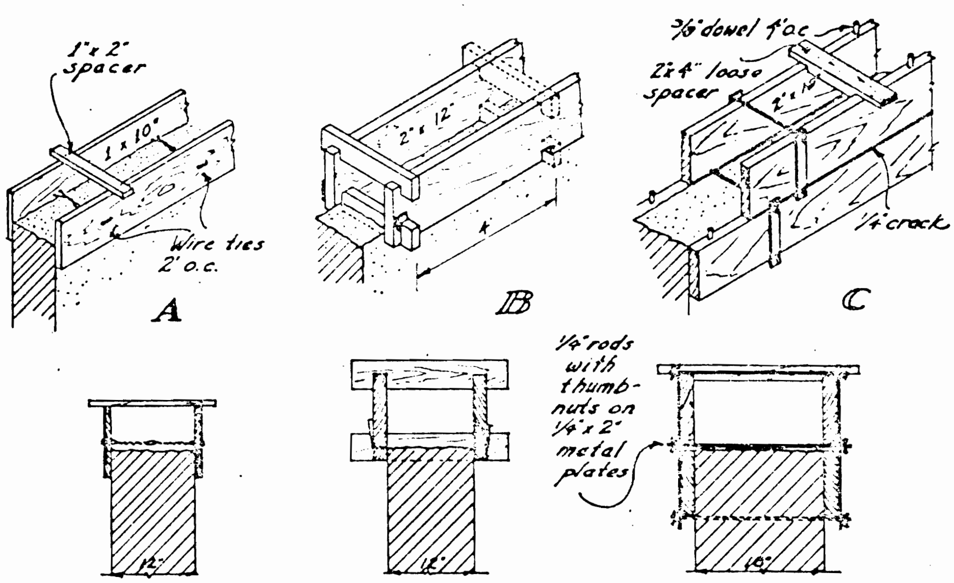
Monolithic Construction

While the use of adobe bricks is now most popular, you can also use monolithic methods, in which the entire mass of adobe is poured or molded in a single unit. Here are a few construction methods that sometimes are used in building adobe houses.

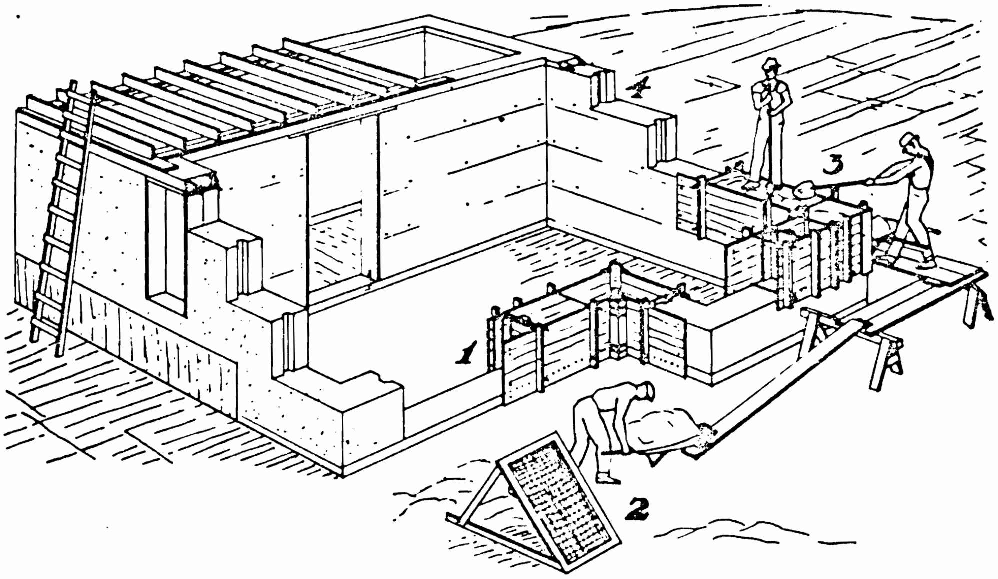
The Cajon Method uses the adobe merely as a wall filler, and depends on other materials for structural support. You build the framework of the wall of wood timbers or concrete posts, and place the earth between these to form the solid wall.

