

5 PRESERVATION BRIEFS

Preservation of Historic Adobe Buildings



U.S. Department of the Interior
National Park Service
Cultural Resources
Heritage Preservation Services



Whether built in the 17th century or in the 20th century, adobe buildings share common problems of maintenance and deterioration. This brief discusses the traditional materials and construction of adobe buildings and the causes of adobe deterioration. It also makes recommendations for preserving historic adobe buildings. By its composition, adobe construction is inclined to deteriorate; however, the buildings can be made durable and renewable when properly maintained.

What is Adobe?

The adobe, or sun-dried brick, is one of the oldest and most common building materials known to man. Traditionally, adobe bricks were never kiln fired. Unbaked adobe bricks consisted of sand, sometimes gravel, clay, water, and often straw or grass mixed together by hand, formed in wooden molds, and dried by the sun. Today some commercially available adobe-like bricks are fired. These are similar in size to unbaked bricks, but have a different texture, color, and strength. Similarly some adobe bricks have been stabilized, containing cement, asphalt, and/or bituminous materials, but these also differ from traditional adobe in their appearance and strength.

Traditional adobe construction techniques in North America have not varied widely for over 3½ centuries. Adobe



SAN XAVIER DEL BAC, TUCSON VICINITY, ARIZONA. Built entirely of adobe construction (1783–1797), this is one of the finest Spanish Colonial churches in the United States, having an elaborate frontispiece of molded, carved, and painted brick imitating stone. (National Park Service)

building methods employed in the Southwest in the 16th century are still used today. Because adobe bricks are not fired in a kiln as are clay bricks, they do not permanently harden, but remain unstable—they shrink and swell constantly with their changing water content. Their strength also fluctuates with their water content: the higher the water content, the lower the strength.

Adobe will not permanently bond with metal, wood, or stone because it exhibits much greater movement than these other materials, either separating, cracking, or twisting where they interface. Yet, many of these more stable building materials such as fired brick, wood, and lime and cement mortars are nonetheless used in adobe construction. For example, stone may be used for a building's foundation, and wood may be used for its roof or its lintels and doorways. In the adobe building, these materials are generally held in place by their own weight or by the compressive weight of the wall above them. Adobe construction possibilities and variations in design have therefore been somewhat limited by the physical constraints of the material.

Preserving and rehabilitating a deteriorated adobe building is most successful when the techniques and methods used for restoration and repairs are as similar as possible to the techniques used in the original construction.

Adobe Construction Techniques

The Brick: The adobe brick is molded from sand and clay mixed with water to a plastic consistency. Commonly, straw or grass is included as a binder. Although they do not help reinforce the bricks or give them added long-term strength, straw and grass do help the bricks shrink more uniformly while they dry. More important for durability, however, is the inherent clay-to-sand ratio found in native soil. The prepared mud is placed in wooden forms, tamped, and leveled by hand. The bricks are then "turned-out" of the mold to dry on a level surface covered with straw or grass so that the bricks will not stick. After several days of drying, the adobe bricks are ready for air-curing. This consists of standing the bricks on end for a period of 4 weeks or longer.

Mortar: Historically, most adobe walls were composed of adobe bricks laid with mud mortar. Such mortar exhibited the same properties as the bricks: relatively weak and susceptible to the same rate of hygroscopic (moisture absorptive) swelling and shrinking, thermal expansion and contrac-

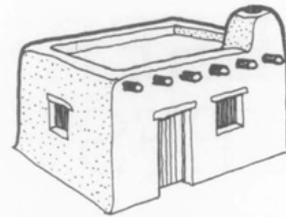
tion, and deterioration. Consequently, no other material has been as successful in bonding adobe bricks. Today, cement and lime mortars are commonly used with stabilized adobe bricks, but cement mortars are incompatible with unstabilized adobe because the two have different thermal expansion and contraction rates. Cement mortars thereby accelerate the deterioration of adobe bricks since the mortars are stronger than the adobe.

Building Foundations: Early adobe building foundations varied because of the difference in local building practices and availability of materials. Many foundations were large and substantially constructed, but others were almost non-existent. Most often, adobe building foundations were constructed of bricks, fieldstones, or cavity walls (double) infilled with rubble stone, tile fragments, or seashells. Adobe buildings were rarely constructed over basements or crawlspaces.

