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Lime Plaster on Adobe Walls
A Workshop

Notes and Glossary

June 11 and 12, 1999

Presbyterian Mission Church
401 Socorro St.
Las Vegas, New Mexico

Courtesy of:

First United Presbyterian Church, Las Vegas

Presented by:

Cornerstones Community Partnerships
Northern Research Group
New Mexico Heritage Preservation Alliance

Any part of body that is moist is vulnerable - eyes, lungs.
1 TSP salt : 1 pt water
wash eye if lime in eye
Wash hands w/ vinegar, lemon or lime after.

Principles of the Behavior of Materials

E. Crocker

Introduction: Buildings as Systems

Buildings, regardless of the materials used in their construction, are comprised of various components which are interlocked mechanically and interrelated functionally. The roof for example, is attached to the walls in such a manner as to allow the latter to provide support and the former to provide protection. One is non-functional without the other. It is important, then, when assessing buildings for repair that wall and roof be viewed as two elements of one system. All other components of a building including floors, windows, doors, portals, plasters, paints, etc., relate to one another as well. Key to the successful functioning of this system is the compatibility of the materials used in its construction, and by extension, its repair.

To draw an extreme analogy, a building might be compared to a human body. It is common nowadays to transplant organs and tissues from one person into another. However, it is essential that the tissue of the donor biologically "match" the tissue of the recipient. If the tissues are incompatible, the body rejects the organ and the recipient suffers a considerable setback. That does not typically occur when the tissues match.

Similarly, a building constructed of adobe will "reject" repairs made with cement, often in disastrous ways. There are thousands of examples of this in the southwest alone. A common pathology seen some years after hard cement is placed over soft adobe is moisture absorption. Water finds its way into the earthen walls through cracks, leaky roofs, and broken plumbing, always resulting in deterioration. Left alone, the walls inevitably reach the point where they loose their structural qualities and collapse. The "death" of the wall is usually unforeseen because the problems are hidden behind the self-supporting hard plaster.

Identification of Materials

As part of the assessment process, the materials used in construction and subsequent remodelings and restorations, need to be identified and analyzed. If modern, or radically dissimilar materials have been applied consideration in some cases, needs to be given to their removal. Such consideration needs to encompass three elements; the structural integrity of the building, its appearance, and its use. Clearly, the first goal of a sound structure must weigh heavily in conservation planning, and should be treated more objectively than the others. Appearance and use, the more subjective elements, can be manipulated by the owner or community only if the building remains standing.

Some Issues of Compatibility

1. Cement products and Stone vs Mud and Stone

   Cementitious products are durable and not very permeable (prone to permit the passage of water and air through its mass). Both characteristics result from its hardness.

   Most southwestern sandstones and limestones are relatively soft and permeable. When combined with cement and exposed to the elements, water is rejected by the cement, but absorbed by the stone. If the stone is set in cement mortar, the mortar acts as a dish retaining the water. During cold months, the freeze-thaw cycle will lead to deterioration of the stone, leaving the cement matrix intact. During the wet season, the cement dish holds water which dissolves the solubles in the stone, accelerating their deterioration.

a rule of thumb that mortars and plasters should be softer than the masonry units (stone or adobe) they bind and cover. As softer materials, they comprise sacrificial layers which take the brunt of erosion away from the masonry unit and add longevity to the building. Softer materials require more frequent maintenance, but result in a sounder structure.

2. Cement and Adobe vs Mud and Adobe

If cement adversely affects stone, the problem is increased manyfold when it is applied with adobe. The softer earth encased in cement, retains the water. If the accumulated moisture reaches 12 to 14 percent by weight, the wall is in imminent danger of collapse.

Adobe laid in mud mortar, and rendered with a mud plaster will retain its ability to absorb and disperse moisture cyclically and reliably. It does not hurt adobe to get wet, even very wet, as long as it is permitted to dry out. Even during storms of long duration, moisture seldom penetrates more than a quarter inch from the exposed surfaces. The areas of high vulnerability to erosion, namely the parapets and wall bases, can be dealt with very effectively through several types of interventions which are compatible with the materials.

3. Lime as an Amendment in Conjunction with Mud

One method of prolonging the maintenance cycle of earthen plasters is by amending them with lime. A very small percentage of lime results in increased durability and adhesion, without affecting permeability. This technology is know to have existed from pre-Hispanic times in Central and South America where lime blocks and prepared lime mortars and plasters were commonplace. In the north, it is now recognized that lime, often in the form a *caliche*, a secondary precipitate of calcium carbonate, was used to amend mud.

4. Lime as a Mortar in Conjunction with Mud

Before the introduction of cement, it was common practice in the southwest to point stone masonry laid in mud mortar with lime. This simply means applying a thin (1/2-inch) layer of lime mortar in the joints between the stones. The lime, being a harder material than the mud, resists erosion, but retains the quality of permeability.

Later, as lime technologies became more prevalent, lime, in large part, replaced mud mortar altogether in stone and fired brick masonry.

5. Lime as a Plaster in Conjunction with Mud

Although it is not widely recognized, lime plasters were prevalent in New Mexico prior to the introduction of Portland cement. Though more common in the south, they are not at all uncommon in the north, and in particular in the Mora Valley north of Las Vegas. Historic lime quarries have been identified in many parts of New Mexico, and a few slaking pits dating to the 1920's are also known. With the coming of the railroad, and the increasing availability of Portland cement, both mud and lime as renders were displaced.