The Poured-Adobe, or Mud-Concrete Method modifies the Cajon method, to the extent that you use no wood studs but pour thoroughly mixed mud between forms directly in place in the wall. You allow the mud to dry, then remove the forms, and the mud wall alone supports the roof load. See the sketches on this page for some types of forms you may use.

The English Cob Method requires a stiff mud, piled in relatively thick layers on the wall without the use of forms. You mix the mud to a heavy enough



THREE TYPES OF FORMS for poured adobe or mud-concrete. A, Light forms tied with wires, which may be cut and left in the wall. Wire ends may assist in fastening furring or stucco reinforcing. B, Heavy planks provide more substantial forms. Cross members are notched and the planks notched along the lower edge. Holes left in the wall are tamped full of mud. C, A type of "climbing" form, the bottom members being easily removed to place on top of a filled section above. Dowels will aid in securing proper alignment. All forms should be painted or oiled, to facilitate frequent cleaning.



RAMMED-EARTH WALL CONSTRUCTION. Heavy sectional forms are clamped to the masonry foundation (1). Damp soil is put through a coarse screen (2) and is spread 4 inches thick in the forms (3). This is tamped to a dense mass, and the routine continued until the form is full. Cross-bolts are then withdrawn and the forms moved. Vertical joints are staggered at least 3 feet, and shaped with tongue and groove (4). A reinforced concrete bond beam is poured along the top of the wall.

consistency so it will have little tendency to slump. If it does slump or spread, trowel it back in place, or slice off the edge and place it back on top. This method has the advantage that it needs no forms. But shrinkage cracks often cause serious trouble, and the English cob method is not used very much in this country.

Rammed Earth, or Pisé de Terre. This is the most popular of all monolithic constructions. You consolidate damp or moist earth by tamping or ramming it in place in the wall between forms. The soil should be just moist enough to hold together in a ball when you squeeze it in your hand, and yet dry enough to fall apart when dropped to the ground from waist height. It should not be sticky. Soil that is too wet or too dry will not consolidate under the tamper.

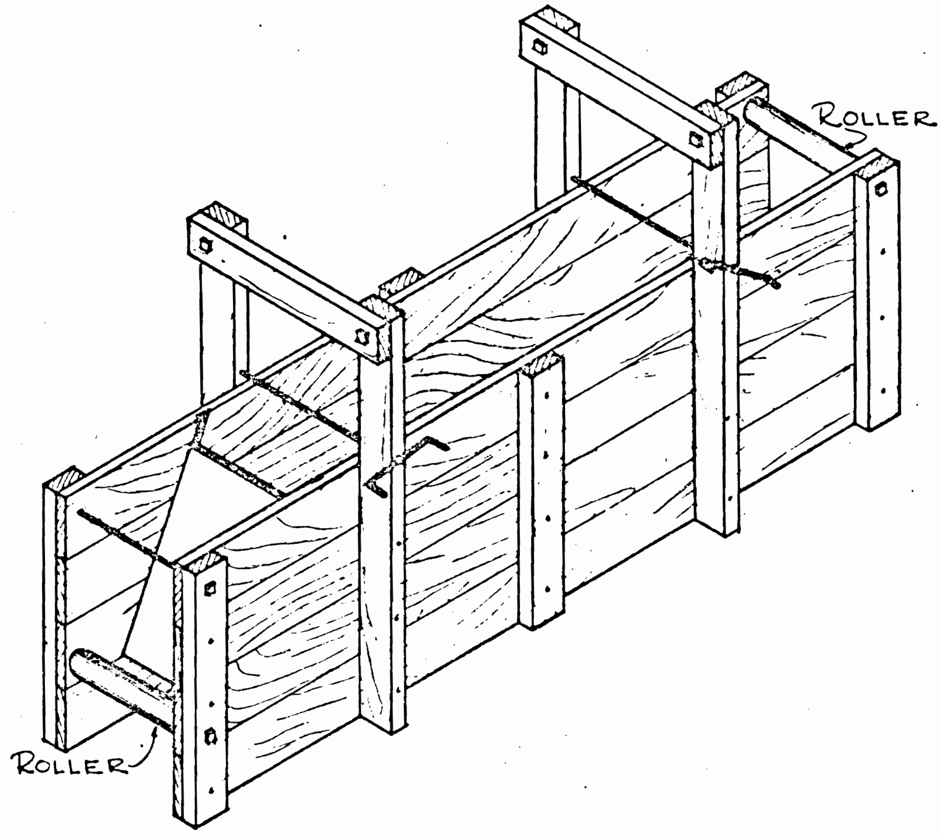
You need heavy, strong forms and special tamping tools. One-inch lumber is not strong enough to withstand the high lateral pressures; you had better use planks $1\frac{1}{4}''$ to $2''$ thick.