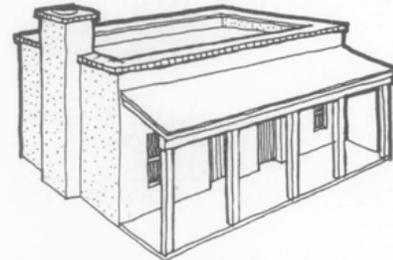
Walls: Since adobe construction was load-bearing with low structural strength, adobe walls tended to be massive, and seldom rose over 2 stories. In fact, the maximum height of adobe mission churches in the Southwest was approximately 35 feet. Often buttresses braced exterior walls for added stability.

In some parts of the Southwest, it was common to place a long wooden timber within the last courses of adobe bricks. This timber provided a long horizontal bearing plate for the roof thereby distributing the weight of the roof along the wall.

Roofs: Early Southwest adobe roofs (17th–mid–19th centuries) tended to be flat with low parapet walls. These roofs consisted of logs which supported wooden poles, and which in turn supported wooden lathing or layers of twigs covered with packed adobe earth. The wood was aspen, mesquite, cedar, or whatever was available. Roughly dressed logs (called "vigas") or shaped squared timbers were spaced on close (2–3 feet or less) centers resting either on the horizontal wooden member which topped the adobe wall, or on decorated cantilevered blocks, called "corbels," which were set into the adobe wall. Traditionally, these vigas often projected through the wall facades creating the typical adobe



flat roof, small openings



brick coping, wood porch

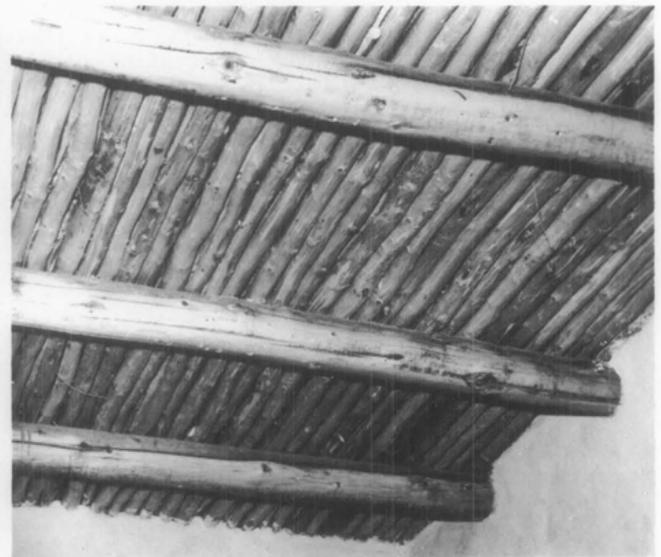


hip roof, wood trim

Evolution of Roof Forms. The roofs of early adobe buildings were flat, made with mud, with low parapets. Later, brick copings were placed on top of parapets and chimneys to protect them from erosion, and shed roof porches were added to shelter doors and windows. After the railroad reached the Southwest, hip roofs and wooden trim began to appear as sawn lumber, shingles, tile, and sheet metal became available. (Drawing by Albert N. Hopper)



Roof Bearing. A roof bearing timber placed within the adobe walls provides even support for the weight of the roof. (Farm Security Administration Collection, Library of Congress)



Roof Framing. Viga logs and savinos are seen in the interior of the adobe building. Often the wooden materials that compose the traditional flat adobe roof create interesting and pleasing patterns on the ceilings of the interior rooms. (Photo by Russell Lee, Farm Security Administration Collection, Library of Congress)

construction detail copied in the 20th-century revival styles. Wooden poles about 2 inches in diameter (called "latias") were then laid across the top of the *vigas*. Handsplit planks (called "cedros" if cedar and "savinós" if cypress) instead of poles were used when available. In some areas, these were laid in a herringbone pattern. In the west Texas and Tucson areas, *saguaro* (cactus) ribs were used to span between *vigas*. After railroad transportation arrived in most areas, sawn boards and planks, much like roof sheathing, became available and was often used in late-19th- and early-20th-century buildings or for repairs to earlier ones.

Next cedar twigs, plant fibers, or fabric were placed on top of the poles or planks. These served as a lathing on which the 6 or more inches of adobe earth was compacted. If planks were used, twigs were not necessary. A coating of adobe mud was then applied overall. The flat roofs were sloped somewhat toward drains of hollowed logs (called "canales," or "gargolas"), tile, or sheet metal that projected through the parapet walls.

Gable and hipped roofs became increasingly popular in adobe buildings in the 19th and 20th centuries. "Territorial" styles and preferences for certain materials developed. For example, roof tiles were widely used in southern California. Although the railroad brought in some wooden shingles and some terra-cotta, sheet metal roofing was the prevalent material for roofs in New Mexico.