LIME RENDERS

Specifications

1.0. DEFINITIONS

Adhesion: The ability of a material to "stick" to a surface or substrate.

Adobe: Sun dried earthen block used for building. Style of architecture characterized by the prevalent use of adobes.

Bedding joint: The horizontal mortar joint between two masonry units.

Brown coat: Term use in the United States indicating the second coat of plaster applied over the leveling, or "scratch" coat.

Aggregate: Durable materials used as filler in mortars and renders. Often sands and gravels with a high silica content.

Calcium carbonate: $CaCO_3$, the base material from which lime is prepared. Also the final material to which lime renders and mortars return after going through a cycle of hydration.

Calcium hydroxide: $Ca(Oh)_2$; calcium carbonate once it is mixed with water; slaked lime, hydrated lime, lime putty and lime milk.

Clay: Plate-like particles less than two microns (.002cm) across that are among the smallest remains left over from the weathering of rocks. Chemically, clays are hydrated alumino silicates which bind electrostatically and thus promote cohesion in mortars, plasters and blocks.

Cohesion: The ability of a material to bind to itself.

Finish coat: The last coat of a plaster or render which typically is treated decoratively. Also called "set".

Float: The process of finishing an application of a render or plaster. The tool used to finish an application of a render.

Fresco: Colored lime plaster added to the finish or "set" coat which is applied to a still-damp scratch or render coat.

Header Joint: The vertical mortar joint between two blocks. The joint is often left open in adobe masonry to allow for the plaster to form a mechanical bond.

Impermeable: The lack of pores or interstitial spaces which, if present, allow moisture or air to penetrate a render. The inability to transmit water.

Interstice or Interstitial space: The open space between particles .

Lath: Any of a variety of systems which aid the mechanical attachment of a plaster to a wall.

Lean: Higher than the norm in aggregate, lower in clays and fines. See also Rich.

Lime: The oxides and hydroxides of calcium and magnesium. The term typically excludes the oxides and hydroxides of the carbonates. Quicklime and slaked lime are commonly called "limes," but chalk and limestone typically are not.

Lime Putty: Lime which has been slaked and stored in an excess of water and isolated from the atmosphere. Also called fat lime.

Lime Water or Lime Milk: A clear fluid usually derived by mixing calcium carbonate in water and allowing the solids to precipitate. Lime water typically contains less than one half of one percent lime by volume. Lime milk has a higher percentage of lime, is milky in appearance and usually must be kept agitated or stirred to keep the lime in suspension. Both are used for mixing lime -amended muds for mortars and renders.

Mucilage: Organic material extracted from Prickly Pear (Opuntia sp.) cactus which acts as a binder and water repellent in lime washes. The mucilage is a viscous liquid resulting from the boiling down of the juice in the leaves.

Permeable: The ability of a material to transmit water vapor and air.

Plaster: In the United States, plaster is used to describe the system of mixed, plastic material applied to interior and exterior walls to protect them. "Plaster"

can mean both the system and the material, and the term is nearly synonymous with the European term "Render." See also "Render."

Quicklime: Burnt lime which has not been slaked. Also called lump lime and calcium oxide, CaO.

Slake: The process of combining quicklime with water to form lime milk or lime putty.

***Rajuela*:** The lathing system which uses small stones embedded in the leveling coat to help mechanically attach the lime plaster to the wall.

Render: An English term to describe an outside plaster system. In a two- or three-coat system, the first pass is called the scratch coat. Roughly synonymous with the term "plaster" used in the United States, although "render" is never used to describe an interior plaster. See also "Plaster."

Reversibility: In architectural conservation, the property of a material which allows it to be removed without damage to the material to which it was applied.

Rich: Higher than the norm in clays, lower in aggregates. See also Lean.

Scratch coat: In the Unites States, the first of a two- or three-coat system. Synonymous with Leveling Coat.

Substrate: The material to which renders or plasters are applied. In an adobe building, earth is the substrate.

Lime Plaster Specifications
After the Tradition of Northern and Central Mexico

2.0. WALL PREPARATION

2.1. EXISTING BUILDINGS

2.1.1. Stripping of existing materials.

When the wall to be re-rendered still retains all or part of a previous rendering system. The old material must be removed down to the substrate of the wall. This process should be done with care to protect original materials.

2.1.2. Removal of loose and delaminating material.

Once the wall has been stripped of the old plasters, the underlying material must be examined for strength and integrity. If the wall is adobe, any loose or shattered material, or any surface area of the blocks that is delaminated from moisture or freeze-thaw cycles, must be removed. Loose material can easily be scraped or extracted using a mason's trowel and, subsequently, with the use of a gentle spray of water from a low-pressure hose.

2.1.3. Repair of adobe walls.

See Appendix i.

2.1.4. Voids in mortar joints.

In preparation for the application of the mud leveling coat, the header and bedding joints in an adobe wall which will recieve a *rajuela* lathing system should be scraped to a depth of three-quarters inch, sprayed clean and left open. In most *rajuela* systems, all header and alternating bedding joints are treated.

2.2. NEW BUILDINGS

(Not covered in this specification)

3.0. LEVELING COAT

Function. After the repair of an adobe wall, the leveling coat serves to fill low spots and small voids, and to provide a flat, uniform surface for the application of the render. Leveling coats can be of either mud or lime. Lime is preferred.

