Historic Un-stabilized

Adobe Training

San Diego County Parks

Mission Statement

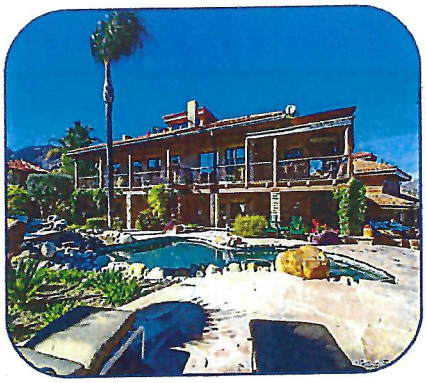
Mark Sauer Construction, Inc. (MSC) is committed to excellence, performance, and accountability. Our goal is to execute the most rigorous construction projects with a traditional craft trade vigilance and attention to detail.

EXCELLENCE SINCE 1986!

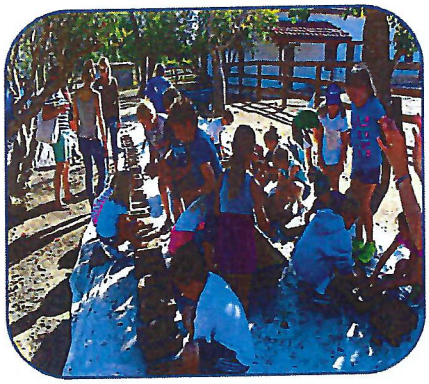
MSC

INTEGRITY ◆ CRAFTSMANSHIP ◆ VALUE ◆ SAFETY

Adobe Restoration



Custom Construction



Community

Mark Sauer Construction, Inc.
19712 Temescal Canyon Road
Corona, CA 92881
(951) 279-4245

www.msauer.com

contact@msauer.com

California License #500572B

Mark Sauer Construction, Inc.
19712 Temescal Canyon Road
Corona, CA 92881

Phone: (951) 279-4245
Fax: (951) 279-5917
Website: www.msauer.com
Email: contact@msauer.com
Small Business Cert. #0035176

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Introductions:

Back ground on MSC:

Where adobe came from:

- A building product used for 1000's of years.
- California adobe comes from the south.
- Influences from the mid-west and south-west.

Building qualities of Adobe

- Strength by mass
- Warm in the winter, cool in the summer
- Architectural qualities
- Evolution of adobe structures over time

Adobe materials:

- Un-stabilized adobe
  - Straw added
- Stabilized adobe
- Cement / soil adobe
- Cobb
- Rammed earth
- Sod
- Dung

Building code:

- UBC 21-9

Testing:

- Sieve test
- Compressive Strength
- Modulus of Rupture
- Absorption (not required for un-stabilized adobe)

New adobe masonry construction:

- Block lay up same as any other masonry unit (adobe is heavy)
- Adobe mortar preferred on un-stabilized block

Repairs of adobe:

- Moisture infusion and control
- Packing (chunks of dry adobe added for large repair areas)
- Cracks

- Mudding
- Unit replacement
- Plastering of adobe
    - Straw added in the scratch and brown phases
- Application similar to cement plaster
- Moisture control
- Build up
- Cracking pick up

Salvage of adobe:

- Save all adobe and reuse = like materials / compatible
- Shoring of adobe
- Shore in-place
- Water / weather protection

Seismic retrofit of adobe:

- Epoxy anchoring
- Simpson type hardware, steel shapes, columns, ledgers, blocking, drag strips, sheathing/diagram, bond beams.

Maintenance of Adobes:

- Water protection
- sacrificial surfaces
    - White wash / NHL Plaster / Paint
- Base erosion
- Irrigation issues
- Planting and ground cover
- Drainage
- Regular maintenance schedule

General misc. notes from historical (non-stabilized) adobe training Jan. 5, 2022 by MSC

Adobe Bricks

Mission bricks were 12X4X24

Straw waddle is a good source of brick straw

Brick making: too much sand causes melting, too much clay causes cracking

Save your spare adobes, they can be ground up and re-used for casting bricks (this applies to non-stabilized adobes only). MSC uses dirt from a Queen Creek AZ supplier for adobe dirt, when needed.

Best way to mix adobe dirt is with a hoe, in a wheelbarrow.

Historical protective coatings

Whitewash is considered a sacrificial surface. Chemstar type S lime for whitewashing can be bought at most hardware stores such as Lowes or Home Depot. Concrete bonding adhesive (glue) is added to the lime water mix. Mix in bucket with a paddle stirrer. Add lime to water. (Do not add water to lime.) Paint onto adobe in several thin coats over several days, each drying a day. Do not try to apply too thick. Breathable latex paint, from Dunn Edwards or Sherman Williams, can also be used as a sacrificial coating over the limewash.

A much thicker Lime plaster coating is also an option. NHL (natural hydrated lime) plaster is available from two suppliers: U.S. Lime and Trans-mineral, in Petaluma. They also make lime-based paint. Lime plaster goes on like Stucco, scratch coat, brown coat, top coat. 3/4" to 7/8" thick. Stainless steel lath, attached with deck screws is recommended to assure attachment to the adobe substrate.

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Whitewash or Lime Wash Design Mix

Needed:

1. 5 gallon bucket
2. 2 gallon bucket
3. Plastic measuring cup
4. Type S Lime
5. Concrete glue
6. Drill motor
7. Mixing paddle
8. Wide masonry brush
9. Large sponge
10. Misc. site protection materials
    - Multiple of these materials needed relative to size of application

Mixing:

A. In a 5 gallon bucket fill ½ way with clean water
B. In a 2 gallon bucket fill to top with Type S Lime
C. Pour lime into the water in the 5 gallon bucket
D. Add 16 OZ of concrete glue
E. Mix
F. Gradually add more clear water to 5 gallon bucket
G. Continue to mix (fully combine materials)
H. End with 80% full 5 gallon bucket with the Whitewash mix.
I. It is desirable to let stand overnight but not critical
J. If standing overnight or over time, add more water and mix again prior to use.

