

# Carriage house stabilization at the Las Flores Adobe site: field school training in the conservation of historic adobe structures

J.M. Barrow

*National Park Service, Santa Fe, New Mexico, United States of America*

D.W. Porter

*Graduate Program in Historic Preservation, University of Vermont, Burlington, Vermont, United States of America*

## ABSTRACT

Located in Southern California of the United States in an active seismic area, the National Landmark Rancho Las Flores, built in 1868, is one of a few authentic nineteenth-century, two-story, adobe ranch houses combining the Hacienda and the Monterey styles, which are unique to California. The United States Marine Corps, the National Park Service, and the Graduate Program in Historic Preservation at the University of Vermont have partnered in stabilization of the buildings at the site. Much of the recent work at Las Flores has been organized as a series of field school projects. The primary goals of these projects have been structural and seismic stabilization of the adobe buildings. Seismic stabilization has focused on implementing techniques recently advanced in the United States, which provide strengthening while preserving historic fabric. In 2004, the team collaborated in the stabilization of the carriage house; the scope of work included installation of a seismic retrofit system, replacement of concrete wall infills with adobe materials, reinstatement of the connection between the ranch house and carriage house, conservation of earthen and lime plasters and finishes, and replacement of the roof covering. Project organization has been used to advance preservation and training goals.

## INTRODUCTION

The Las Flores Adobe National Historic Landmark, constructed in 1868, has been seismically and structurally stabilized over a three year program. The buildings and site reflect a cumulative 2000-year cultural history. Located in southern California (USA), within the jurisdiction of Camp Pendleton Marine Corps Base, Las Flores represents one of a few authentic nineteenth-century two-story adobes combining Hacienda and Monterey styles unique to California. The buildings are constructed of adobe brick and are surfaced with a combination of earthen- and lime-based finishes. Since the 1970s, the unused buildings have fallen into disrepair. The National Park Service (NPS) is managing the phased stabilization project and has assembled a multidisciplinary team to participate.

Beginning in year 2000, team partners (including NPS historic preservation specialists, private sector architectural and engineering professionals specialized in California building codes and the seismic retrofit of adobe buildings, and staff from the University of Vermont Graduate Program in Historic Preservation) conducted condition surveys,

documentation, and project planning and design. The ranch house was the subject of a major stabilization campaign in 2002/2003; preservation work included floor foundation restructuring, installation of seismic retrofit systems, timber repair, protective lime plaster application, ventilation of the building, restoration of the roof, drainage improvements, vegetation removal, and hazard remediation.

The site is located in seismic zone 4 and seismic stabilization of the buildings has been one of the principal objectives of the project. Until very recently, retrofitting adobe buildings for seismic stability routinely involved installation of invasive concrete bond beam assemblies, requiring major demolition of historic fabric. At Las Flores, the team has installed minimally invasive systems utilizing rods, steel strapping, grouted pins, and plywood sheer panels, all of which impart the stability required by the California State Historic Building Code. This technology, developed in research programs supported by the Getty Conservation Institute during the 1990s, has only recently been field-implemented.

During the 2004 season, the team implemented the seismic and structural stabilization of the carriage house. Repairs were conducted as a field school project, so that the crew performing the repair work was made up of graduate interns from UVM and the skilled craftspeople hired as their instructors. The scope of work included installation of a seismic retrofit system, replacement of concrete wall infills with adobe repairs, partial removal of a concrete *contra pared*, reinstatement of the connection between the ranch house and carriage house, framing repairs, replacement of the roof covering, and repair and conservation of earthen and lime plasters and finishes. During the project, the team developed some low-tech methods for using modified earthen grouts in the seismic retrofit system. Earthen grouts are more compatible with historic wall materials than cementitious and resin-based grouts, and may offer increased reversibility as well as re-treatment options not available with harder grouts.

## HISTORY AND SIGNIFICANCE

The Las Flores site, including the ranch house, nearby ruins, and the remaining open landscape surrounding the complex offer a microcosm of California history in one compact and largely undisturbed microenvironment. The military presence has not negatively impacted the site, and in contrast to the surrounding communities where development obliterated any historical context of the landscape, this property is unique.