3.1. Lime leveling coat.

3.1.1 Quicklime.

To produce the most durable, as well as the most workable material, the quicklime should be as white as possible. Discoloration in quicklime is indicative of impurities. The material should have been fired at a temperature of at least 1850° Fahrenheit for a minimum of 36 hours.

3.1.2 Safety.

The process of firing drives the moisture out of the lime. In this state the lime is

extremely caustic and should be handled with care. Contact with skin can result in severe burns as the lime draws moisture out of the body. Always use eye and skin protection when handling quicklime, and a filtering mask when you are exposed to lime dust.

3.1.3. Slaking.

3.1.3.1. Process.

Slaking begins when quicklime is immersed in an excess of water. Fill a five gallon bucket half full with clean water. Add lumps of quick lime. The reaction will be volatile as the lime absorbs the water and turns to calcium hydroxide. Mix constantly and thoroughly. Maintain enough water in the bucket to keep the material liquid. As the "boiling" dies, screen the liquid through a one-quarter inch mesh into plastic barrels (metal barrels cannot be used because they corrode before the slaking process is complete). When the barrel is three-quarters full, top it off with at least 6 inches of water. This will help assure that the lime does not come into contact with the atmosphere and begin to re-carbonate. Tightly cap the barrel.

3.1.3.2. Aging.

The longer the lime slakes, the higher quality it becomes. Some master craftsmen only use lime that has been slaking for decades. In the southwest, there is no documented tradition for a minimum period for aging, but experience dictates that a minimum of 90 days is necessary to provide both the characteristics of plasticity and durability that are desirable. One to two years of barrel-slaking provides a very high quality product.

3.1.4. Storage.

It is imperative that the lime putty be kept in air-tight containers with at least two inches of water over the top. Periodically uncap the barrels to verify that the putty is covered with water.

3.1.5. Lath; the *rajuela* system.

3.1.5.1. Size and shape of stones.

The *rajuela* system utilizes small stones embedded in the header and bedding joints of the masonry units to help the plaster adhere to the wall. *Rajuelas* should be small, flat, irregular stones, no larger than three (3) inches in any dimension.

3.1.5.2. Application.

The stones should be inserted into the hearder and bedding joints of the wall after they have been filled with plaster. No more than one-half inch should protrude from the surface. Each header joint should receive one stone; every second bedding joint should receive a continuous row of stones.

3.1.5.3. *Rajuela* as filler.

In situations where the wall has deep hollows, flat, non glazed tile or brick fragments may be embedded in the leveling coat to help bring the vertical surface into plane. Porous stone may also be used.

3.1.6. Mixing of plaster.

3.1.6.1. Materials

3.1.6.1.1. Lime putty.
Use lime putty that has be slaked a minimum of 90 days as described in Section 3.1.3. and stored as described in Section 3.1.4.

3.1.6.1.2. Aggregate.
Number eight washed masonry sand is commonly used as aggregate in lime plasters. The leveling (scratch) and render (brown) coat may have a larger overall aggregate than the finish or set coat, however. In no instance should the aggregate exceed 1/4 (one quarter) inch in any dimension. Commercially available sands and small gravels are acceptable, but it is advisable to have the material taken from the middle to upper levels of the pile to assure that it is clean.

3.1.6.1.3. Water.
Use only clean tap water when mixing lime. If the local water is highly chlorinated, allow the water to sit in an open barrel for a few hours before use to allow the chlorine to dissipate into the atmosphere.

3.1.6.2. Proportions.
A standard mix is three parts aggregate to one part lime with just enough water to make the material workable.

3.1.6.3. Use of mechanized equipment.
A motor driven paddle or mortar mixer is the most effective way to mix lime plasters. Be sure the barrel of the mixer is clean before use. Add the water first, lime putty second, and aggregate last. Mix at moderate speed for at least ten minutes. The consistency of the mix should be such that it does not cling to the paddles of the mixer, but falls off the rubber wipers when they come around to the vertical position.

3.1.6.4. Immediate use.
Mix only the quantity of lime plaster that can be used within two hours. Once mixed and exposed to the atmosphere, the lime plaster begins to re-carbonate. If the plaster is not used within four hours, it must be discarded. Old material cannot be reconstituted or re-slaked.

3.1.7. Application

3.1.7.1. Wetting of wall.
Before the leveling coat is applied, thoroughly dampen the wall with lime water or lime milk. This may be accomplished with a mason's dash brush, with a small container used to splash water onto the surface. In a hot, dry climate, the moisture will quickly evaporate. It is advisable, therefore, to dampen only small areas at a time. Walls may be dampened repeatedly, a practice which helps assure bonding of the lime to the wall.

3.1.7.2. Tools.
Lime leveling coats are typically applied by "flipping" small quantities of

the mix onto the wall with a pointed mason's trowel. The material is then smoothed with a rigid, wooden trowel (*plana de madera*).

3.1.7.3. Thickness.
The leveling coat should be applied in a thickness which covers irregularities in the wall. A single application of plaster should not exceed one inch in thickness.

3.1.7.4. Drying time
Lime begins to dry, or re-carbonate as soon as it is exposed to carbon dioxide in the atmosphere. The render will become firm within thirty minutes of application, and hard within six hours. It is characteristic of lime that through repeated wetting and drying cycles the render gains strength. The drying time can and should be retarded by repeated dampening of the surface; this will slow the re-carbonation process and result in a more durable plaster.