Floors: Historically, flooring materials were placed directly on the ground with little or no subflooring preparation. Flooring materials in adobe buildings have varied from earth to adobe brick, fired brick, tile, or flagstone (called "lajas"), to conventional wooden floors.

Traditional Surface Coatings

Adobe surfaces are notoriously fragile and need frequent maintenance. To protect the exterior and interior surfaces of new adobe walls, surface coatings such as mud plaster, lime plaster, whitewash, and stucco have been used. Such coatings applied to the exterior of adobe construction have retarded surface deterioration by offering a renewable surface to the adobe wall. In the past, these methods have been inexpensive and readily available to the adobe owner as a solution to periodic maintenance and visual improvement. However, recent increases in labor costs and changes in cultural and socio-economic values have caused many adobe building owners to seek more lasting materials as alternatives to these traditional and once-inexpensive surface coatings.

Mud Plaster: Mud plaster has long been used as a surface coating. Like adobe, mud plaster is composed of clay, sand, water, and straw or grass, and therefore exhibits sympathetic properties to those of the original adobe. The mud plaster bonds to the adobe because the two are made of the same materials. Although applying mud plaster requires little skill, it is a time-consuming and laborious process. Once in place, the mud plaster must be smoothed. This is done by hand; sometimes deerskins, sheepskins, and small, slightly rounded stones are used to smooth the plaster to create a "polished" surface. In some areas, pink or ochre pigments are mixed into the final layer and "polished."

Whitewash: Whitewash has been used on earthen buildings since before recorded history. Consisting of ground gypsum rock, water, and clay, whitewash acts as a sealer, which can be either brushed on the adobe wall or applied with large pieces of coarse fabric such as burlap.

Initially, whitewash was considered inexpensive and easy to apply. But its impermanence and the cost of annually

renewing it has made it less popular as a surface coating in recent years.

Lime Plaster: Lime plaster, widely used in the 19th century as both an exterior and interior coating, is much harder than mud plaster. It is, however, less flexible and cracks easily. It consists of lime, sand, and water and is applied in heavy coats with trowels or brushes. To make the lime plaster adhere to adobe, walls are often scored diagonally with hatchets, making grooves about 1 1/2 inches deep. The grooves are filled with a mixture of lime mortar and small chips of stone or broken roof tiles. The wall is then covered heavily with the lime plaster.

Cement Stucco: In the United States, cement stucco came into use as an adobe surface coating in the early 20th century for the revival styles of Southwest adobe architecture. Cement stucco consists of cement, sand, and water and it is applied with a trowel in from 1 to 3 coats over a wire mesh nailed to the adobe surface. This material has been very popular because it requires little maintenance when applied over fired or stabilized adobe brick, and because it can be easily painted.

It should be noted however, that the cement stucco does not create a bond with unfired or unstabilized adobe; it relies on the wire mesh and nails to hold it in place. Since nails cannot bond with the adobe, a firm surface cannot be guaranteed. Even when very long nails are used, moisture within the adobe may cause the nails and the wire to rust, thus, losing contact with the adobe.

Other Traditional Surface Coatings: These have included items such as paints (oil base, resin, or emulsion), portland cement washes, coatings of plant extracts, and even coatings of fresh animal blood (mainly for adobe floors). Some of these coatings are inexpensive and easy to apply, provide temporary surface protection, and are still available to the adobe owner.

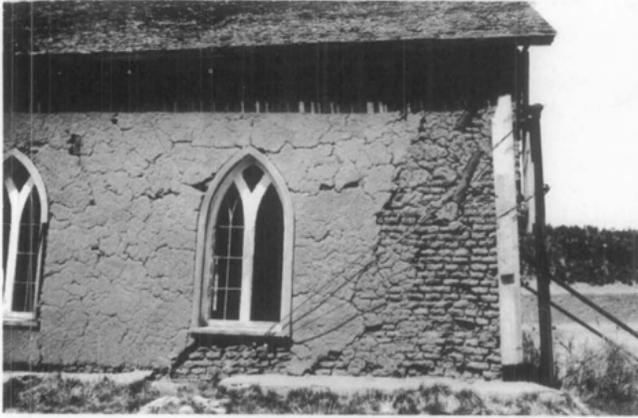
Adobe Deterioration

When preservation or rehabilitation is contemplated for a historic adobe building, it is generally because the walls or roof of the building have deteriorated in some fashion—walls may be cracked, eroded, pitted, bulging, or the roof may be sagging. In planning the stabilization and repair of an adobe building, it is necessary:

- To determine the nature of the deterioration
- To identify and correct the source of the problem causing the deterioration
- To develop rehabilitation and restoration plans that are sensitive to the integrity of the historic adobe building
- To develop a maintenance program once the rehabilitation or restoration is completed.