Place the damp soil in the form and level it to a uniform $4''$ layer. This depth is most practical because it seems to be the limit to which you can compact loose soils with a hand tool. A thorough ramming will compact the $4''$ layer of loose soil to about $2\frac{1}{2}''$.

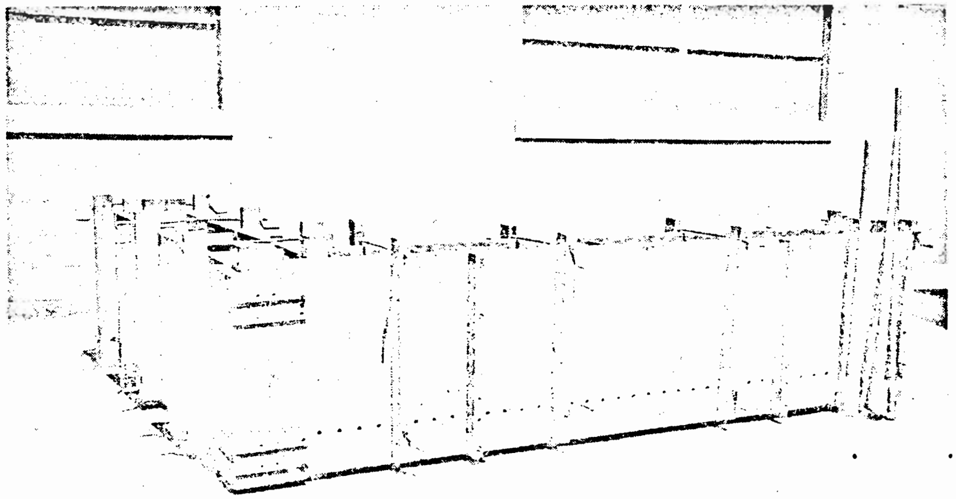
Under favorable conditions, rammed-earth construction often goes faster than other types of adobe-wall building, but the making and moving of the heavy forms are tiresome and discouraging.

A roller-supported form work is one of the newest methods for forming a straight section of rammed-earth wall. The sketch on page 24 shows how the side-planks are held and spaced by cantilever clamps at the top, so no ties or braces need to be covered with earth. The 3″-diameter rollers are fastened to the lower front end and the upper rear end of the movable form, so that it can easily be rolled forward on the newly rammed wall to a new position at the finish of each small section.