3.1.7.5. Hot Weather
In very warm, dry weather, in temperatures above 90° F., the render can dry too rapidly and fail to re-carbonate thoroughly. The result will be a plaster with a chalky consistency which will have a tendency to delaminate from the wall. In areas where temperatures are in the 90° range or above for weeks or months at a time, it is advisable to wait for cooler weather.

3.1.7.6. Cracking.
Lime leveling coats applied over dampened walls with adequate force are not likely to crack. Minor, hairline cracks may be disregarded. If large cracks appear, the mix may be too rich, or the plaster may be drying too quickly. Excessively cracked plasters should be removed and replaced.

3.2 Mud leveling coat.

3.2.1. Materials

3.2.1.1. Lime water or lime milk.
The use of lime water or milk in wetting the substrate and in the mixing of the mud helps increase the adhesive and cohesive characteristics of the mud. As the lime water in the walls and the muds dry and re-carbonate together, a chemical bond is formed between the two. All water used in the process or preparing for the application of a lime render should contain a low percentage of lime. Begin with clean water, in a 55 gallon barrel. Add a quart of lime putty (see Sections 3.1.3. and 3.1.4.) and agitate with a shovel handle or clean board. Water that appears milky will have in excess of five percent lime in suspension. After the solids have settled, the clear water will still have up to .05 percent lime in suspension.

3.2.1.2. Aggregate.
Clean sand and fine gravels, not exceeding 1/4 (one quarter) inch in any dimension may be used in the leveling coat. Commercially acquired sands are acceptable but it is a good idea to request that the material not be taken from the bottom of the pile. Arroyo sand, if it is clean, is also acceptable. Aggregates should comprise 75% to 80% of the mix.

3.2.1.3. Clays and silts.
The soils used to produce the mud plasters can often be barrowed on or near the site of the restoration work. The soils can be "shake" tested for

clay and silt vs. coarser materials. The mix should not exceed 25% clays and silts. See Appendix i on shake testing.

3.2.1.4. Straw.
If the local tradition calls for the use of straw in the mud, commercially available grain straws are usually the most economical and are very effective. Do not use hay or alfalfa. The straw should be chopped finely, so that no piece is more than an inch and one half long. In a typical mix of twenty-five dry gallons of soils and aggregate, two large double handsful of straw is sufficient.

3.2.2. Mixing.
Muds can also be mixed by hand in a pit or trough, or in a mechanized mixer. If a mixer is used, the materials should be added to the barrel of the mixer in this order: water, straw, clayey soil and sand. Materials should be measured into the mixer as consistently as possible. Use of a bucket to measure, rather then counting shovels full, is preferred.

3.2.3. Aging.
The best muds are those which are mixed, either by hand or in a mechanical mixer and left soaking in a pile overnight.

3.2.4. Storage of mixed materials.
Muds can be kept viable for long periods through consistent wetting. Material exposed to the atmosphere for several hours will need to be wetted and turned occasionally to maintain a plastic consistency.

3.2.5. Lath: The *rajuela* system. See Section 3.1.5.

3.2.6. Application.
Mud can either be thrown on to the wall by hand, or troweled. If it is hand-worked, the mix should be forcefully thrown into the voids in the header joints and the surface, and then worked smooth with the heel of the hand. If a trowel is used, care should be taken to assure that the mud adheres well to the wall. Small amounts of mud on the trowel, applied with considerable force to the wall will help assure adhesion. The leveling coat should not exceed one inch in thickness in any area. Some areas may need two or more successive applications.

3.2.7. Cracking.
Some cracking in a mud leveling coat is not only acceptable it can be desirable. Small cracks are an indicator that the mix is as rich in clay as possible without being vulnerable to curling and delamination. If, however, the leveling coat cracks excessively during the drying process, the mix may be too rich in clay and additional aggregate may be called for. If the mud cracks to such a degree that it curls or flakes, the leveling coat must be removed and a leaner mix applied.

4.0. LIME RENDER ("BROWN COAT")

4.1. Raw material. See Section 3.1.1

4.2. Safety. See Section 3.1.2

4.3. Slaking. See Section 3.1.3

4.4. Storage. See Section 3.1.4

4.5. Mixing. See Section 3.1.6

4.6. Application. See Section 3.1.7

4.7.2. Tools. To Section 3.1.7.2. add:
A long leveling or "Darby" trowel may be used to spread the render.

4.7.3. Thickness. See Section 3.1.7.3
The lime render should be applied in a thickness which covers the exposed *rajuela* thoroughly. This is typically about three/quarters of an inch.

4.7.4. Drying time. See Section 3.1.7.4.

4.7.5. Hot Weather. See Section 3.1.7.5.

4.7.6. Cracking. See Section 3.1.7.6.
Lime renders applied over dampened surfaces and adequately worked with a rigid trowel are not likely to crack. If minor cracks appear, dampen the area and work it with a rigid trowel. If large cracks appear, the mix may be too rich in lime, or the plaster may be drying too quickly. Excessively cracked plasters should be removed and replaced.

5.0. LIME RENDER (FINISH OR SET COAT)

5.1. Raw Material. See Section 3.1.1

5.2. Safety. See Section 3.1.2.

5.3. Slaking. See Section 3.1.3.

5.4. Storage. See Section 3.1.4

5.5. Mixing. See Section 3.1.6.

5.5.1. Materials.

5.5.1.1. Lime Putty. See Section 3.1.6.1.1.

5.5.1.2. Aggregate.
The finish or set coat should have no aggregate that will not pass through a number eight sieve. Commercially available, clean number eight masonry sand, taken from the middle or top of the storage pile is acceptable. Clean arroyo sand, screened and washed is also acceptable.