Application:

- Prepare wall surface(s) by removing loose and/or non-bonding materials
    - *If adobe repairs are required that work needs to be completed first and fully dry prior to application of Whitewash.*
- Apply Whitewash coat adobe wall
- Allow to dry in between coats
- Expect to apply a minimum of 2 coats and maximum of 5 coats

RESUBMIT FOR REVIEW		REVIEW COMPLETED
☐ REVISE AND/OR CORRECT ☐ REJECTED	THIS REVIEW DOES NOT RELIEVE CONTRACTOR FROM COMPLIANCE WITH REQUIREMENTS OF DRAWINGS AND SPECIFICATIONS. THIS CHECK IS ONLY FOR REVIEW OF GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS. THE CONTRACTOR IS RESPONSIBLE FOR CONFIRMING AND CORRELATING ALL QUANTITIES AND DIMENSIONS, SELECTING FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATING THE WORK WITH THAT OF OTHER TRADES, AND PERFORMING HIS WORK IN A SAFE AND SATISFACTORY MANNER.	☒ NO CORRECTIONS NOTED ☐ MAKE CORRECTIONS NOTED
DATE 12/20/18	PAGE & TURNBULL 417 S. Hill St., Ste. 211, Los Angeles, CA 90013 213.221.1200 | www.page-turnbull.com	BY DG

PRIME PAINT

108.04A

SHERWIN WILLIAMS.

GREENGUARD
PRODUCT CERTIFIED FOR LOW CHEMICAL EMISSIONS
UL.COM/GG
UL 2818
GOLD

PREPRITE® PROBLOCK®

Interior/Exterior Latex Primer/Sealer B51-600 Series

As of 02/22/2017, Complies with:			
OTC	Yes	LEED® 09 NC CI	Yes
OTC Phase II	Yes	LEED® 09 CS	Yes
SCAQMD	Yes	LEED® 09 H	Yes
CARB	Yes	LEED® v4 Emissions	Yes
CARB SCM2007	Yes	LEED® v4 VOC	Yes
Canada	Yes	MPI	Yes

CHARACTERISTICS

- Assures uniform appearance of topcoats
- Fast dry
- Apply at temperatures down to 35°F
- Assures adhesion of the topcoat to slick, glossy surfaces
- Seals out solvent sensitive stains - tar, solvent based markers, etc.
- Seals minor dried water stains and tannin
- Provides easy "slip" for positioning of wallpaper

Use on interior:
- Ceiling Tiles
- Paneling
- Wall Laminate
- Cured Plaster
- Varnished Woodwork
- Kitchen Cabinets
- Ceramic Wall Tile
- Under wallcovering

Use on interior & exterior:
- Wood
- Aluminum
- Galvanized Metal
- Previously Painted Surfaces
- PVC Piping
- Drywall
- Concrete and Masonry
- Many Plastics
- Glossy Surfaces
- Fiberglass
- Copper
- Glazed Block

Anti-microbial - This product contains agents which inhibit the growth of microbes on the surface of this paint film.

CHARACTERISTICS

Color: White & Deep Base
Coverage: 400 sq ft/gal @ 4 mils wet; 1.4 mils dry
Drying Time, @ 77°F, 50% RH:
Touch: 30 minutes
Recoat as a primer 1 hour
Recoat as a stain sealer: 4 hours
To apply wallcovering 3 hours
Drying and recoat times are temperature, humidity and film thickness dependent.
Flash Point: N/A
Finish: 5-10 units @ 85°
Tinting with CCE only

Base	oz/gal	Strength
White	0 - 4	100%
Deep Base	4-12	100%

Vehicle Type: Styrenated Acrylic Latex B51W00620
VOC (less exempt solvents): <50 g/L; <0.42 lb/gal
As per 40 CFR 59.406 and SOR/2009-264, s.12
Volume Solids: 35 ± 2%
Weight Solids: 52 ± 2%
Weight per Gallon: 10.9 lb

For best topcoat color development, use the recommended "P"-shade primer. If desired, up to 4 oz per gallon of ColorCast Ecotoners can be used. Check color before use.

When spot priming on some surfaces, a non-uniform appearance of the final coat may result, due to differences in holdout between primed and unprimed areas. To avoid this, prime the entire surface rather than spot priming.
For optimal performance, this primer must be topcoated with a latex, alkyd/oil, water based epoxy, or solvent based epoxy coating on architectural applications.
For exterior exposure, this primer must be topcoated within 14 days with architectural latex or oil finishes.
For better performance when priming an entire house, use Exterior Latex or Oil-Based Primers

SURFACE PREPARATION

WARNING! Removal of old paint by sanding, scraping or other means may generate dust or fumes that contain lead. Exposure to lead dust or fumes may cause brain damage or other adverse health effects, especially in children or pregnant women. Controlling exposure to lead or other hazardous substances requires the use of proper protective equipment, such as a properly fitted respirator (**NIOSH** approved) and proper containment and cleanup. For more information, call the National Lead Information Center at **1-800-424-LEAD** (in US) or contact your local health authority.

Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry. Existing peeled or checked paint should be scraped and sanded to a sound surface. Glossy surfaces should be sanded dull. Recognize that any surface preparation short of total removal of the old coating may compromise the service length of the system.

Special recommendations - After priming stained areas, allow to dry 4 hours, test a small area for bleeding by applying the topcoat before painting the entire project. If the stain bleeds through, apply a second coat of primer and allow to dry overnight and retest before topcoating.

Fire restoration work - Thoroughly clean the surface before applying to smoke stained areas. Apply one or two coats of PrepRite ProBlock Latex Primer/Sealer and test a small area for bleeding before painting the entire surface.

Testing- Always check for compatibility and adhesion to the surface by applying a test patch of 2 - 3 square feet. Allow to dry thoroughly for 1 week before checking adhesion.

continued on back

SHERWIN WILLIAMS.

108.04A

PREPRITE® PROBLOCK®

Interior/Exterior Latex Primer/Sealer B51-600 Series

SURFACE PREPARATION

Plaster - Must be cured, usually 30 days, and hard. If painting cannot wait, allow the surface to dry 7 days and prime with Loxon Concrete and Masonry Primer. Soft, porous, or powdery plaster should be treated with a solution of 1 pint household vinegar to 1 gallon of water. Repeat until the surface is hard, rinse with water and allow to dry before painting.

Wood - Sand any exposed wood to a fresh surface. Patch all holes and imperfections with a wood filler or putty and sand smooth.

Tile, laminate, ceramic and plastic tiles, and similar glossy surfaces, must be free of all oil, grease, and soap residue. Do not use this product in areas subject to excessive water, e.g.: in showers, around sinks, on counter tops.

Caulking - Fill gaps between walls, ceilings, crown moldings, and other trim with the appropriate caulk after priming the surface.