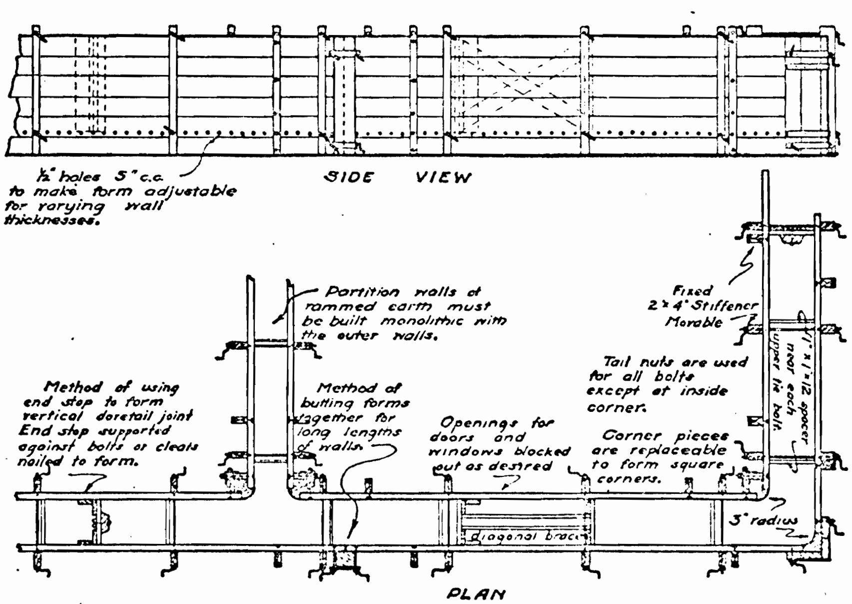
The illustrations on page 25 give more information on forms and over-all arrangement for operations on rammed-earth structures.



EASILY-MOVED ROLLING FORM built of 1¼″ side boards, fastened to 2″ × 4″ studs and cantilevers. After ramming one section of wall, the form is moved to a new position by means of the two 3″-rollers. It does not have to be lifted. The form is held in place above the finished part of the wall by clamping it firmly with the two double-ended cranks.



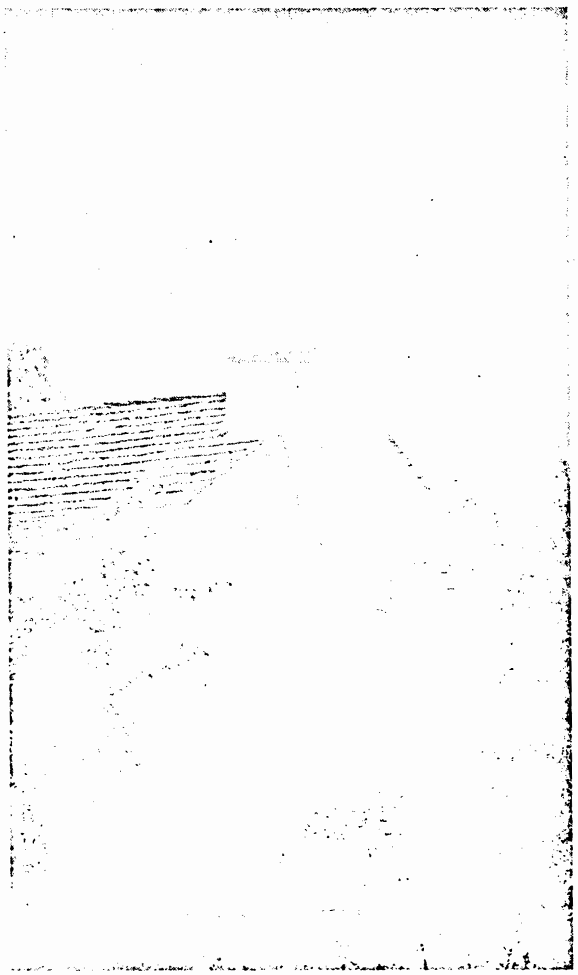
FORMS for rammed earth construction, showing the arrangement for forming corner and partition walls and for blocking out openings. The spacing of the bolt holes along the bottom of the form permits adjustment to all wall thicknesses that are divisible by 3". Three types of hand-tamping tools are shown in the photograph at the far right.



Plans Available

You can convert almost any standard house plan to adobe-brick construction. Blueprint plans are available, at the prices shown below, from the University of California.