General Advice: There are several principles that when followed generally result in a relatively stable and permanent adobe resource.

1. Whenever possible, secure the services or advice of a professional architect or other preservationist proficient in adobe preservation and stabilization. Although this may be more costly than to "do-it-yourself," it will probably be less expensive in the long run. Working with a deteriorated adobe building is a complex and difficult process. Irreversible damage may be done by well-meaning but inexperienced "restorationists." Moreover, professional assistance may be required to interpret local code requirements.
2. Never begin restoration or repairs until the problems that



Deteriorated Adobe Building. By virtue of its fragile nature, the adobe building must be restored by thorough, systematic, and professional measures that will insure its future survival. (Technical Preservation Services Division)

have been causing the deterioration of the adobe have been found, analyzed, and solved. For instance, sagging or bulging walls may be the result of a problem called "rising damp" and/or excessive roof loads. Because adobe deterioration is almost always the end product of a combination of problems, it takes a trained professional to analyze the deterioration, identify the source or sources of deterioration, and halt the deterioration before full restoration begins.

3. Repair or replace adobe building materials with the same types of materials used originally and use the same construction techniques. Usually the best and the safest procedure is to use traditional building materials. Repair or replace deteriorated adobe bricks with similar adobe bricks. Repair or replace rotted wooden lintels with similar wooden lintels. The problems created by introducing dissimilar replacement materials may cause problems far exceeding those which deteriorated the adobe in the first place.

Sources of Deterioration

The following are some common signs and sources of adobe deterioration and some common solutions. It should be cautioned again, however, that adobe deterioration is often the end-product of more than one of these problems. The remedying of only one of these will not necessarily arrest deterioration if others are left untreated.

Structural Damage: There are several common structural problems in adobe buildings, and while the results of these problems are easy to see, their causes are not. Many of these problems originate from improper design or construction, insufficient foundations, weak or inadequate materials, or the effects of external forces such as wind, water, snow, or earthquakes. In any case the services of a soils engineer and/or structural engineer knowledgeable in adobe construction may be necessary to evaluate these problems. Solutions may involve repairing foundations, realigning leaning and bulging walls, buttressing walls, inserting new window and door lintels, and repairing or replacing badly deteriorated roof structures.

There are many tell-tale signs of structural problems in adobe buildings, the most common being cracks in walls, foundations, and roofs. In adobe, cracks are generally quite visible, but their causes may be difficult to diagnose. Some cracking is normal, such as the short hairline cracks that are caused as the adobe shrinks and continues to dry out. More



Structural Damage and Cracking. Sagging, bulging, and cracking of walls and roofs are signs of serious problems in the adobe building. It is always advisable to secure professional services in the repair of such problems. (National Park Service)

extensive cracking, however, usually indicates serious structural problems. In any case, cracks, like all structural problems, should be examined by a professional who can make recommendations for their repair.

Water Related Problems: Generally, adobe buildings deteriorate because of moisture, either excessive rainwater or ground water. Successful stabilization, restoration, and the ultimate survival of an adobe building depends upon how effectively a structure sheds water. The importance in keeping an adobe building free from excessive moisture cannot be overestimated. The erosive action of rainwater and the subsequent drying out of adobe roofs, parapet walls, and wall surfaces can cause furrows, cracks, deep fissures, and pitted surfaces to form. Rain saturated adobe loses its cohesive strength and sloughs off forming rounded corners and parapets. If left unattended, rainwater damage can eventually destroy adobe walls and roofs, causing their continued deterioration and ultimate collapse. Standing rainwater that accumulates at foundation level and rain splash may cause "coving" (the hollowing-out of the wall just above grade level).

Ground water (water below ground level) might be present because of a spring, a high water table, improper drainage, seasonal water fluctuations, excessive plant watering, or changes in grade on either side of the wall. Ground water rises through capillary action into the wall and causes the adobe to erode, bulge, and cove. Coving is also caused by spalling during the freeze-thaw cycles. As water rises from the ground into the wall, the bond between the clay particles in the adobe brick breaks down. In addition, dissolved minerals or salts brought up from the soil by the water can be deposited on or near the surface of the wall as the moisture evaporates. If these deposits become heavily concentrated, they too can deteriorate the adobe fabric. As the adobe dries out, shrinkage cracks usually appear; loose sections of adobe bricks and mud plaster may crumble.