Mildew - Prior to attempting to remove mildew, it is always recommended to test any cleaner on a small, inconspicuous area prior to use. Bleach and bleaching type cleaners may damage or discolor existing paint films. Bleach alternative cleaning solutions may be advised.
Mildew may be removed before painting by washing with a solution of 1 part liquid bleach and 3 parts water. Apply the solution and scrub the mildewed area. Allow the solution to remain on the surface for 10 minutes. Rinse thoroughly with water and allow the surface to dry before painting. Wear protective eyewear, waterproof gloves, and protective clothing. Quickly wash off any of the mixture that comes in contact with your skin. Do not add detergents or ammonia to the bleach/water solution.

APPLICATION

When the air temperature is at 35°F, substrates may be colder; prior to painting, check to be sure the air, surface, and material temperature are above 35°F and at least 5°F above the dew point. Avoid using if rain or snow is expected within 2-3 hours. Air and surface temperatures must not drop below 35°F for 48 hours after application.

Do not reduce for stain blocking.
No reduction necessary.
Brush - Use a nylon/polyester brush.
Roller - Use a 3/8" nap soft woven roller cover.
Spray—Airless
Pressure .....2000 psi
Tip.....015"-.021"

Tips-General Priming: PrepRite ProBlock Latex Primer/Sealer can be topcoated in 1 hour in non-stain blocking applications.

On hard, slick, glossy, or otherwise hard to paint surfaces, after preparing the surface, apply a test area of this primer, allow to dry properly and test for adhesion.

When used as a primer under wallcovering. After wallcovering has been applied and the adhesive has dried and cured, wait at least 21 days before removing the wallcovering to avoid damage to the drywall.

CLEANUP INFORMATION

Clean spills, spatters, hands and tools immediately after use with soap and warm water. After cleaning, flush spray equipment with a compliant cleanup solvent to prevent rusting of the equipment. Follow manufacturer's safety recommendations when using solvents.

CAUTIONS

Protect from freezing..

Before using, carefully read **CAUTIONS** on label.

HOTW 02/22/2017 B51W00620 18 00

KOR, SP

FINISH PAINT

102.40

SHERWIN WILLIAMS.

DURACRAFT®
Exterior Latex Flat

C01W00251 Extra White
C01W00253 Deep Base
C01T00254 Ultradeep Base

As of 10/04/2017, Complies with:			
OTC	Yes	LEED® 09 NC CI	N/A
OTC Phase II	Yes	LEED® 09 CS	N/A
SCAQMD	Yes	LEED® v4 Emissions	N/A
CARB	Yes	LEED® v4 VOC	Yes
CARB SCM2007	Yes		
Canada	Yes	MPI	

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☐ REVISE AND/OR CORRECT ☐ REJECTED		☒ NO CORRECTIONS NOTED ☐ MAKE CORRECTIONS NOTED
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CHARACTERISTICS

DuraCraft Exterior Latex is a good commercial quality exterior finish. **DuraCraft** is recommended for use on aluminum, vinyl, and wood siding, clapboard, shakes, shingles, plywood, masonry, cementitious board, and metal. **DuraCraft Exterior Latex** can be applied down to a surface and air temperature of 35°F.

Color: Most colors
To optimize hide and color development, always use the recommended P-Shade primer

Coverage: 350 - 400 sq ft/gal @ 4 mils wet; 1.2 mils dry

Drying Time, @ 50% RH:

	@ 35-45°F	@ 45°F+
Touch:	2 hour	2 hours
Recoat:	24-48 hours	4 hours

Drying and recoat times are temperature, humidity, and film thickness dependent

Finish: 0-5 units @ 85°

Tinting with CCE:

Base	oz/gal	Strength
Extra White	0-6	SherColor
Deep Base	4-12	SherColor
Ultradeep	10-12	SherColor

Vehicle Type: 100% Acrylic

C01W00251
(may vary by color)

VOC (less exempt solvents):
<50 g/L; <0.42 lb/gal
As per 40 CFR 59.406 and SOR/2009-264, s.12

Volume Solids: 31 ± 2%
Weight Solids: 47 ± 2%
Weight per Gallon: 10.82 lb
Flash Point: N/A
WVP Perms (US) 37.37
grains/(hr ft² in Hg)

Mildew Resistant
This coating contains agents which inhibit the growth of mildew on the surface of this coating film.

SPECIFICATIONS

Standard latex primers cannot be used below 50°F. See specific primer label for that product's application conditions.

Aluminum & Aluminum Siding[1]
2 cts. DuraCraft Exterior Latex

Concrete Block, CMU, Split face Block
1 ct. Loxon Block Surfacer
2 cts. DuraCraft Exterior Latex

Brick
1 ct. Loxon Conditioner[2]
2 cts. DuraCraft Exterior Latex

Cement Composition Siding/Panels
1 ct. Loxon Concrete & Masonry Primer[2]
or Loxon Conditioner[2]
2 cts. DuraCraft Exterior Latex

Galvanized Steel[1]
2 cts. DuraCraft Exterior Latex

Stucco, Cement, Concrete
1 ct. Loxon Concrete & Masonry Primer[2]
2 cts. DuraCraft Exterior Latex

Plywood
1 ct. Exterior Latex Wood Primer
2 cts. DuraCraft Exterior Latex

Vinyl Siding*
2 cts. DuraCraft Exterior Latex

Wood
1 ct. Exterior Oil-Based Wood Primer
2 cts. DuraCraft Exterior Latex

[1] On large expanses of metal siding, the air, surface, and material temperatures must be 50°F or higher.
[2] Not for use at temperatures under 50°F. See specific primer label for that product's application conditions.

Other primers may be appropriate.

When repainting involves a drastic color change, a coat of primer will improve the hiding performance of the topcoat color.

SURFACE PREPARATION

WARNING! Removal of old paint by sanding, scraping or other means may generate dust or fumes that contain lead. Exposure to lead dust or fumes may cause brain damage or other adverse health effects, especially in children or pregnant women. Controlling exposure to lead or other hazardous substances requires the use of proper protective equipment, such as a properly fitted respirator (**NIOSH** approved) and proper containment and cleanup. For more information, call the National Lead Information Center at **1-800-424-LEAD** (in US) or contact your local health authority.

Remove all surface contamination by washing with an appropriate cleaner, rinse thoroughly and allow to dry. Scrape and sand peeled or checked paint to a sound surface. Sand glossy surfaces dull. Seal stains from water, smoke, ink, pencil, grease, etc. with the appropriate primer/sealer. Recognize that any surface preparation short of total removal of the old coating may compromise the service length of the system.