Archaeological and historical records at Las Flores indicate nearly 2000 years of occupation by Native American tribes in the vicinity of the ranch house. The first European colonization of California by Franciscan missionaries occurred in the eighteenth century; in 1798 the pueblo at Las Flores was included in the Mission San Luis Rey system. When Mexico gained its independence from Spain in 1834, the mission system was secularized and Las Flores was made a free pueblo. The Pico family, who owned the adjacent Santa Margarita ranch, bought Las Flores from the natives in 1844. Pio Pico went on to become the last Mexican Governor of California.



In this 1913 image, painted by E.S. Fenyes, the ranch house and outbuildings at Las Flores are depicted as they appeared before the 1916 flood and subsequent remodeling project. In the image, the Monterey block is the two-story section appearing on the right; the Hacienda block is the long, single-story portion connecting the Monterey block on the right and the Carriage House on the left. Of the many buildings in this image, only the ranch house and carriage house survive.

The frontier, closed under Spanish dominion, was opened under Mexican control, allowing trade, commerce, and travel to and from the United States. An influx of American and British settlers began to influence the culture, and the Mexican War of 1846–48 resulted in the transfer of sovereignty of California to the United States. During these tumultuous years, the ranch remained an intact land grant known as *Rancho Santa Margarita y Las Flores*. By 1868, Pico's heir, John Forster constructed an adobe house at the Las Flores site for his son as a wedding gift.

The latter part of the nineteenth century saw a shift away from old-style ranching with large cattle herds and the Spanish *padrone* lifestyle to smaller farming operations and fenced properties. In 1888, twenty years after construction of the ranch house, the property passed out of the Pico/Forster family to new owners who in turn engaged the Magee family to live at and manage Las Flores. The Magees converted the cattle ranch operation into a large lima bean farm, which they maintained from the early 1900s until mid-century. In 1941, the Santa Margarita Ranch was absorbed into the new Camp Pendleton Marine Corps Base. The Magees were given lifetime occupancy and continued at the ranch until the last family member died in 1968, at which time the Marine Corps assumed management of the property.

By 1968, the ranch house and surrounding buildings were in an advanced state of disrepair. Demolition of many of the farm structures occurred when the viability of the farm declined. Public intervention saved the house and had it placed on the National Register of Historic Places and proclaimed a National Landmark. The Marine Corps, seeking a tenant to help maintain the property, leased it to the Boy Scouts of America (BSA) in 1974. The BSA was unable to arrest the deterioration and by the 1990s, the house was boarded up and closed for safety reasons.

In 1999, the Marine Corps contacted the NPS for the purpose of preserving the ranch house. A series of planning meetings were held from which emerged a multi-disciplinary team consisting of a Corps representative, a historic architect, an engineer with a specialty in seismic protection of adobe buildings, an architectural conservator, and staff from the UVM Graduate Program in Historic Preservation. At certain key points in planning, the California State Historic Preservation Officer was included in the review of program and design.

### PRESTABILIZATION CONDITIONS

The Las Flores Adobe is an historic adobe ranch house complex consisting of three fairly distinct blocks. The most prominent component, the Monterey block, is a two-story, one-room-deep, hipped-roof structure, laid out around a central hallway or *zaguan*. Original high style porches on the front and rear have been replaced by a porch that wraps around the entirety of the block. Original fenestration has been altered to accommodate plan changes and the addition of rooms.

Joining the main block on the north side and at right angles is a long, single-story ell, known as the Hacienda block. The low, gable-roofed structure is one room deep and features a continuous shed-roof *corredor*, and all but one of the rooms in the Hacienda block has a door opening directly onto the *corredor*. A gable-roofed carriage barn is located at the north end of the Hacienda block, oriented parallel to the Monterey block so that the three buildings together form three sides of a rectangle. An early hedgerow on the east side of the property completed the enclosure of a courtyard.

The carriage house was changed extensively during a 1974 remodeling project conducted by the Boy Scouts of America. The roof covering and structure were removed completely, as were shed additions to the north and east and the large doors located on the west end of the building. A concrete bond beam was added to the adobe walls, increasing their height by some eight inches. The roof was reframed, using modern materials; the roof pitch was altered in the process. During the course of these changes the roof connection between the two buildings was eliminated and a substantial portion of the south wall was left exposed to weather. A concrete *contra pared*, or skirting wall was added against foundation stonework and the lowest courses of adobe on the building perimeter, and a concrete floor was poured on the interior. Interior and exterior walls were covered with a hard, relatively impermeable Portland cement plaster.