A water-tight roof with proper drainage is the best protection against rainfall erosion. Adobe wall and roof surfaces properly maintained with traditional tiles or surface coatings generally resist the destructive effects of rainwater. Roof drains should be in good repair and sufficient to carry rainwater run-off from the roof. In an effort to halt the destructive effects of rainwater, 19th-century builders often capped parapet walls with fired bricks. These bricks were harder and better suited to weather the erosive action of rainwater; however, the addition of a brick cap to an existing parapet wall creates a drastic change in a structure's appearance and fabric. The use of traditional lime mortar

with the fired brick is advised because it is more water-tight and compatible with the harder brick.

Rainwater that has accumulated at adobe foundations should be diverted away from the building. This may be done by regrading, by building gravel-filled trenches or brick, tile, or stone drip gutters, or by any technique that will effectively remove the standing rainwater. Regrading is perhaps the best solution because defective gutters and trenches may in effect collect and hold water at the base of the wall or foundation.

In repairing "coving," the damage caused by rain splash, adobe bricks stabilized with soil cement might be considered. On the other hand, concrete patches, cement stucco, and curb-like buttresses against the coving usually have a negative effect because moisture may be attracted and trapped behind the concrete.

Cement stucco and cement patches have the potential for specific kinds of water related adobe deterioration. The thermal expansion coefficient of cement stucco is 3 to 10 times greater than that of adobe resulting in cracking of the stucco. Cracks allow both liquid water and vapor to penetrate the adobe beneath, and the stucco prevents the wall from drying.

As the moisture content of the adobe increases, there is a point at which the adobe will become soft like putty. When the wall becomes totally saturated, the adobe mud will flow as a liquid. This varies with the sand, clay, and silt content of the adobe.

If the adobe becomes so wet that the clay reaches its plastic limit, or if the adobe is exposed to a freeze-thaw action, serious damage can result. Under the weight of the roof, the wet adobe may deform or bulge. Since the deterioration is hidden from view by the cement stucco, damage may go undetected for some time. Traditional adobe construction techniques and materials should therefore, be used to repair or rebuild parts of the walls.

The destructive effects of moisture on adobe buildings may be substantially halted by several remedies.

1. Shrubs, trees, and other foundation plantings may be causing physical damage. Their roots may be growing into the adobe, and/or they may be trapping excessive moisture in their roots and conducting it into walls. Their removal might be considered to halt this process.
2. Level ground immediately adjacent to the walls may be causing poor drainage. Regrading could be considered so that the ground slopes away from the building, eliminating rainwater pools.
3. The installation of footing drains may be considered. Trenches about 2 to 2½ feet wide and several feet deep are dug around the adobe building at the base of the walls or at the foundation if there is any. If the soil is weak, it may be necessary to slope the sides of the trench to prevent cave-in of the trench and subsequent damage to the wall. The walls and bottom of the trench should be lined with a polyethylene vapor barrier to prevent the collected water from saturating the surrounding soil and adobe wall. Clay tile, or plastic pipe, which drain to a sump or to an open gutter, are then laid in the bottom of the trench. The trench is filled with gravel to within 6 inches of grade. The remaining excavation is then filled to grade with porous soil.

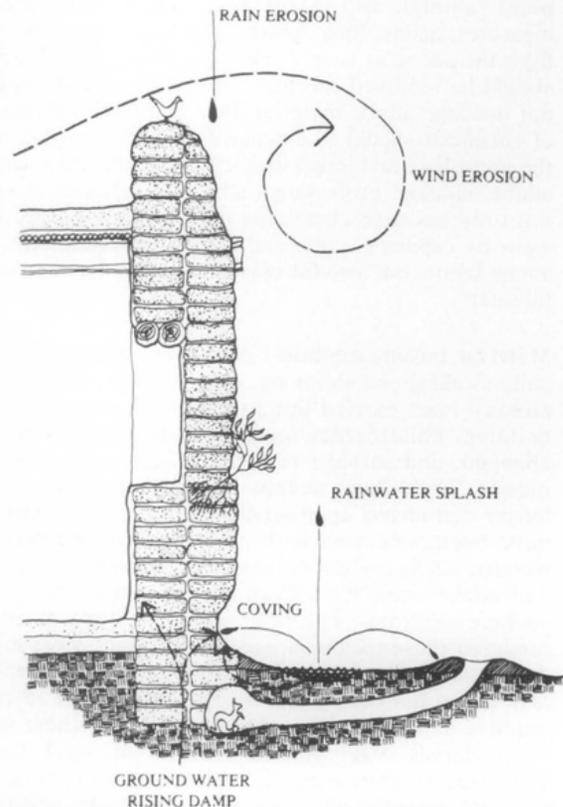
A Word of Caution: Plant removal, regrading, or trenching may be potentially destructive to archeological remains associated with historic adobe building sites. Any disturbance of the ground should, therefore, be undertaken with prudence and careful planning.