5.5.1.3. Water. See Section 3.1.6.1.3.

5.5.2. Proportions.
The finish or set coat of lime plaster can be slightly richer than the render or brown coat. A two-and-one-half to one (2 1/2:1) aggregate to lime putty, is typical.

5.5.3. Use of mechanized equipment. See Section 3.1.6.3

5.5.4. Immediate use. See Section 3.1.6.4

5.6. Application.

5.6.1. Wetting the wall. See Section 3.1.7.1.

5.6.2. Tools. See Section 3.1.7.2.

5.6.3. Thickness.
The finish or set coat of lime is typically thin, seldom more than one eighth (1/8) to (1/4) inch in thickness.

5.6.4. Drying time. See Section 3.1.7.4.

5.6.5. Hot weather. See Section 3.1.7.5.

5.6.6. Cracking. See Section 3.1.7.6. and below.
Cracks in the finish coat will appear from time to time over the life of the plaster. It is one of the characteristics of lime that it is self-healing, and hairline cracks tend to disappear and re-appear in different locations over time. Expansion and contraction are often the cause of cracking, and absorption of moisture from the air during humid times are often the catalyst for "healing."

5.7. Surface finishing.

5.7.1. Troweled finish.
Most lime rendering systems have a "hard" trowel finish. This is accomplished by working the material with a rigid wooden trowel until it is smooth.

5.7.2. Coloring.
Lime plasters can be successfully colored any shade. Even bright colors like greens, reds and oranges are possible. Mineral oxide tints can be added to the finish mix in highly controlled quantities. The mix is then applied over a "green" or still-damp scratch coat. The result is a colored lime or "fresco" finish. Because the color is in the mix instead of on the surface, it is as permanent as the plaster itself.

6.0. LIME WASH

6.1. Raw Material. See Section 3.1.

6.2. Safety. See Section 3.1.2.

6.3. Slaking. See Section 3.1.3.

6.4. Storage. See Section 3.1.4.

6.5. Mixing.

6.5.1. Materials.

6.5.1.1. Lime Putty.
The same putty used for the plasters is used for the wash. The putty must be at least 90 days old and have been stored according

to the specifications in Sections 3.1.3 and stored according to the specifications in Section 3.1.4.

6.5.1.2. Aggregate. No aggregate is used in lime wash.

6.5.1.3. Water. See Section 3.1.6.1.3.

6.5.1.4. Cactus mucilage.
Lime washes are intended to provide a thin, water repellent film over the plaster. To provide the wash with good adhesive qualities and to imbue it with water repellent characteristics, cactus mucilage (juice) is entrained into the water used to mix the wash.

6.5.1.4.2. Prickly Pear (Opuntia sp.) or Nopal cactus.
The best mucilage comes from the Prickly Pear variety of cactus, characterized by its broad flat leaves. The cactus is commonly found throughout New Mexico. The cactus leaves should be cut or scored with a shovel, rake or machete to help the mucilage extraction. Fill a 55 gallon steel drum half full of water and boil it over a fire. Once the water is boiling, submerge approximately a bushel of nopal cactus in the water and continue to heat for 1 to 1 1/2 hours at which time the liquid can be removed into another barrel. The cactus can often by boiled twice or more to extract more mucilage. Add the mucilage liquid to approximately 20 gallons of lime putty in a 55 gallon drum and stir until the mix turns pink. The consistency should be that of a thinned latex paint.

6.5.1.4.2. Salt.
Add one twenty-ounce container of common table salt and stir into the mix.

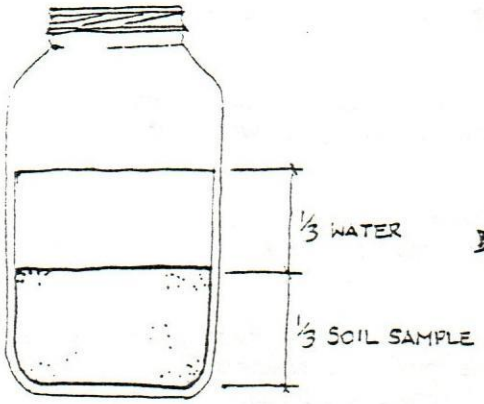
6.6. Application

6.6.1 Wetting the wall. See Section 3.1.7.1.

6.6.2 Brushing the wash on.
Using a heavy vegetable bristle brush, paint the first coat of the mix on in consistent horizontal or vertical strokes. When the mix has dried, brush the second coat on in strokes perpendicular to the first.

GRAIN SIZE & DISTRIBUTION "SHAKE JAR TESTING"

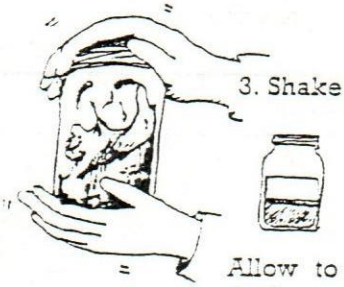
The "Shake Jar" is used to test composition of soils or percentage by volume of silts, clays and sands.



1. Take a clear glass jar and fill it 1/3 full with the soil to be tested. Remove any particles which are larger than ¼" diameter. Then pour in water until jar is 2/3 full.