Prior to the 2004 repair project, the carriage house required replacement of an asphalt roof covering, repair of concrete infills in the south wall (visible near the center of the photo), reinstatement of a connection between Hacienda block and carriage house, installation of a seismic retrofit system, repair of decayed woodwork, and conservation and repair of earthen and lime plasters and finishes.

Graduate student interns enrolled in the Historic Preservation Program at the University of Vermont began documentation of the carriage house during the 2003 season, and in a supervised project at UVM, graduate students began analyzing and organizing field survey data. Preliminary survey results suggested that:

- The bond beam was in good condition and appeared to have steel reinforcement that is axially oriented and continuous along the length of the entire beam;
- The roof framing and substructure were in good condition except for a few rotted rafter ends on the south side of the carriage house portal;
- While the adobe wall materials appeared to be dry, several areas of the adobe were in very poor condition. During initial sampling, the crew encountered several voids, and in some areas hard cement infills were discovered behind the plaster. As part of a 1974 repair campaign, a large void along the south wall was infilled with concrete and concrete block. Vertical cracks in the southeast corner suggested settlement in the area;
- Cement plaster on interior and exterior walls was in generally good condition (except where cracks had occurred in the southeast corner and where plaster had been removed along the south wall to expose the concrete repair).

## DESIGN AND CONSERVATION APPROACH

The team established design criteria and performance expectations. Because a specific end use is only partly determined, a limited and restrained preservation agenda was adopted. The carriage house is a contributing structure in the National Historic Landmark complex at Las Flores, despite substantial changes made to the building in the 1970s. This is principally due to surviving early adobe fabric and the placement of the building in the complex, forming one side of an historic courtyard. The main objective of the stabilization was to preserve the building and all the values inherent in the structure that reflect the National Landmark nomination.

Project goals were based on pragmatic adaptive re-use of the structure. The USMC determined that the carriage house is to function in a utilitarian capacity, supporting programs housed in the ranch house, so that some flexibility with respect to interior finish and location of mechanical equipment may ultimately be desirable. Philosophically, the team and management chose a course accepting the 1970s alterations generally, making improvements where it was necessary to protect wall materials exposed to weather and to re-establish a connection between the ranch house and carriage house. Because of changes in the elevation and pitch of the carriage house roof, it was understood that the connection between the buildings would not replicate the original configuration. Instead, the team decided to extend the house roof to the carriage house to the extent required to weather-protect the walkway between the buildings. Because of the change in elevation effected in 1974, the roof extension would abut the wall rather than the eave of the carriage house, and would differ in pitch and elevation from the south portal.

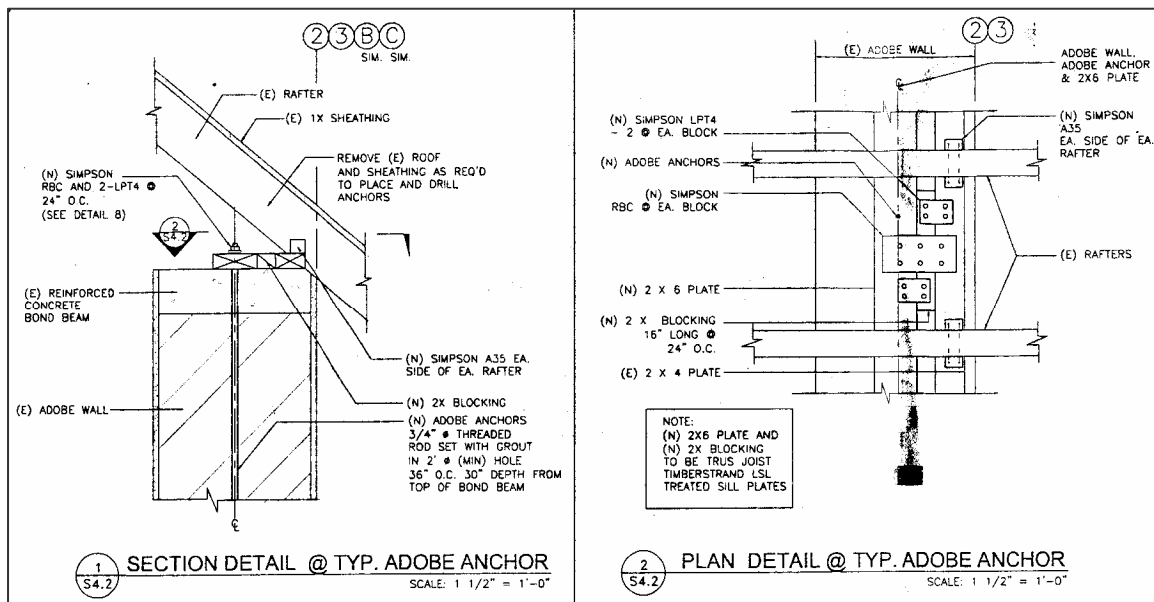
Prior to adopting this approach, the team considered restoration of the carriage house roof to the configuration depicted in available historic photographs. Restoration, however, would entail reinstatement of shed additions and a large wing on the east side. To date, the team has not discovered adequate documentation to support this sort of thorough-going restoration, and rejected partial restoration of some of the roof structure as overly conjectural. As a result, the project emphasized conservation of remaining adobe wall materials, foundation stonework, and early plasters; restoration was limited to elements essential to meet preservation and stabilization goals. This approach maximized retention of historic fabric and will not preclude restoration of the building in the future.