Aluminum and Galvanized Steel
Wash to remove any oil, grease, or other surface contamination. All corrosion must be removed with sandpaper, wire brush, or other abrading method.

Caulking
Gaps between windows, doors, trim, and other through-wall openings can be filled with the appropriate caulk after priming the surface.

Cement Composition Siding/Panels
Remove all dirt, dust, grease, oil, loose particles, laitance, foreign material, and peeling or defective coatings. Allow the surface to dry thoroughly. If the surface is new, test it for pH, if the pH is higher than 9, prime with Loxon Concrete & Masonry Primer.

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Uniform Building Code Standard 21-9

UNIFORM BUILDING CODE STANDARD 21-9
UNBURNED CLAY MASONRY UNITS AND STANDARD METHODS OF SAMPLING AND TESTING UNBURNED CLAY MASONRY UNITS

Test Standard of the International Conference of Building Officials

See Section 2102.2, Item 6, *Uniform Building Code*

Part I—Unburned Clay Masonry

SECTION 21.901 — SCOPE

This standard covers unburned clay masonry units made from a suitable mixture of soil, clay and stabilizing agent, and intended for use in brick masonry.

SECTION 21.902 — COMPOSITION OF UNITS

21.902.1 Soil. The soil used shall contain not less than 25 percent and not more than 45 percent of material passing a No. 200 mesh (75 μm) sieve. The soil shall contain sufficient clay to bind the particles together, but shall contain not more than 0.2 percent of water-soluble salts.

21.902.2 Stabilizer. The stabilizing agent shall be emulsified asphalt. The stabilizing agent shall be uniformly mixed with the soil in amounts sufficient to provide the required resistance to absorption.

SECTION 21.903 — PHYSICAL REQUIREMENTS

The units shall conform to the physical requirements prescribed in Table 21-1-B of UBC Standard 21-1.

SECTION 21.904 — SHRINKAGE CRACKS

No units shall contain more than three shrinkage cracks, and no shrinkage crack shall exceed 3 inches (76 mm) in length or $^1/_8$ inch (3.2 mm) in width.

Part II—Sampling and Testing of Unburned Clay Masonry Units

SECTION 21.905 — SCOPE

These methods cover procedures for the sampling and testing of unburned clay masonry units for compressive strength, modulus of rupture, absorption and moisture content.

Sampling

SECTION 21.906 — TEST SPECIMENS

For each of the tests prescribed in this standard, five sample units shall be selected at random from each lot of 5,000 units or fraction thereof.

SECTION 21.907 — IDENTIFICATION

Each specimen shall be marked so that it may be identified at any time. Markings shall not cover more than 5 percent of the superficial area of the specimen.

Compressive Strength

SECTION 21.908 — PROCEDURE

Five full-size specimens shall be tested for compressive strength according to the following procedure:

1. Dry the specimens at a temperature of 85°F ± 15°F (29°C ± 9°C) in an atmosphere having a relative humidity of not more than 50 percent. Weigh the specimens at one-day intervals until constant weight is attained.

2. Test the specimens in the position in which the unburned clay masonry unit is designed to be used, and bed on and cap with a felt pad not less than $^1/_8$ inch (3.2 mm) nor more than $^1/_4$ inch (6.4 mm) in thickness.

3. The specimens may be suitably capped with calcined gypsum mortar or the bearing surfaces of the tile may be planed or rubbed smooth and true. When calcined gypsum is used for capping, conduct the test after the capping has set and the specimen has been dried to constant weight in accordance with Item 1 of this section.

4. The loading head shall completely cover the bearing area of the specimen and the applied load shall be transmitted through a spherical bearing block of proper design. The speed of the moving head of the testing machine shall not be more than 0.05 inch (1.27 mm) per minute.

5. Calculate the average compressive strength of the specimens tested and report this as the compressive strength of the block.

Modulus of Rupture

SECTION 21.909 — PROCEDURE

Five full-size specimens shall be tested for modulus of rupture according to the following procedure:

1. Cured specimen shall be positioned on cylindrical supports 2 inches (51 mm) in diameter, located 2 inches (51 mm) from each end, and extending across the full width of the specimen.

2. A cylinder 2 inches (51 mm) in diameter shall be positioned on the specimen midway between and parallel to the cylindrical supports.

3. Load shall be applied to the cylinder at the rate of 500 pounds (2224 N) per minute until failure occurs.

4. Calculate modulus of rupture from the formula $S = \frac{3WL}{2Bd^2}$

WHERE:

B = width of specimen.
d = thickness of specimen.
L = distance between supports.
S = modulus of rupture, psi (kPa).
W = load at failure.

CHAPTER 21
MASONRY

SECTION 2101
GENERAL

2101.1 Scope. This chapter shall govern the materials, design, construction and quality of masonry.

2101.2 Design methods. Masonry shall comply with the provisions of one of the following design methods in this chapter as well as the requirements of Sections 2101 through 2104. Masonry designed by the allowable stress design provisions of Section 2101.2.1, the strength design provisions of Section 2101.2.2 or the prestressed masonry provisions of Section 2101.2.3 shall comply with Section 2105.

2101.2.1 Allowable stress design. Masonry designed by the allowable stress design method shall comply with the provisions of Sections 2106 and 2107.

2101.2.2 Strength design. Masonry designed by the strength design method shall comply with the provisions of Sections 2106 and 2108, except that autoclaved aerated concrete (AAC) masonry shall comply with the provisions of Section 2106 and Chapter 1 and Appendix A of ACI 530/ASCE 5/TMS 402. AAC masonry shall not be used in the seismic-force-resisting system of structures classified as Seismic Design Category B, C, D, E or F.

2101.2.3 Prestressed masonry. Prestressed masonry shall be designed in accordance with Chapters 1 and 4 of ACI 530/ASCE 5/TMS 402 and Section 2106. Special inspection during construction shall be provided as set forth in Section 1704.5.

2101.2.4 Empirical design. Masonry designed by the empirical design method shall comply with the provisions of Sections 2106 and 2109 or Chapter 5 of ACI 530/ASCE 5/TMS 402.

2101.2.5 Glass unit masonry. Glass unit masonry shall comply with the provisions of Section 2110 or Chapter 7 of ACI 530/ASCE 5/TMS 402.