Plan 157 (typical adobe details, can be used together with any of the complete blueprint plans listed here)	25¢
Plan 159 (one bedroom, 843 square feet)	75¢
Plan 163 (three bedrooms, 1,300 square feet)	75¢
Plan 7061 (expansible house, wood frame)	$1.00
Plan 7062 (expansible house, concrete block)	$1.00



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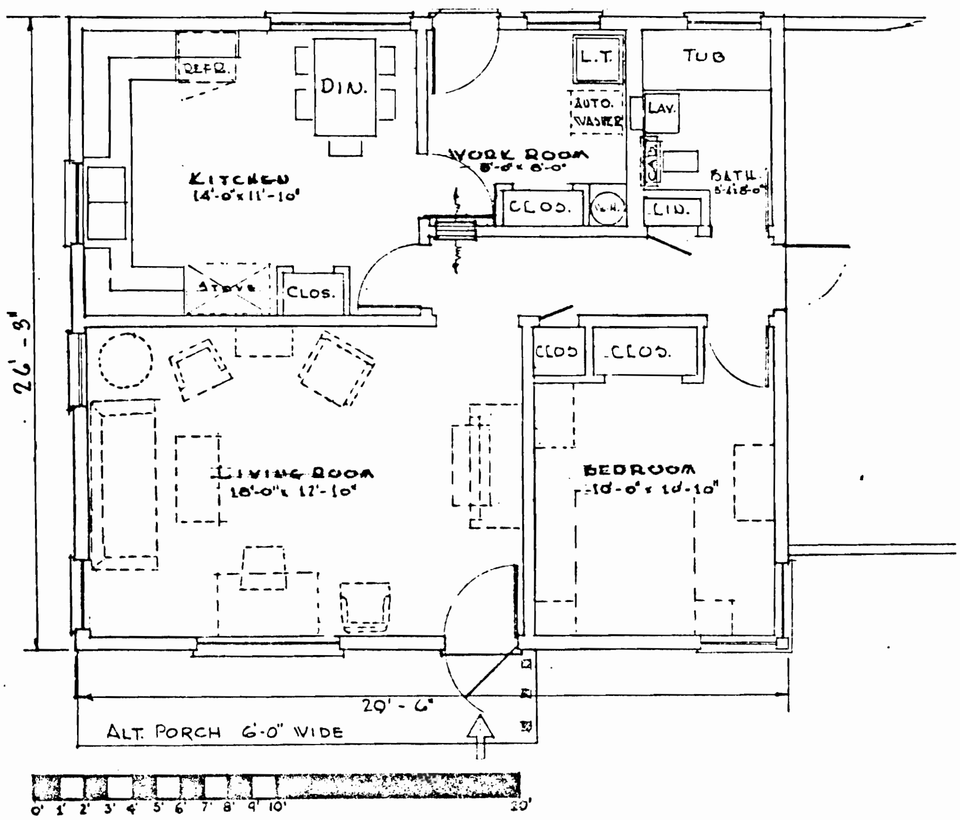
The floor plans shown on the following pages, while not available in detail, may give you some . . .