Specific tasks included in the scope of work were:

- Structural and seismic stabilization;
- Conservation of adobe wall materials, including the replacement of deleterious cement-based interior and exterior plasters with earthen and lime based finishes;
- Removal of the concrete *contra pared* skirting the building;
- Framing of the connection between the north end of the house and the carriage house;
- Retention of the c.1970 roof and portal frames and decks;
- Replacement of the current roof covering with cedar shingles.

With respect to building performance during and following a seismic event, the objective was to ensure the life safety of the building occupants, while recognizing that damage to the building will occur. The performance standards for the structural design included the Uniform Code for Building Conservation for lateral design of unreinforced masonry buildings, and the research findings and guidelines of the Getty Seismic Adobe Project (GSAP).<sup>1</sup> Since a substantial bond beam had already been installed, the design would need to address the unknown connection of the bond beam to the adobe wall. Surprisingly, sometimes bond beams have been installed without significant connection to the supporting walls, so that in seismic events this area can be subject to separation and potentially dangerous dislocation. The carriage house seemed to be a case in point.

GSAP shake table testing showed that for buildings with low slenderness ratios (5:1 and below), like the carriage house, overturning of walls can typically be prevented by anchoring the walls to roof framing. The principal elements of the seismic retrofit system for the carriage house are the bond beam, the connections at the top of the walls, and a tie rod placed in the wood-framed west wall connecting the ends of the bond beam. The connection of the bond beam to the adobe wall serves to: 1) provide out-of-plane support for the top of an adobe wall to prevent overturning; 2) provide tensile capacity along the length of a wall to resist displacement of separated wall sections following cracking.



The seismic retrofit system designed for this building included a series of stainless steel anchors, set in earthen grout, pinning the existing bond beam and a new wooden plate to the adobe walls. Using commercially available metal clips, existing roof framing was tied to the new wooden plate.

Anchorage of the bond beam to the adobe walls is accomplished by installation of a series of steel or fiberglass anchors through the bond beam and into the center of the adobe courses at the top of the wall. To maximize anchorage capacity, anchors should be spaced no closer together than one and one half to two times the thickness of the walls. The roof framing was to be tied to this anchorage system using a wooden plate and steel clips. Because the bond beam was discontinuous through the framed west wall of the

carriage house, it was necessary to install a steel tie rod connecting the ends of the bond beam on the north and south sides.

## IMPLEMENTATION

Work began at the site in May 2004 under the auspices of a joint National Park Service and University sponsored training program. The program included NPS and UVM staff, interns from the UVM Graduate Program in Historic Preservation, recent graduates seeking advanced training in architectural conservation and traditional crafts skills, selected volunteers, and skilled craftspeople serving as instructors. Interns, graduates, and volunteers represented several different skill levels; the ratio of skilled craftspeople to relatively unskilled crew was about 1:1 for most of the time spent onsite.