2101.2.6 Masonry veneer. Masonry veneer shall comply with the provisions of Chapter 14 or Chapter 6 of ACI 530/ASCE 5/TMS 402.

2101.3 Construction documents. The construction documents shall show all of the items required by this code including the following:

1. Specified size, grade, type and location of reinforcement, anchors and wall ties.
2. Reinforcing bars to be welded and welding procedure.
3. Size and location of structural elements.
4. Provisions for dimensional changes resulting from elastic deformation, creep, shrinkage, temperature and moisture.

2101.3.1 Fireplace drawings. The construction documents shall describe in sufficient detail the location, size and construction of masonry fireplaces. The thickness and characteristics of materials and the clearances from walls, partitions and ceilings shall be clearly indicated.

SECTION 2102
DEFINITIONS AND NOTATIONS

2102.1 General. The following words and terms shall, for the purposes of this chapter and as used elsewhere in this code, have the meanings shown herein.

AAC MASONRY. Masonry made of autoclaved aerated concrete (AAC) units, manufactured without internal reinforcement and bonded together using thin- or thick-bed mortar.

ADOBE CONSTRUCTION. Construction in which the exterior load-bearing and nonload-bearing walls and partitions are of unfired clay masonry units, and floors, roofs and interior framing are wholly or partly of wood or other approved materials.

Adobe, stabilized. Unfired clay masonry units to which admixtures, such as emulsified asphalt, are added during the manufacturing process to limit the units' water absorption so as to increase their durability.

Adobe, unstabilized. Unfired clay masonry units that do not meet the definition of "Adobe, stabilized."

ANCHOR. Metal rod, wire or strap that secures masonry to its structural support.

ARCHITECTURAL TERRA COTTA. Plain or ornamental hard-burned modified clay units, larger in size than brick, with glazed or unglazed ceramic finish.

AREA.

Bedded. The area of the surface of a masonry unit that is in contact with mortar in the plane of the joint.

Gross cross-sectional. The area delineated by the out-to-out specified dimensions of masonry in the plane under consideration.

Net cross-sectional. The area of masonry units, grout and mortar crossed by the plane under consideration based on out-to-out specified dimensions.

AUTOCLAVED AERATED CONCRETE (AAC). Low-density cementitious product of calcium silicate hydrates, whose material specifications are defined in ASTM C 1386.

BED JOINT. The horizontal layer of mortar on which a masonry unit is laid.

BOND BEAM. A horizontal grouted element within masonry in which reinforcement is embedded.

BOND REINFORCING. The adhesion between steel reinforcement and mortar or grout.

inches (610 mm), shall have one bonder unit for each 6 square feet (0.56 m^2) of wall surface on both sides.

2109.6.5 Masonry bonding pattern.

2109.6.5.1 Masonry laid in running bond. Each wythe of masonry shall be laid in running bond, head joints in successive courses shall be offset by not less than one-fourth the unit length or the masonry walls shall be reinforced longitudinally as required in Section 2109.6.5.2.

2109.6.5.2 Masonry laid in stack bond. Where unit masonry is laid with less head joint offset than in Section 2109.6.5.1, the minimum area of horizontal reinforcement placed in mortar bed joints or in bond beams spaced not more than 48 inches (1219 mm) apart, shall be 0.0003 times the vertical cross-sectional area of the wall.

2109.7 Anchorage.

2109.7.1 General. Masonry elements shall be anchored in accordance with Sections 2109.7.2 through 2109.7.4.

2109.7.2 Intersecting walls. Masonry walls depending upon one another for lateral support shall be anchored or bonded at locations where they meet or intersect by one of the methods indicated in Sections 2109.7.2.1 through 2109.7.2.5.

2109.7.2.1 Bonding pattern. Fifty percent of the units at the intersection shall be laid in an overlapping masonry bonding pattern, with alternate units having a bearing of not less than 3 inches (76 mm) on the unit below.

2109.7.2.2 Steel connectors. Walls shall be anchored by steel connectors having a minimum section of $^1/_4$ inch (6.4 mm) by $1^1/_2$ inches (38 mm), with ends bent up at least 2 inches (51 mm) or with cross pins to form anchorage. Such anchors shall be at least 24 inches (610 mm) long and the maximum spacing shall be 48 inches (1219 mm).

2109.7.2.3 Joint reinforcement. Walls shall be anchored by joint reinforcement spaced at a maximum distance of 8 inches (203 mm). Longitudinal wires of such reinforcement shall be at least wire size W1.7 (MW 11) and shall extend at least 30 inches (762 mm) in each direction at the intersection.

2109.7.2.4 Interior nonload-bearing walls. Interior nonload-bearing walls shall be anchored at their intersection, at vertical intervals of not more than 16 inches (406 mm) with joint reinforcement or $^1/_4$-inch (6.4 mm) mesh galvanized hardware cloth.

2109.7.2.5 Ties, joint reinforcement or anchors. Other metal ties, joint reinforcement or anchors, if used, shall be spaced to provide equivalent area of anchorage to that required by this section.

2109.7.3 Floor and roof anchorage. Floor and roof diaphragms providing lateral support to masonry shall comply with the live loads in Section 1607.3 and shall be connected to the masonry in accordance with Sections 2109.7.3.1 through 2109.7.3.3. Roof loading shall be determined in accordance with Chapter 16 and, when net uplift occurs, uplift shall be resisted entirely by an anchorage system designed in accordance with the provisions of Sections 2.1 and 2.3, Sections 3.1 and 3.3 or Chapter 4 of ACI 530/ASCE 5/TMS 402.

2109.7.3.1 Wood floor joists. Wood floor joists bearing on masonry walls shall be anchored to the wall at intervals not to exceed 72 inches (1829 mm) by metal strap anchors. Joists parallel to the wall shall be anchored with metal straps spaced not more than 72 inches (1829 mm) o.c. extending over or under and secured to at least three joists. Blocking shall be provided between joists at each strap anchor.

2109.7.3.2 Steel floor joists. Steel floor joists bearing on masonry walls shall be anchored to the wall with $^3/_8$-inch (9.5 mm) round bars, or their equivalent, spaced not more than 72 inches (1829 mm) o.c. Where joists are parallel to the wall, anchors shall be located at joist bridging.