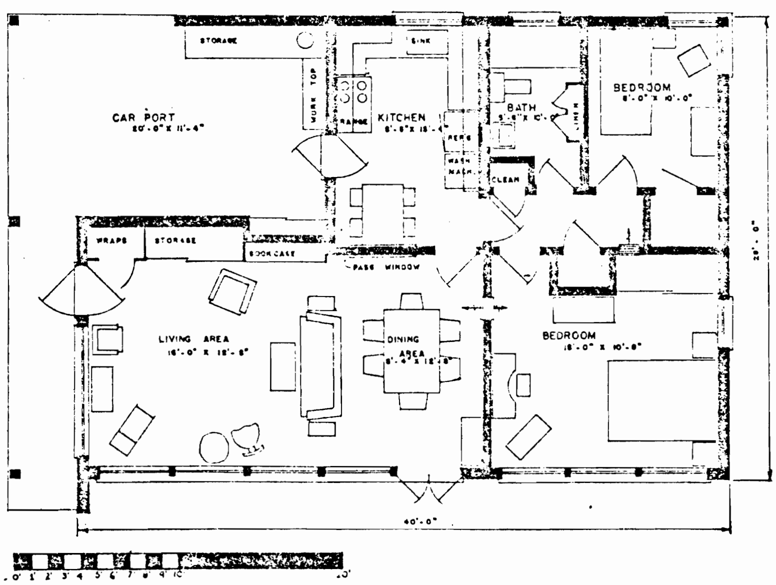
Ideas ⇨

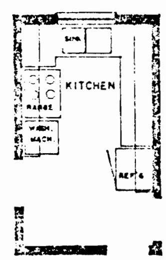
For Basic Houses



Plan for a one-bedroom adobe house, with a floor space of 774 square feet. Small, compact, can be expanded to three bedrooms. Roof may be gabled, flat, or shed type. Doors are placed so traffic does not cross work or living areas. Window location allows space for good arrangement of furniture and equipment.

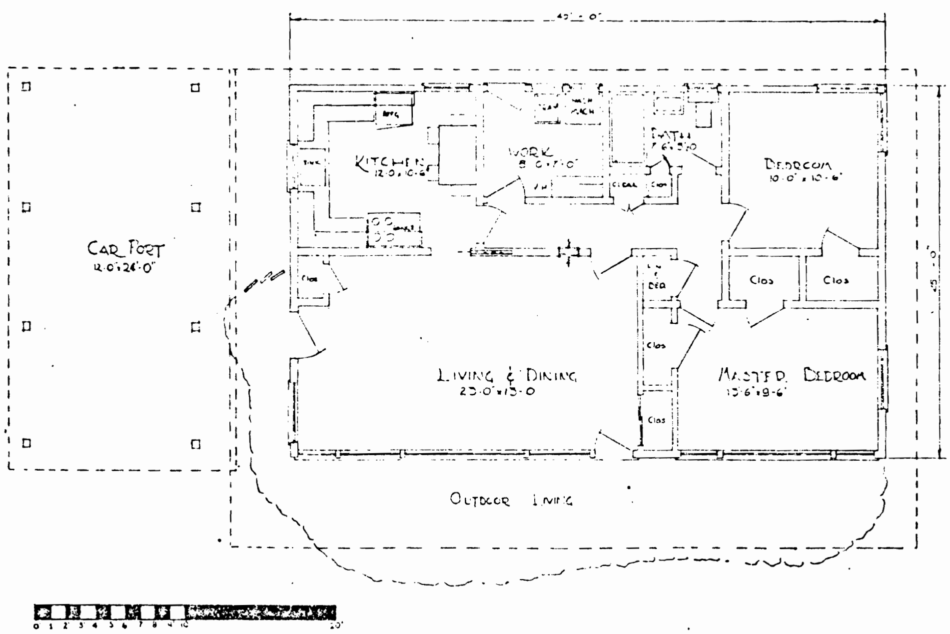
Plan for a 1,120 square-foot solar house. Large window area should face south for heat from the low winter sun. Overhanging roof protects house from the high summer sun. Car port and extra storage space are provided. All plumbing is located in one wall between kitchen and bath.