The crew began by removing the existing roof covering and a portion of the deck; deck materials were salvaged for reinstallation. Removing the roof and deck permitted access to the tops of the walls for installation of the seismic retrofit system. The system consisted of a series of threaded rods that pass vertically through a continuous wooden plate, through the bond beam, and into the adobe wall below. A series of holes, two and one quarter inches in diameter, were bored to a depth of approximately thirty six inches using light coring bits; holes were bored through the concrete bond beam and into the adobe using non-vibratory drilling equipment. Stainless steel threaded rods were used as anchors. The steel selected contains molybdenum for increased corrosion resistance to chlorides and sulfides.

Rods were fixed in place using a soil-cement grout. In the past, retrofit systems have been installed using cementitious or resin-based grouts, but these grouts are much stronger and harder than the adobe materials in which they are installed. Earthen grouts are more compatible with historic adobe materials and offer greater potential for reversibility; systems installed with earthen grouts may also be easier to repair following a seismic event. The grout mix chosen for installing the carriage house system was similar to one developed and tested for use in the repair of the Pio Pico Adobe in Whittier, California, and contained adobe soil, sand, Portland cement, and a grout additive to minimize shrinking during curing.

Low-tech methods were developed for placing the grout. An adobe test wall was constructed and placement methods were developed and practiced until placement could be effected smoothly, yielding a consistent result. A placement device was made by attaching a grout bag to a length of plastic pipe. The pipe allowed placement to begin at the bottom of the holes, preventing voids due to trapped air bubbles. The method for placement involved filling the device with grout and twisting off the bag to prevent loss of material when transferring the grout to the hole to be filled. Holes were pre-wetted with a 1:1 mix of denatured alcohol and water to retard absorption of the mix water by the wall materials. Grout was placed in a pre-wetted hole by squeezing the grout bag and simultaneously withdrawing the pipe from the hole. Once the hole was filled to within two inches of the top, the threaded anchor was inserted.

A new wooden plate was installed around the building perimeter on top of the concrete bond beam fastened down with the threaded anchors and stainless steel nuts and washers. Using commercially available metal clips, the existing roof structure was fastened to the new wooden plate, effectively tying the roof structure to the walls. Because the west wall of the carriage house is of wood-frame construction, a reinforced concrete bond beam was not installed along this wall during the 1974 remodeling project conducted by BSA. To tie the north and south bond beams together, the UVM crew installed a steel tie rod in the wall cavity; the rod is fastened to commercially available clips anchored to the ends of the bond beam at the northwest and southwest corners of the building.



After removing concrete infills, the crew made repairs using adobe bricks. New adobes were carefully “laced” into existing work for maximum wall stability.

Adobe wall materials were surveyed by boring holes laid out on a grid on the interior walls and retrieving samples from near the center of the wall thickness. Samples were examined with respect to moisture content, strength, and cohesion of the wall materials. Conditions varied widely. Over approximately 80% of the wall area, the adobe condition was good. Despite the presence of a concrete *contra pared*, wall materials along the lowest courses were relatively dry. The team discovered several small voids in the walls, due primarily to cracking and burrowing rodents; these were filled with earthen grout.

Adobe conditions were poorest on the south wall, in the vicinity of a large concrete infill. Here, exposure to weather as a result of removal of the historic connection between the buildings coupled with the addition of the *contra pared* had resulted in basal erosion of the adobe. Minimal connection between the two wythes of the adobe wall had been disrupted by erosion and several repair campaigns. In order to restore structural integrity and material continuity, the large concrete infill was removed. Disgregated and crumbling adobe was removed, though the team was able to preserve most of the historic materials, including much of the adobe wall located below the infill and subjected to the greatest deterioration. The concrete infill was replaced with adobe. The new infill was carefully “laced” into historic materials and header courses were installed to prevent separation of the two wythes that make up the 20-inch thick walls. Adobe infill materials were covered with earthen or lime plaster (depending on weather exposure) and then limewashed. In the process, it was possible to conserve some of the historic plaster and limewash finishes.



Following adobe repairs, traditional plasters and finishes were reinstated. Here, crew members are applying an earthen plaster; large areas of conserved plaster and limewash finish are visible to the right of the scaffolding.