2109.7.3.3 Roof diaphragms. Roof diaphragms shall be anchored to masonry walls with $^1/_2$-inch-diameter (12.7 mm) bolts, 72 inches (1829 mm) o.c. or their equivalent. Bolts shall extend and be embedded at least 15 inches (381 mm) into the masonry, or be hooked or welded to not less than 0.20 square inch (129 mm^2) of bond beam reinforcement placed not less than 6 inches (152 mm) from the top of the wall.

2109.7.4 Walls adjoining structural framing. Where walls are dependent upon the structural frame for lateral support, they shall be anchored to the structural members with metal anchors or otherwise keyed to the structural members. Metal anchors shall consist of $^1/_2$-inch (12.7 mm) bolts spaced at 48 inches (1219 mm) o.c. embedded 4 inches (102 mm) into the masonry, or their equivalent area.

2109.8 Adobe construction. Adobe construction shall comply with this section and shall be subject to the requirements of this code for Type V construction.

2109.8.1 Unstabilized adobe.

2109.8.1.1 Compressive strength. Adobe units shall have an average compressive strength of 300 psi (2068 kPa) when tested in accordance with ASTM C 67. Five samples shall be tested and no individual unit is permitted to have a compressive strength of less than 250 psi (1724 kPa).

2109.8.1.2 Modulus of rupture. Adobe units shall have an average modulus of rupture of 50 psi (345 kPa) when tested in accordance with the following procedure. Five samples shall be tested and no individual unit shall have a modulus of rupture of less than 35 psi (241 kPa).

2109.8.1.2.1 Support conditions. A cured unit shall be simply supported by 2-inch-diameter (51 mm) cylindrical supports located 2 inches (51 mm) in from each end and extending the full width of the unit.

2109.8.1.2.2 Loading conditions. A 2-inch-diameter (51 mm) cylinder shall be placed at midspan parallel to the supports.

2109.8.1.2.3 Testing procedure. A vertical load shall be applied to the cylinder at the rate of 500 pounds per minute (37 N/s) until failure occurs.

2109.8.1.2.4 Modulus of rupture determination. The modulus of rupture shall be determined by the equation:

$$f_r = 3WL_s/2bt^2 \quad \text{(Equation 21-4)}$$

where, for the purposes of this section only:

b = Width of the test specimen measured parallel to the loading cylinder, inches (mm).

f_r = Modulus of rupture, psi (MPa).

L_s = Distance between supports, inches (mm).

t = Thickness of the test specimen measured parallel to the direction of load, inches (mm).

W = The applied load at failure, pounds (N).

2109.8.1.3 Moisture content requirements. Adobe units shall have a moisture content not exceeding 4 percent by weight.

2109.8.1.4 Shrinkage cracks. Adobe units shall not contain more than three shrinkage cracks and any single shrinkage crack shall not exceed 3 inches (76 mm) in length or $^1/_8$ inch (3.2 mm) in width.

2109.8.2 Stabilized adobe.

2109.8.2.1 Material requirements. Stabilized adobe shall comply with the material requirements of unstabilized adobe in addition to Sections 2109.8.2.1.1 and 2109.8.2.1.2.

2109.8.2.1.1 Soil requirements. Soil used for stabilized adobe units shall be chemically compatible with the stabilizing material.

2109.8.2.1.2 Absorption requirements. A 4-inch (102 mm) cube, cut from a stabilized adobe unit dried to a constant weight in a ventilated oven at 212°F to 239°F (100°C to 115°C), shall not absorb more than $2^1/_2$ percent moisture by weight when placed upon a constantly water-saturated, porous surface for seven days. A minimum of five specimens shall be tested and each specimen shall be cut from a separate unit.

2109.8.3 Allowable stress. The allowable compressive stress based on gross cross-sectional area of adobe shall not exceed 30 psi (207 kPa).

2109.8.3.1 Bolts. Bolt values shall not exceed those set forth in Table 2109.8.3.1.

2109.8.4 Construction.

2109.8.4.1 General.

2109.8.4.1.1 Height restrictions. Adobe construction shall be limited to buildings not exceeding one story, except that two-story construction is allowed when designed by a registered design professional.

TABLE 2109.8.3.1
ALLOWABLE SHEAR ON BOLTS IN ADOBE MASONRY

DIAMETER OF BOLTS (inches)	MINIMUM EMBEDMENT (inches)	SHEAR (pounds)
$^1/_2$	—	—
$^5/_8$	12	200
$^3/_4$	15	300
$^7/_8$	18	400
1	21	500
$1^1/_8$	24	600

For SI: 1 inch = 25.4 mm, 1 pound = 4.448 N.

2109.8.4.1.2 Mortar restrictions. Mortar for stabilized adobe units shall comply with Chapter 21 or adobe soil. Adobe soil used as mortar shall comply with material requirements for stabilized adobe. Mortar for unstabilized adobe shall be portland cement mortar.

2109.8.4.1.3 Mortar joints. Adobe units shall be laid with full head and bed joints and in full running bond.

2109.8.4.1.4 Parapet walls. Parapet walls constructed of adobe units shall be waterproofed.

2109.8.4.2 Wall thickness. The minimum thickness of exterior walls in one-story buildings shall be 10 inches (254 mm). The walls shall be laterally supported at intervals not exceeding 24 feet (7315 mm). The minimum thickness of interior load-bearing walls shall be 8 inches (203 mm). In no case shall the unsupported height of any wall constructed of adobe units exceed 10 times the thickness of such wall.

2109.8.4.3 Foundations.

2109.8.4.3.1 Foundation support. Walls and partitions constructed of adobe units shall be supported by foundations or footings that extend not less than 6 inches (152 mm) above adjacent ground surfaces and are constructed of solid masonry (excluding adobe) or concrete. Footings and foundations shall comply with Chapter 18.

2109.8.4.3.2 Lower course requirements. Stabilized adobe units shall be used in adobe walls for the first 4 inches (102 mm) above the finished first-floor elevation.

2109.8.4.4 Isolated piers or columns. Adobe units shall not be used for isolated piers or columns in a load-bearing capacity. Walls less than 24 inches (610 mm) in length shall be considered isolated piers or columns.

2109.8.4.5 Tie beams. Exterior walls and interior load-bearing walls constructed of adobe units shall have a continuous tie beam at the level of the floor or roof bearing and meeting the following requirements.

Sample Testing

Warner's Ranch, Highway 79 & S2 Eastern San Diego Co.