Once any one or all of these solutions has effectively minimized the problems of rising ground water, the coving

and deterioration of the walls can be corrected by patching the area with new adobe mud and by applying traditional surface coatings. It should be remembered, however, that unless the capillary action is stopped effectively, this erosive condition will certainly continue. Most important, surface coatings and patching only repair the effects of ground water and wind erosion, they cannot cure the cause.



Coving. Salts deposited by rising ground water can evaporate and cause spalling of the adobe bricks at the base of the wall, a serious condition called "coving." Coving can also be caused and/or exacerbated by the erosion of rain splash. (National Park Service)



Water, Wind, Animal, Insect, and Vegetation Damage. Most deterioration of adobe buildings can be directly correlated with the presence of either excessive rainwater, groundwater, or both. Successful adobe stabilization and restoration depends upon keeping the adobe building moisture free, repaired, and well maintained. (Drawing by David W. Look, AIA, based on sketches by Albert N. Hopper)

Wind Erosion: Wind-blown sand has often been cited as a factor in adobe fabric erosion. Evidence of wind erosion is often difficult to isolate because the results are similar to water erosion; however, furrowing caused by wind is usually more obvious at the upper half of the wall and at the corners, while coving from rainsplash and ground water is usually at the lower third of the wall.

Maintenance is the key to mitigating the destructive effects of wind erosion. Wind damage on adobe walls and roof surfaces should be repaired with new adobe mud. Any traditional surface coating may be applied to protect against any possible future destructive effects. If high wind is a continuing problem, a wind screen or breaker might be built, using fencing or trees. Care should be taken to plant trees far enough away from the structure so that the roots will not destroy the foundation or trap moisture.

Vegetation, Insects, and Vermin: Vegetation and pests are natural phenomena that can accelerate adobe deterioration. Seeds deposited by the wind or by animals may germinate in adobe walls or roofs as they would in any soil. The action of roots may break down adobe bricks or cause moisture retention which will harm the structure. Animals, birds, and insects often live in adobe structures, burrowing and nesting in walls or in foundations. These pests undermine and destroy the structural soundness of the adobe building. The possibility of termite infestation should not be overlooked since termites can travel through adobe walls as they do through natural soil. Wood members (lintels, floors, window and door shutters, and roof members) are all vulnerable to termite attack and destruction.

It is important to rid adobe structures immediately of all plant, animal, and insect pests and to take preventive measures against their return. Seedlings should be removed from the adobe as soon as they are discovered. Large plants should be removed carefully so that their root systems will not dislodge adobe material. Pest control involving the use of chemicals should be examined carefully in order to assess the immediate and longlasting effects of the chemicals on the adobe building. Professional advice in this area is important not only because chemicals may be transported into the walls by capillary action and have a damaging effect on the adobe fabric, but also for reasons of human and environmental safety.

Material Incompatibilities: As adobe buildings are continually swelling and shrinking, it is likely that repair work has already been carried out sometime during the life of the building. Philosophies regarding adobe preservation have changed, and so have restoration and rehabilitation techniques. Techniques acceptable only 10 years ago are no longer considered appropriate. Until recently, adobe bricks have been repointed with portland cement; deteriorated wooden lintels and doors have been replaced with steel ones; and adobe walls have been sprayed with plastic or latex surface coatings. The hygroscopic nature of adobe has rendered these techniques ineffective and, most important, destructive. The high strength of portland cement mortar and stucco has caused the weaker adobe brick to crack and crumble during the differential expansion of these incompatible materials. Steel lintels are much more rigid than adobe. When the building expands, the adobe walls twist because they are more flexible than the steel. Plastic and latex wall coatings have been used to seal the surface, keeping it from expanding with the rest of the brick. Portions of the wall have consequently broken off. In some instances, incompatible materials can be removed from the building without subsequently damaging the structure. Other times, this is not possible. Professional advice is therefore recommended.