Decayed roof and portal frame elements were repaired using dutchman splices, or were replaced in kind. In some instances, replacement members of slightly larger dimension were installed to improve structural performance. New wood was treated with Boracare©

(a Boron salt-based product in an ethylene glycol vehicle), an environmentally safe biocide. A failed window lintel on the south wall of the carriage house was replaced. A series of wooden posts installed in the south wall, flush with historic plaster finishes, may have had a structural function associated with an earlier use of the barn. These were repaired or replaced, depending on the level of deterioration. The historic post at the southwest corner of the carriage house was used to support some of the new framing associated with the connector between the ranch house and carriage house; this post was dowelled to the adobe wall using epoxy and fiberglass rods.



A new connection between the ranch house and carriage house was framed. New work was spliced into historic material on the ranch house side (left side of photo). Because a bond beam was added to the carriage house in 1974, the connection at the carriage house was made below the eave. The connection to the carriage house was made with a series of stainless steel straps (photo, right center) to permit independent movement of the buildings during a seismic event.

A new connection between the carriage barn and the hacienda block of the house was constructed to replace work lost in the 1974 repair project. Because of changes made to walls and roof in 1974, it was not feasible to reinstate the connection as it was previously constructed. Instead, the connection was adapted to new wall heights and rooflines. The portal on the south wall of the carriage barn was extended to connect with new work, so that the south wall is now protected from weather along its entire length. New woodwork was attached to the carriage house using flexible stainless steel hangers that will permit independent movement of the two buildings in an earthquake.

The carriage barn and portal roofs were covered in fire retardant treated cedar shingles fastened with stainless steel nails, to match the roof covering on the house. Where the shingles were installed over a solid deck, Cedar Breather© (a patented three dimensional nylon matrix placed to create an engineered space between roof covering and deck) was installed to facilitate ventilation of the underside of the shingles. By matching materials and exposure to the roof covering on the ranch house, changes in roof pitch and elevation along the south wall were muted.



The plywood deck is an element introduced during the 1974 repair project, and was retained in the latest project partly because it enables the roof to function as a diaphragm, adding stability at the tops of the adobe walls. A nylon matrix was installed over the deck to promote circulation of air under the shingles. New shingles were carefully integrated into existing work where the two buildings were joined.

In the time allotted for this project, the crew was not able to address every issue associated with building envelope elements. Except for repairs made to the south wall, cementitious plasters were not removed from interior and exterior walls; ultimately they will be replaced with softer earthen and lime plasters. All of the windows and doors in the carriage house are in need of conservation. Survey work was completed during the 2004 project and recommendations for repairs are being prepared. In the interim, non-functioning windows have been replaced with temporary ventilation panels. The concrete

*contra pared* installed at the base of each adobe wall has contributed to erosion of wall materials in the lowest courses, particularly on the south facade where adobes were covered with an earthen plaster. A method for removing the *contra pared*, using Bristar© (a silicate product used for demolition of concrete; when mixed with water, Bristar exerts enormous expansive forces) was field tested during the 2004 work and will be implemented in a future project.

The schedule did permit some conservation of interior plasters and finishes in the ranch house, and the UVM crew devoted some time to developing conservation strategies, based on differing levels of deterioration. Three rooms in the Monterey block were selected for conservation. Surviving plasters were cleaned, using the gentlest means possible. Wholesale plaster losses were replaced in kind. Smaller cracks and lacunae were filled with a lime-sand putty. Where existing limewash finishes were in fair to good condition, or where it was important to preserve “ghosts” in existing finishes that were important clues to the construction chronology, finishes were carefully touched up using artist brushes and small sponges. Where there was wholesale detachment of limewash finishes, samples were collected for purposes of documentation, loose material was removed from the wall, and new layers of limewash were applied. In some areas, it was necessary to remove a recent layer of acrylic paint before applying limewash; removal was accomplished by both mechanical and chemical means.