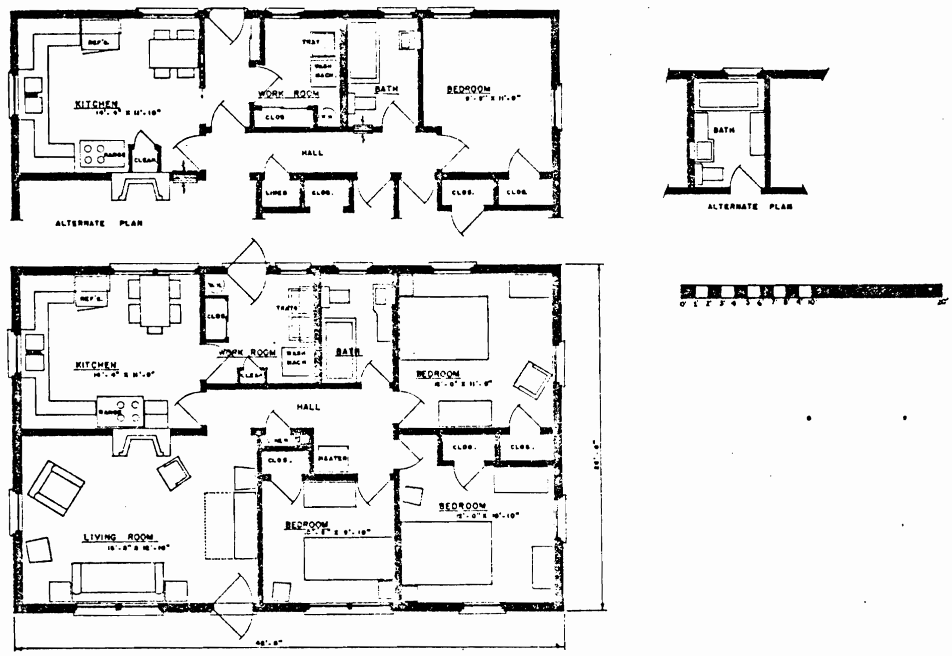




ALTERNATE PLAN

Another solar-type house, with an area of 1,000 square feet. Master bedroom and living-dining area are exposed to the low winter-sun by large windows, while 6-foot overhang protects south of house from high summer sun and gives protection to outdoor living area. An evaporative cooler in the chimney allows cool air to be blown into living room or central hall.





Three-bedroom house, 1,140 square feet. Principal dimensions are multiples of the 4-inch and 8-inch module, for economy and rapid construction. U-shaped kitchen provides storage and work space. A comfortable dinner area is near a large window. In alternate plan, the hall allows entrance from the rear into any room without going through workroom or kitchen.

And 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. $3.00.

American Bitumuls Co., "Bitudobe for Modern Adobe Buildings." 200 Bush Street. San Francisco, California. 16 pp. 1950.

Betts, M. C. and Miller, T. A. H., Rammed Earth Walls for Building, Farmers' Bulletin 1500, U.S.D.A., Supt. of Documents, Washington 25, D.C. 24 pp. 1937. 10¢.

Brown, Francis W., publisher. California Homes, Adobe Houses Edition, 315 Sutter Street, San Francisco 8, California. 32 pp. 1949. 25¢.

Comstock, Hugh W., "Post-Adobe." Carmel-by-the-Sea, California. P. O. Box 533. 1948, 40 pp. $1.00.

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

Eyre, Thomas J., M. E., The Physical Properties of Adobe Used as a Building Material. The University of New Mexico Bulletin No. 263, Albuquerque, New Mexico, 32 pp., 1935. 25¢.

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

Glenn, H. E., Rammed Earth Building Construction. Bulletin No. 3, Engineering Experiment Station, Clemson Agricultural College, Clemson, South Carolina. 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. 36 pp., 1941.

Hansen, Edwin L., The Suitability of Stabilized Soil for Building Construction. Bulletin No. 333. University of Illinois, Engineering Experiment Station, Urbana, Illinois. 40 pp., 1941. 45¢.

Harrington, Edwin Lincoln, Adobe as a Construction Material in Texas. Bulletin No. 90, School of Engineering, Texas Engineering Experiment Station, College Station, Texas. 36 pp., 1945.

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

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

Long, J. D. (revised by L. W. Neubauer), "Adobe Construction," Bulletin 472. California Agricultural Experiment Station, University of California, Berkeley, 64 pp., free—November 1946.

Middleton, G. F., Earth Wall Construction, Duplicated Document No. 28. Commonwealth Experimental Building Station, P. O. Box 30, Chatswood, N.S.W., 56 pp., 1949. 1 shilling.