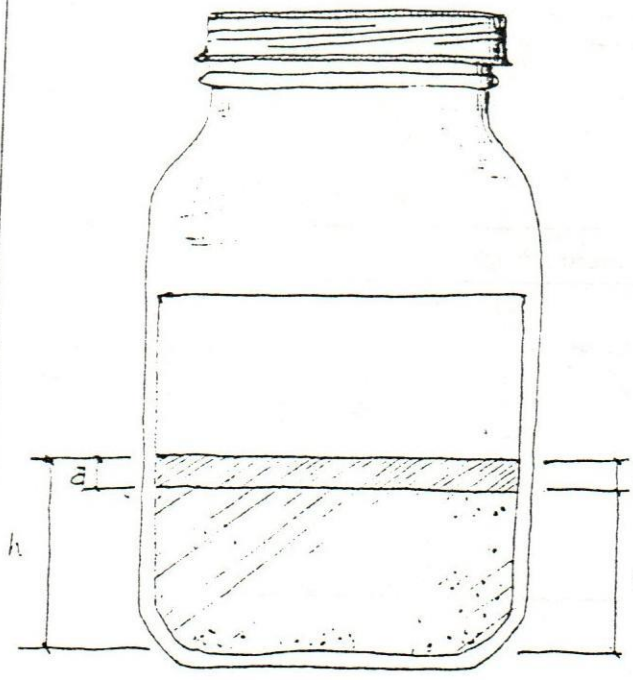
2. Shake jar thoroughly.

Allow to settle for 1 hour.



3. Shake again.

Allow to settle for at least 8 hours.



4. Observe the soil suspension in the glass jar. The largest particles or sands will settle to the bottom of the jar while the smallest particles or clays and silts will rest on top. A fairly distinct line between the particles will exist. Below the line, the individual sand particles can be seen with the naked eye. Above the line the clay and silt appear the same.

The percentage of silt and clay can be calculated by measuring (a) and (h) and using the following equation: (a) ÷ (h) x 100%. = (%)

A 20% Silt-Clay is recommended for soil composition.

REPAIRING AND REBUILDING ADOBE WALLS

- REPAIRING ADOBE WALLS
- REPAIRING CRACKS IN ADOBE WALLS
- RECONSTRUCTING ADOBE WALLS

Improperly maintained adobe walls may suffer from a variety of deterioration problems. Among the most common are wind and rain erosion leading to moisture activity in the walls.

The next sections show some simple ways to repair or rebuild adobe walls. There are different ways you may approach the problem, and repairs will vary according to the cause and effect of the deterioration.

The Handbook demonstrates the use of wooden ties, animal bones, and other techniques to repair adobe walls. Compatibility of mud mortar and adobes is key to all repairs.

First however, determine the cause of the deterioration. Often many problems are the result of water damage. Therefore the cause must be corrected first to prevent further deterioration. Several sections of the Handbook address these causes of water damage and offer solutions for example extending: the eaves or installing a drainage system.

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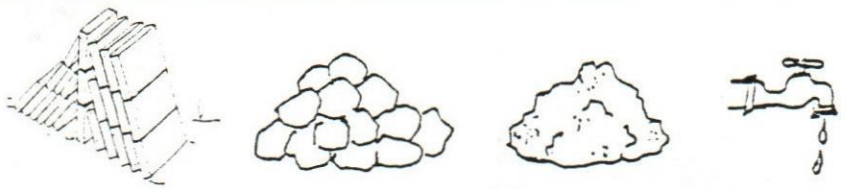
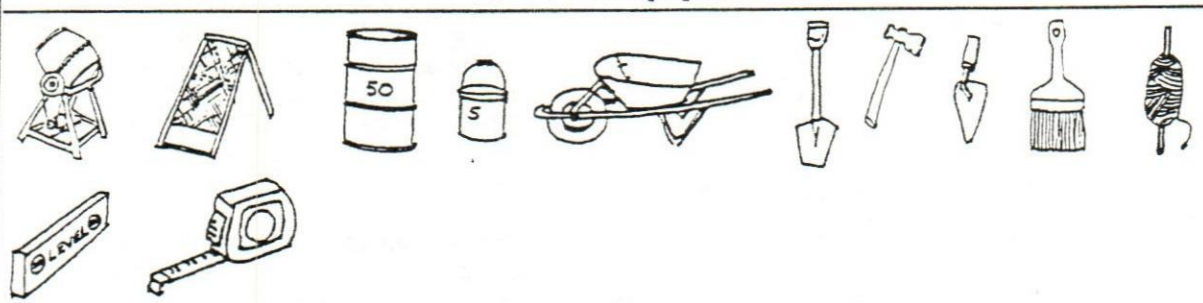
	

Tools and Equipment



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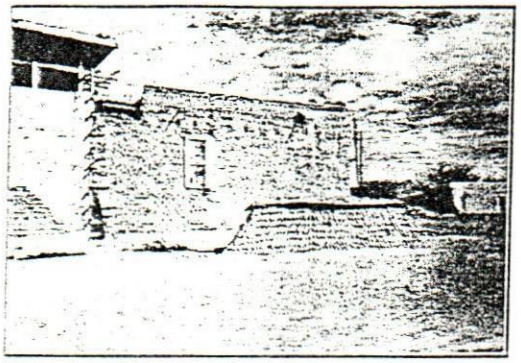
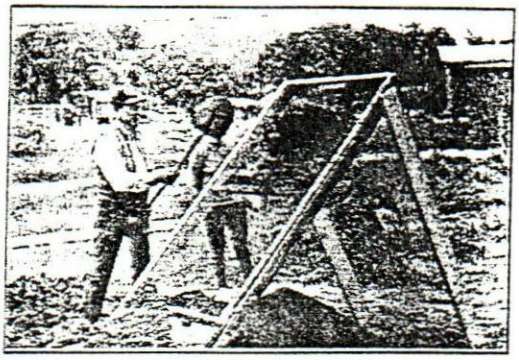