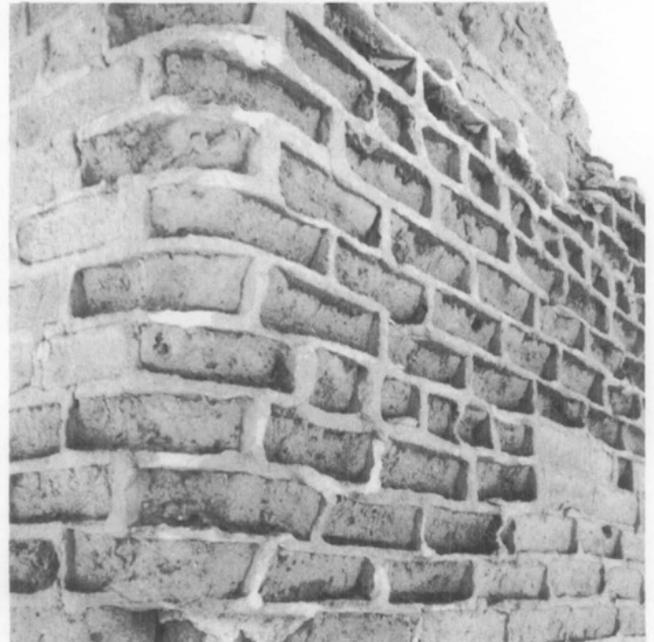
Repairing and Maintaining the Historic Adobe Building

Once the adobe deterioration and any resulting structural damage is repaired, the restoration of the adobe building can proceed. Careful attention should be given to replace, repair, and/or reproduce all damaged materials with traditional or original materials.

Patching and Repairing Adobe Brick: In patching and replacing adobe brick, every reasonable effort should be made to find clay with a texture and color similar to the original fabric. When an individual adobe brick has partially disintegrated, it may be patched in place. The deteriorated material may be scraped out and replaced with appropriate adobe mud. Often fragments of the original adobe brick have been ground up, mixed with water, and reused to patch the eroded area. However, some professionals advise against the reuse of material which has spalled off because it frequently contains a high concentration of salts.

If a substantial amount of the brick has been destroyed or spalled, commercially made adobe bricks and half-bricks can be obtained, or they may be made at the site or nearby. Generally these are 3 or 4 inches thick, and ideally they are composed of unstabilized adobe (that is, without any chemical additives). The deteriorated adobe bricks should be scraped out to insert the new bricks. If most of the brick is not deteriorated, then the deteriorated portion may be replaced with a half-brick. It may be necessary to cut back into undeteriorated portions of the brick to achieve a flush fit of the new or half-bricks. Spray (do not soak) the new brick and surrounding area lightly with water to facilitate a better bond. Too much moisture can cause swelling. Always use traditional adobe mud mortar.

When entire bricks or sections of the brick walls have to be replaced, caution should be exercised when buying ready-made bricks. Many are now manufactured using stabilizing agents (portland cement, lime, or emulsified asphalt) in their composition. While the inclusion of these agents in new adobe bricks is a technical advancement in their durability, they will prove incompatible with the fabric of the historic



Cement Mortar Incompatibility. *The stronger and less flexible cement mortar has caused the softer adobe bricks to crumble thus leaving a "honeycomb" of cement mortar joints. (National Park Service)*

adobe building. Concrete blocks and cinderblocks are likewise tempting solutions to extensive adobe brick replacement; but, like commercially stabilized adobe bricks, they are not compatible with older and more unstable adobe bricks. However, concrete blocks have been used for interior partitions successfully.

Patching and Replacing Mortar: In repairing loose and deteriorated adobe mortar, care should also be taken to match the original material, color, and texture. Most important, never replace adobe mud mortar with lime mortar or portland cement mortar. It is a common error to assume that mortar hardness or strength is a measure of its suitability in adobe repair or reconstruction. Mortars composed of portland cement or lime do not have the same thermal expansion rate as adobe brick. With the continual thermal expansion and contraction of adobe bricks, portland cement or lime mortars will cause the bricks—the weaker material—to crack, crumble, and eventually disintegrate.

It is recognized, however, that some late historic adobe buildings have always had portland cement or lime mortars used in their initial construction. The removal and replacement of these mortars with mud mortar is not advised because their removal is usually destructive to the adobe bricks.

In repairing adobe cracks, a procedure similar to repointing masonry joints may be used. It is necessary to rake out the cracks to a depth of 2 or 3 times the width of a mortar joint to obtain a good "key" (mechanical bond) of the mortar to the adobe bricks. The bricks should be sprayed lightly with water to increase the cohesive bond. A trowel or a large grout gun with new adobe mud mortar may then be used to fill the cracks.

Repairing and Replacing Wooden Members: Rotted or termite infested wood members such as *vigas*, *savinos*, lintels, wall braces, or flooring should be repaired or replaced. Wood should always be replaced with wood. For carved corbels, however, specially formulated low-strength epoxy consolidants and patching compounds may be used to make repairs, thus saving original craftsmanship. Tests, however, should be made prior to repairs to check on desired results since they usually are not reversible. This is an area of building repair that ought not be attempted by the amateur. For further information, see *Epoxies for Wood Repairs in Historic Buildings*, cited in the reading list of this brief.