#### TRAINING OBJECTIVES

In addition to meeting all high priority construction goals, the carriage house stabilization project produced training opportunities for the students and volunteers involved. Typically, the crew consisted of roughly equal numbers of accomplished trades people and trainees representing several skill levels. By pairing trainees with skilled craftspeople, trainees received instruction while a high level of workmanship was maintained. During the course of the research project conducted at UVM and the seven weeks that the crew spent onsite, three student interns and two volunteers were trained, and six recent graduates of the Historic Preservation Program at UVM were afforded the opportunity to participate in advanced conservation training. Training goals were to develop skills in the following activities: adobe restoration, earthen plastering, lime plastering, limewashing adobe and/or lime plaster, conservation of existing lime washed surfaces, wood shingling, and exposure to the seismic retrofit technology.

The 2004 carriage house stabilization project marked the third year that NPS and UVM have collaborated in field school projects at Las Flores. During that time period, more than twenty-five interns, recent graduates, and project volunteers have received invaluable training in architectural conservation and traditional trades practice. In several cases, graduates have gone on to find employment in field work positions. In addition, staff from NPS and UVM have improved their conservation skills as a result of cross-mentoring opportunities created by the projects.



During the course of this project, new technologies were implemented, graduate students and staff received training in traditional crafts and conservation skills, and an important resource was conserved.

## CONCLUSION

Projects such as these that include research, training, and field pilot treatment components are prime candidates for developing cooperative programs between government agencies and educational institutions. Essential to the process is a close and well-developed understanding between the principle parties. It is also essential that the institutions get rewards for their involvement. Bricks and mortar work gets accomplished. Students satisfy graduate-level program requirements as well as gain work experience on the job. Recruitment opportunities then become available with the National Park Service.

Additional benefits come in the form of advancing research agendas necessary for responsible heritage management. The field projects often provide specialized model or experimental treatments in the field. The cooperative agreement model is one in which both parties play substantive roles all the way through the process. The Las Flores case study is a prime example of this capacity building through cooperation.

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<sup>1</sup>The Getty Conservation Institute is a program of J. Paul Getty Trust in Los Angeles that works internationally to advance the field of conservation through scientific research, field projects, education, and dissemination of information. GSAP (a 10-year study) began in 1990, and culminated with design guidelines released in 2003 (Tolles et al, 2002). The research included a survey of common techniques currently used by adobe design professionals, past practices, current codes, a survey of historic adobe buildings in the southwestern United States, and a summary of current design methodologies for the retrofit of adobe buildings. Most current retrofit practices were based upon a strength-based approach combined with static design forces. Instead, GSAP research focused on a stability-based approach coupled with dynamic force input.

## REFERENCES

Barrow, John M., 2004, Project files of Las Flores Stabilization, on file at National Park Service, Intermountain Region-Santa Fe, New Mexico.

*California Code for Building Conservation*, 1998, California Building Standards Commission, Sacramento, California, USA.

*California Historical Building Code*, 1998, California Building Standards Commission, Sacramento, California, USA.

Houben, Hugo & Guillaud, Hubert, 1994, *Earth Construction—A Comprehensive Guide*, CRATerre-EAG, Intermediate Technology Publications, Southampton Row, London, UK.

Mortier, Mark L., 2001, *Conditions Assessment and Stabilization Recommendations for the Las Flores Adobe National Historic Landmark*, unpublished report, National Park Service, Intermountain Region-Santa Fe, New Mexico, USA

Postprints Terra 2000, 8th International Conference on the Study and Conservation of Earthen Architecture, 2002, English Heritage, James & James, London, UK

6th International Conference on Conservation of Earthen Architecture, Adobe 90 Preprints, 1990, Getty Conservation Institute, Los Angeles, California, USA.

Tolles, E. Leroy & Kimbro, Edna E. & Ginell, William S.; 2002, *Planning and Engineering Guidelines for the Seismic Retrofitting of Historic Adobe Structures*, *Getty Conservation Institute Scientific Report Series*, Los Angeles, California, USA.

Tolles, E. Leroy & Kimbro, Edna E. & Webster, Frederick A. & Ginell, William S.; 2000, *Seismic Stabilization of Historic Structures*, *Getty Conservation Institute Scientific Report Series*, Los Angeles, California, USA.

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Tolles, E. Leroy & Webster, Frederick A. & Crosby, Anthony & Kimbro, Edna E., 1996, Survey of Damage to Adobe Buildings after the January 1994 Northridge Earthquake, *Getty Conservation Institute Scientific Report Series*, Los Angeles, California, USA.