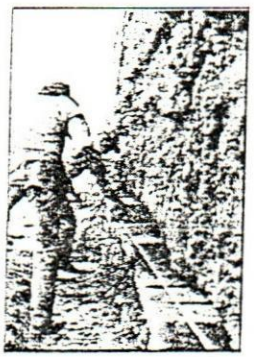
1. When repairing or rebuilding adobe walls, do not use additives or amendments to the adobes or mud mortar. (See Adobe Brick Making)



2. Use soil which is close in size, composition, color, and texture to the existing wall material.

3. Remove deteriorated adobe. Establish a flat base or base that inclines into the wall slightly for the new adobes. Structurally key adobes into void.

4. Prepare a good mud mixture for mortar (See Adobe Material Selection, Mixing and Testing).



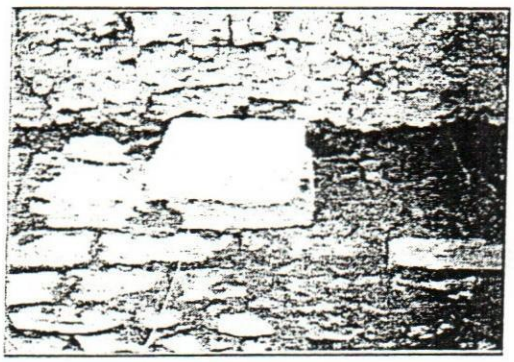
5. Place a string line to lay adobes as straight as possible.

6. Dampen the wall prior to laying adobes.

7. Place the mud mortar on damp adobe area.

8. Moisten the adobes before laying them into the wall.

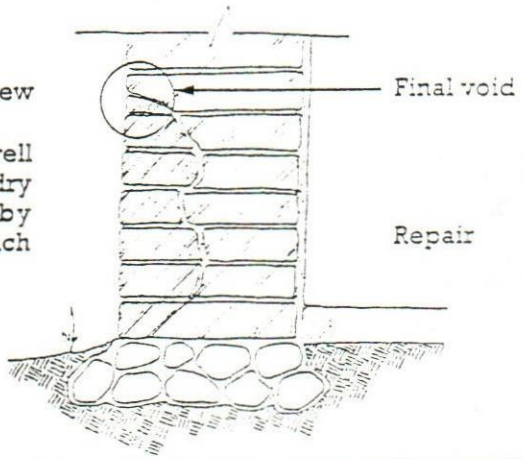
9. Lay new adobe brick to replicate same coursing as the existing, matching headers and stretchers. Lay a maximum of 3-4 courses at a time. If more than two courses are laid at one time, place small adobe bats or pieces of adobe in the mortar bed to resist slump of mortar.



10. Where the replacement or addition of many courses of adobe is required, allow a minimum of 48 hours of drying to each four courses, before adding the next vertical section of adobe courses.

FILLING THE FINAL VOID

- Dampen existing and new area.
- Pack void tightly using a well mixed but relatively dry mud and proceed by installing it under as much pressure as possible.



REPAIRING CRACKS IN ADOBE WALLS

Walls that have been severely eroded by the channeling of water are one of the most frequently encountered problems in earthen architecture. Interior and exterior damage is typically caused by high velocity runoff from flat and/or pitched roofs that (1) have improperly flashed parapets or penetrations, (2) do not extend adequately at the eave to protect walls, or (3) are themselves damaged thus allowing water to enter the walls at separations (as with metal panels) or where elements are missing (as with shakes or shingles). Channeling can result in damage that ranges from superficial erosion of the plaster to complete separation and failure of the wall.

In some cases where erosion has penetrated the full width of the wall, the old adobes can be selectively removed in a "toothed" pattern, and replaced with new bricks interlocking with the old. In other cases where walls have become free standing, adobes can be removed in a "stepped" configuration on both sides of the damaged area and rebuilt from the footing up (see rebuilding adobe walls).

The following section will explain a traditional technology from a community that was engaged in the repairs where erosion had removed one-half to two-thirds of the thickness of the adobe wall fabric in cross section. Instead of cleaning and sculpting the damaged area to receive adobes or adobe batts, and rather than applying thin

Quantity	Materials
	

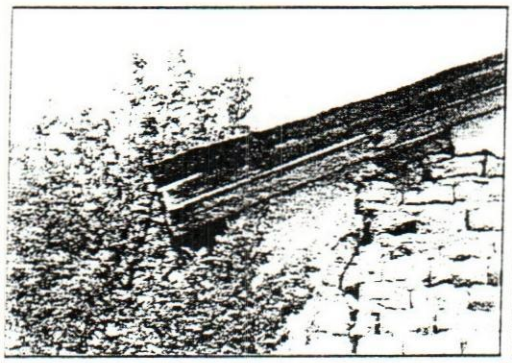
Tools and Equipment

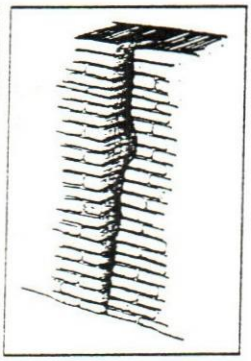
NOTES:

layers of mud repeatedly to fill the voids, the community called upon its memories of similar repairs made many years prior. Irregularly shaped, dried animal bones were used to repair the voids of the damaged adobe walls.