Middleton, G. F., Build Your House of Earth. Angus and Robertson, Sydney, Australia. 105 pp., 1953. About $2.00.

Miller, T. A. H., "Adobe or Sun-Dried Brick for Farm Buildings." Farmers' Bulletin 1720. U.S.D.A., Supt. of Documents, Washington 25, D.C., 18 pp., 1934. 5¢.

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, 24 pp., 1936.

Patty, Ralph L., Paints and Plasters for Rammed Earth Walls, Bulletin 336. Agricultural Experiment Station, South Dakota State College, Brookings, South Dakota, 40 pp., 1940.

Patty, Ralph L. and Minium, L. W., Rammed Earth Walls for Farm Buildings, Bulletin 277. South Dakota Experiment Station, Brookings, South Dakota, 78 pp., 1938.

Schwalen, Harold C., Effect of Soil Texture Upon the Physical Characteristics of Adobe Bricks, Technical Bulletin No. 58. College of Agriculture, University of Arizona, Tucson, Arizona. 22 pp., 1935.

United Nations, Adobe and Rammed Earth. Housing and Town and Country Planning, Bulletin No. 4. United Nations, N.Y., 121 pp., 1950. $1.50.

Williams, E. McKinley, "Cemadobe." Box 81. West Los Angeles Station, Los Angeles 25, California, 32 pp., 1946. $1.00.

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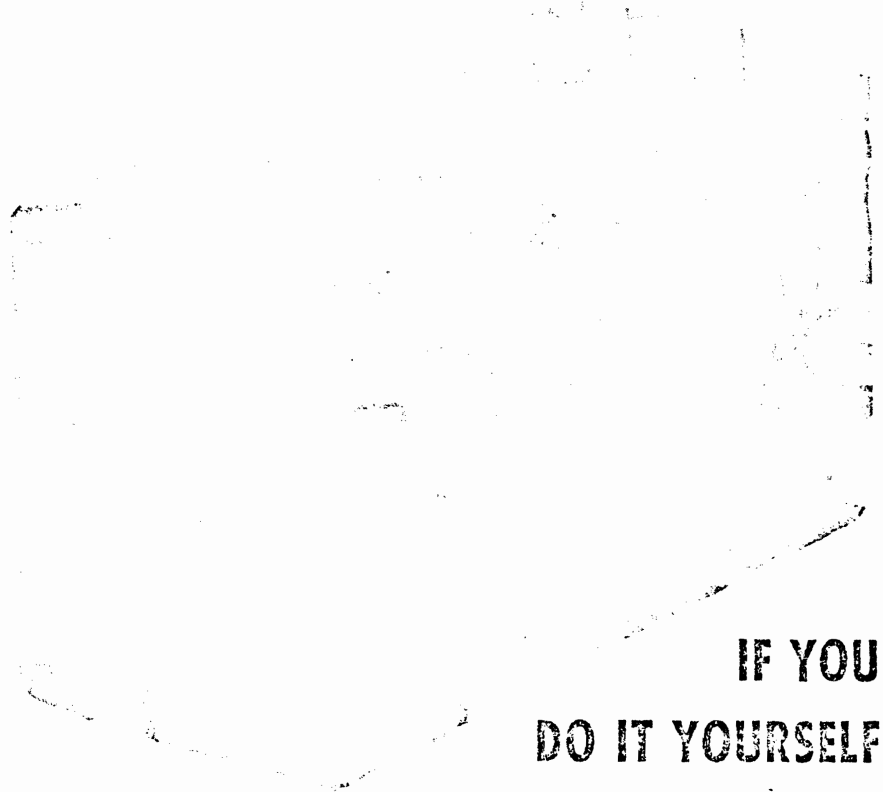

IF YOU DO IT YOURSELF or HIRE IT DONE

This manual will help you to decide a number of basic and extremely important questions about how and where to build (or perhaps not build) with adobe. If you do decide to build you'll find the photos and drawings of construction details most helpful.

Net price 25c