GROUP DELTA CONSULTANTS

PROJECT: Materials Testing
CLIENT: Mark Sauer Construction
MATERIAL: Adobe / Old Adobe/Warner Springs
SAMPLE SOURCE: Adobe Plant

JOB NO: IE-107
WORK ORDER NO: Verbal Troy Perr
LAB NO: SO-079
SAMPLED BY: Client
DATE SAMPLED:

REVISION #

PARTICLE-SIZE ANALYSIS OF SOILS (ASTM D422)

WEIGHT OF SAMPLE DISPERSED 64.54
PERCENT PASSING #10 SIEVE 100.0

SPECIFIC GRAVITY OF SOILS (ASTM D854) 2.64

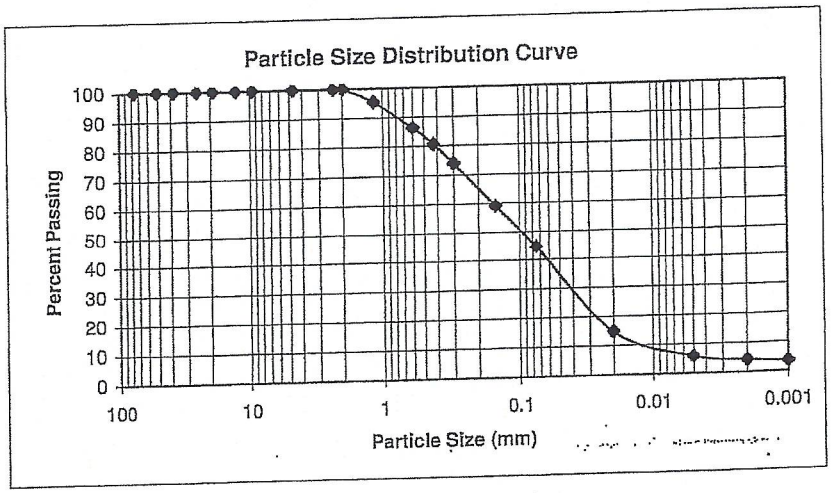
HYDROMETER RESULTS (% PASSING)

PARTICLE SIZE DIAMETER (mm)	0.0338	0.0225	0.0132	0.0094	0.0066	0.0033	0.0014	0.0010
PERCENT OF TEST SAMPLE	28.4	16.0	11.3	8.2	6.8	4.7	3.9	3.6
PERCENT OF TOTAL SAMPLE	28.4	16.0	11.3	8.2	6.8	4.7	3.9	3.6

SIEVE ANALYSIS (ASTM C136/C117)

Size Classification	Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Colloids
Percent	0.0	0.0	19.4	36.1	38.8	5.8	3.6

Sieve Size	% Passing
3"	100.0
2"	100.0
1 1/2"	100.0
1"	100.0
3/4"	100.0
1/2"	100.0
3/8"	100.0
#4	100.0
#8	100.0
#10	100.0
#16	95.5
#30	86.4
#40	80.6
#50	74.0
#100	58.9
#200	44.5
0.02 mm	14.8
0.005 mm	5.8
0.002 mm	4.1
0.001 mm	3.6



Reviewed by: _____
Marta E. Landaverde
Laboratory Manager

EXCEPTION TAKEN ☐ MAKE CORRECTIONS NOTED ☐
REJECTED ☐ REVISE AND RESUBMIT ☐
REVIEWED AND NOTED ☒ SUBMIT SPECIFIED ITEM ☐

REVIEW IS ONLY FOR GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS. ANY ACTION SHOWN IS SUBJECT TO THE REQUIREMENTS OF THE PLANS AND SPECIFICATIONS. CONTRACTOR IS RESPONSIBLE FOR: DIMENSIONS WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE, FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATION OF HIS WORK WITH THAT OF ALL OTHER TRADES AND THE SATISFACTORY PERFORMANCE OF HIS WORK.

MELVYN GREEN & ASSOCIATES, INC.
STRUCTURAL ENGINEERS

Reviewed by _____ Date 12/2/09

Group Delta Consultants, Inc.
4201 Santa Ana St.
Ontario, CA, 91761
Phone: (909) 605-6500
Fax: (909) 605-6502

www.groupdelta.com

Adobe Blocks Testing UBC 21-9

Project:	Materials Testing	Job No.:	IE-106
Client:	Mark Sauer Construction	Work Order No.:	
Color/Type Material:	Adobe /Old Adove/ Warner Springs	Lab No.:	SO-079
Sample Source:	Client	Sampled By:	Client
		Date Sampled:	
		Date Due:	12/4/2009

Test Date: 4-Dec

COMPRESSIVE STRENGTH UBC 21-9

	A	B		C = A * B	D	E	
Specimen No.	Size (In) Width	Length	Height	Gross Area (sq.in.)	Load (lbs.)	Strength (psi)	State of NM Section 2405 Specifications (psi)
1	7.75	12.03	3.725	93.23	79,200	849	
					Average:	849	300 Minimum

Test Date: 4-Dec

MODULUS OF RUPTURE (FLEXURAL STRENGTH)

	F	G	H	I	J	K	
Specimen No.	Distance Midspan to Failure	Net Width (Face to Face Minus Voids)	Depth (Bed Surface to Bed Surface)	Distance Between Supports	Load (lbs.)	Strength (psi)	Specifications (psi)
1	0.5"	13"	3.5"	14"	1740	229	
					Average:	229	

ABSORPTION

	L	M	N = (L - M) / M
Specimen No.	Saturated Weight	Dry Weight	% Absorption
1	4922.3	4485.2	9.7

CONDITION OF MATERIAL AS RECEIVED:
ACCEPTABLE NOT ACCEPTABLE

Notes:

TECHNICIAN: TRL/MEL

DATE: 12/5/2009-12/11/09

NO EXCEPTION TAKEN ☐ MAKE CORRECTIONS NOTED ☐
REJECTED ☐ REVISE AND RESUBMIT ☐
REVIEWED AND NOTED ☐ SUBMIT SPECIFIED ITEM ☐

REVIEW IS ONLY FOR GENERAL CONFORMANCE WITH THE DESIGN CONCEPT OF THE PROJECT AND GENERAL COMPLIANCE WITH THE INFORMATION GIVEN IN THE CONTRACT DOCUMENTS. ANY ACTION SHOWN IS SUBJECT TO THE REQUIREMENTS OF THE PLANS AND SPECIFICATIONS. CONTRACTOR IS RESPONSIBLE FOR: DIMENSIONS WHICH SHALL BE CONFIRMED AND CORRELATED AT THE JOB SITE, FABRICATION PROCESSES AND TECHNIQUES OF CONSTRUCTION, COORDINATION OF HIS WORK WITH THAT OF ALL OTHER TRADES AND THE SATISFACTORY PERFORMANCE OF HIS WORK.