It is interesting to note that the Pre-Columbian Moché Culture in Perú utilized a similar method to shape earthen relief. In the Huaca del Brujo located northwest of the capital city, Lima, embedded femur bones were found in earthen walls projecting a couple of inches to shape the feet of an earthen relief known as "El Brujo".

The technical reasons for the success of this method has both mechanical and chemical components. This section will also briefly explain the quality of the material surrounding the reinforcing element.

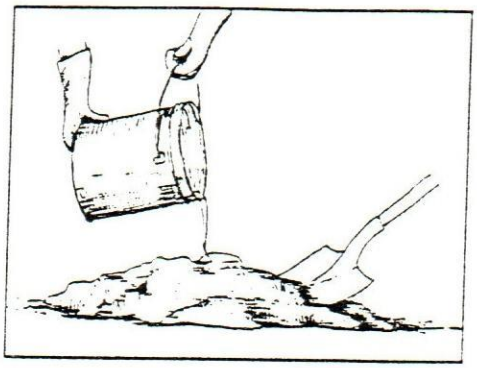




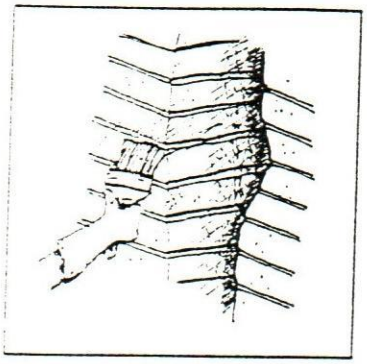
This method of crack repair should be used in instances where erosion has removed one-half to two-thirds of the thickness of the adobe wall.

Dried animal bones are collected and sorted roughly by size and shape.

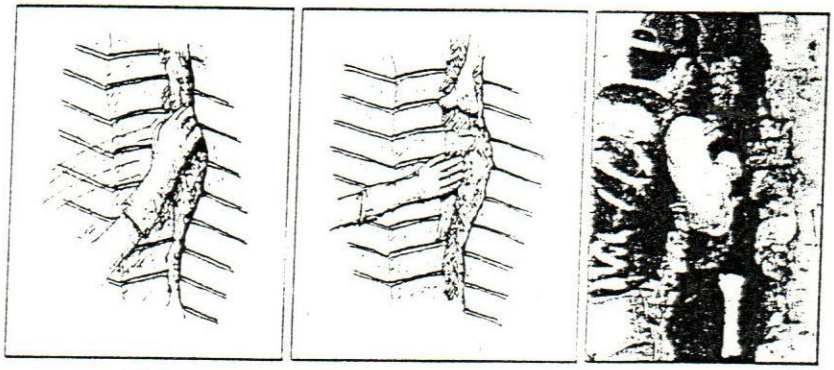
1. Place a full cup of type "N" lime in a five gallon bucket 1/3 full of water. Place the dried animal bones into the bucket and allow them to soak.



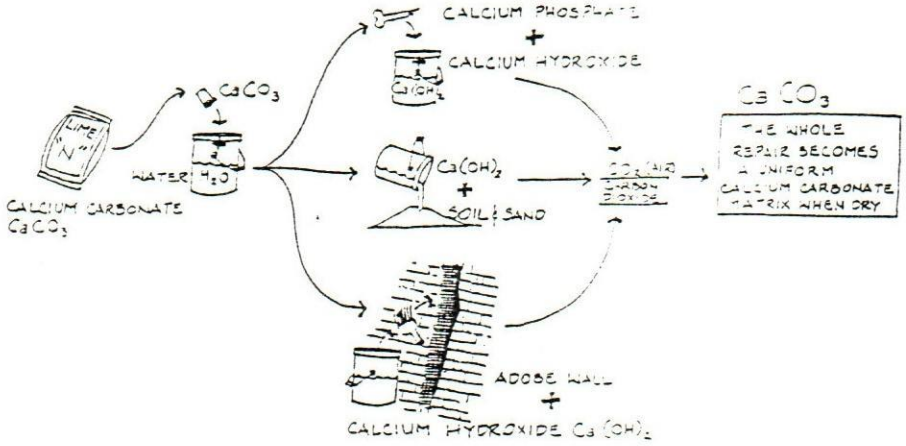
2. Find a good compatible soil to use for the mud mixture. Use lime-water solution to mix your soil and sand to make a workable consistency. (See Adobe Material Selection, Mixing, and Testing and Mud Plastering)



3. The damaged wall area should be thoroughly soaked with the lime-water solution.



4. The mud mixture should be thrown forcefully into the crack to adhere to the damp adobes. With several inches of mud in place, dip the bones in the lime water and embed in the mud. In some spots, place the bones to form a bridge between protrusions of existing adobe. Where mud is thickly applied, the wider, flatter bones should be embedded to prevent the mud from sagging and to prevent the mud from pulling away from the wall.



The technical reasons for the success of this method of infill have both mechanical and chemical components. The irregularly shaped bones embedded in mud act like rebar does when embedded in cement.