Patching and Replacing Surface Coatings: Historically, almost every adobe building surface was coated. When these coatings deteriorate, they need to be replaced. Every effort should be made to recoat the surface with the same material that originally coated the surface.

When the coating has been mud plaster, the process requires that the deteriorated mud plaster be scraped off and replaced with like materials and similar techniques, attempting in all cases to match the repair work as closely as possible to the original. It is always better to cover adobe with mud plaster even though the mud plaster must be renewed more frequently.

The process is not so simple where lime plaster and portland cement stuccos are involved. As much of the deteriorated surface coating as possible should be removed without damaging the adobe brick fabric underneath. Never put another coat of lime plaster or portland cement stucco over a deteriorated surface coating. If serious deterioration does exist on the surface, then it is likely that far greater deterioration exists below. Generally this problem is related to water, in which case it is advisable to consult a professional.

If extensive recoatings in lime plaster or portland cement stucco are necessary, the owner of an adobe building might consider furring out the walls with lathing, then plastering over, thus creating a moisture barrier. Always patch with the same material that is being replaced. Although lime plaster and portland cement stucco are less satisfactory as a surface coating, many adobe buildings have always had them as a surface coating. Their complete removal is inadvisable as the process may prove to be more damaging than the natural deterioration.

Roofs: Flat adobe roofs should be restored and maintained with their original form and materials; however, it may not be feasible or prudent to restore or reconstruct a flat adobe roof on a building if the roof has previously been modified to a gable roof with sheet metal, tiles, or wood shingles.

If an existing flat adobe roof is restored with a fresh layer of adobe mud over an existing mud roof, care should be taken to temporarily support the roof during the work because adobe mud is heavier wet than after it has cured. If not supported, the roof may collapse or deflect. If the wooden roof supports are allowed to sag during such work, the wood may take a permanent deflection, resulting in inadequate drainage and/or "ponding" at low points. Ponding is especially damaging to adobe roofs since standing water will eventually soak through the mud and cause the wooden roof members to rot.

On an adobe building, it is not advisable to construct a new roof that is heavier than the roof it is replacing. If the walls below have uncorrected moisture problems, the added weight of a new roof may cause the walls to bulge (a deformation caused while the adobe mud is in a plastic state). If the walls are dry but severely deteriorated, the added weight may cause the walls to crack or crumble (compression failure).

Floors, Windows, Doors, Etc.: Windows, doors, floors, and other original details of the older adobe building should be retained whenever feasible. It is, however, understandable when the demands of modern living make it necessary to change some of these features: thermal windows and doors, easily maintained floors, etc. But every reasonable effort should be made to retain original interior and exterior details.

Maintenance

Cyclical maintenance has always been the key to successful adobe building survival. As soon as rehabilitation or restoration has been completed, some program of continuing maintenance should be initiated. Changes in the building should particularly be noted. The early stages of cracking, sagging, or bulging in adobe walls should be monitored regularly. All water damage should be noted and remedied at its earliest possible stages. Plant, animal, and insect damage should be halted before it becomes substantial. The roof should be inspected periodically. Surface coatings must be inspected frequently and repaired or replaced as the need indicates.

Mechanical systems should be monitored for break-down. For instance, leaking water pipes and condensation can be potentially more damaging to the adobe building than to a brick, stone, or frame structure. Observing adobe buildings for subtle changes and performing maintenance on a regular basis is a policy which cannot be over emphasized. It is the nature of adobe buildings to deteriorate, but cyclical maintenance can substantially deter this process, thus producing a relatively stable historic adobe building.

Summary

In conclusion, to attempt the preservation of an adobe building is almost a contradiction. Adobe is a formed-earth material, a little stronger perhaps than the soil itself, but a material whose nature is to deteriorate. The preservation of historic adobe buildings, then, is a broader and more complex problem than most people realize. The propensity of adobe to deteriorate is a natural, on-going process. While it would be desirable to arrest that process in order to safeguard the building, no satisfactory method has yet been developed. Competent preservation and maintenance of historic adobe buildings in the American Southwest must (1) accept the adobe material and its natural deterioration, (2) understand the building as a system, and (3) understand the forces of nature which seek to return the building to its original state.

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Renewing the Surface Coating. Traditionally, adobe surface coatings that protected the fragile adobe building fabric were renewed every few years. Recently however, high labor costs have made this a relatively expensive process. Women are seen here recoating an adobe wall with mud plaster mixed with straw at Chamisal, New Mexico. (Photo by Russell Lee, Farm Security Administration Collection, Library of Congress)