MELVYN GREEN & ASSOCIATES, INC.
STRUCTURAL ENGINEERS

Reviewed by: Date: 12/10/09

Reviewed By:
Marta E. Landaverde
Laboratory Manager

Group Delta Consultants, Inc.
4201 Santa Ana St. Suite F
Ontario, CA 91761
Tel (909) 605-6500
Fax (909) 605-6502

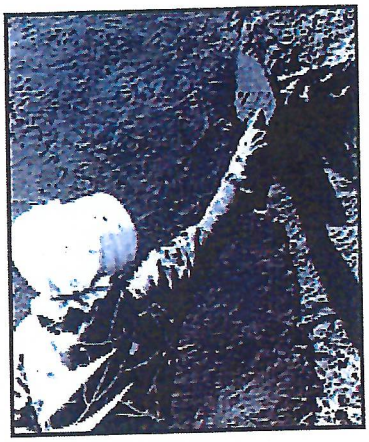
Preservation Brief #5

Preservation of Historic Adobe Buildings

5 Preservation Briefs

Technical Preservation Services
National Park Service
U.S. Department of the Interior

Preservation of Historic Adobe Buildings



A NOTE TO OUR USERS: The web versions of the **Preservation Briefs** differ somewhat from the printed versions. Many illustrations are new, captions are simplified, illustrations are typically in color rather than black and white, and some complex charts have been omitted.

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.

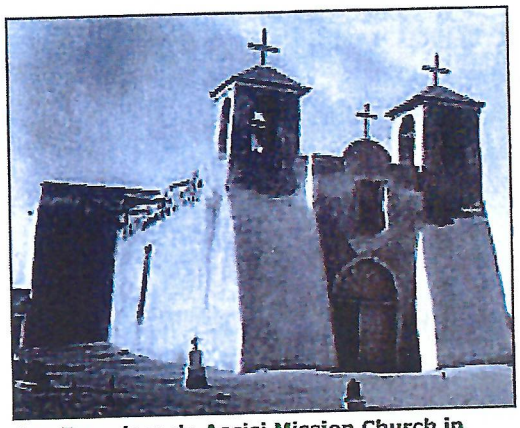
What is Adobe?

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.

A mixture of mud and straw is pressed into a mold to form an adobe brick. After the adobe brick is removed from the mold, it must dry in the open air for a month or more before it can be used. Photo: Russell Lee, Farm Security Administration Collection, Library of Congress.

Traditional adobe construction techniques in North America have not varied widely for over 3-1/2 centuries. Adobe 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.



San Francisco de Assisi Mission Church in Rancho de Taos, NM, was constructed of adobe between 1772 and 1819 and, because of its distinctive sculptural quality, is one of the most famous and frequently photographed of the mission churches. Photo: HABS Collection, NPS.

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.

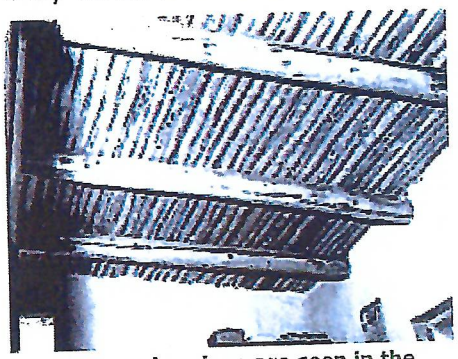
Preserving and rehabilitating a deteriorated adobe building is most successful when the techniques and methods used for restoration and repairs are as similar as possible to the techniques used in the original construction.

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 contraction, 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 mortals 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 nonexistent. 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.



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

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 (23 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 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 "savinos" 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 socioeconomic 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."

Traditionally, adobe surface coatings that protected the fragile adobe building fabric were renewed every few years. Women are seen here recoating an adobe wall with mud plaster mixed with straw at Chamisal, New Mexico. Photo: Russell Lee, Farm Security Administration Collection, Library of Congress.

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 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 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,

Moreover, professional assistance may be required to interpret local code requirements.

2. **Never begin restoration or repairs until the problems that 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.

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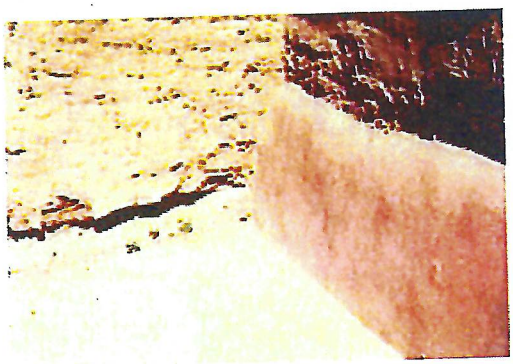


Coving at the base of this adobe wall may have been caused by salts deposited by rising groundwater and/or rainwater splash. Photo: NPS files.

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 watertight and compatible with the harder brick.

Rainwater that has accumulated at adobe foundations should be diverted away from the building. This may he 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 freezethaw 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 2-1/2 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 archaeological 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.

Wind Erosion: Windblown 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.

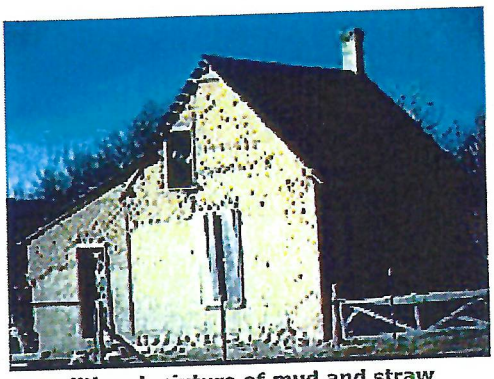
Material Incompatibilities: As adobe buildings are continually swelling and shrinking, it is likely that repair work has already been carried out sometime during the life of the building. Philosophies regarding adobe preservation have changed, and so have restoration and rehabilitation techniques. Techniques 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.



A traditional mixture of mud and straw plaster should be applied to stabilize the exterior of this house. Photo: NPS files.

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 halfbricks. 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 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 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 mortal 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.

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 breakdown. 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, ongoing 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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Home page logo: Traditional adobe repair. Photo: Russell Lee, Farm Security Administration Collection, Library of Congress.

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