The Getty Conservation Institute

Survey of Damage to Historic Adobe Buildings After the January 1994 Northridge Earthquake

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GCI Scientific Program Report 1996

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Foreword

Adobe has a very significant place in the vast array of materials used for the construction of buildings. Historic buildings made of adobe can be found in almost all the regions of the world. The same could be said of earthquakes. Among the many hazards to which the cultural heritage is subject today, earthquakes because of their unpredictable magnitude and devastating results are among the most threatening.

The Getty Conservation Institute has been involved for several years in the study of adobe and the mechanisms for its protection. Given the significant numbers of historic buildings made of adobe that exist in the area, the Northridge earthquake in California in 1994 provided a unique opportunity, close to home, to further the research in this area of long-standing interest.

Following the approach used in its research and other activities, the Institute invited a multidisciplinary team of experts to undertake an assessment of the type and extent of the damage suffered by these buildings as a consequence of the earthquake. The information gathered in the survey and its analysis provide a solid basis for comparison between shake-table simulations with models and real-scale damage. Their correlation allows for a better understanding of the effectiveness of retrofitting historic adobe structures.

William S. Ginell of the Getty Conservation Institute brought together the team of experts—authors E. Leroy Tolles, Frederick A. Webster, Anthony Crosby, and Edna E. Kimbro—and provided his unstinting support to their significant efforts and deliberations.

The GCI Scientific Program Reports series contains the results of the most current research being conducted at the Institute. Our intention is to make public the efforts of the research to a wide audience as soon as it becomes available. We hope to contribute in this manner to the protection and preservation of our cultural heritage in ways that make the application of this research accessible and relevant to the needs of the conservation profession and its related fields. Our readers can contribute significantly to our efforts with their comments and suggestions, which we welcome.

This book has been desktop published. Dinah Berland coordinated its publication with grace and patience, Anita Keys was her usual efficient self in the copy editing, Paul Ushijima and Alyson Dalgity developed the electronic publication, Helen Mauchi did the production coordination, and the new cover for this series was designed by Garland Kirkpatrick. To all of them we are grateful.

Miguel Angel Corzo
Director, The Getty Conservation Institute

Preface

California's periodic and often destructive earthquakes are grim reminders that many historic and culturally significant buildings pose substantial risks to the life and safety of their occupants. In addition, the loss or damage to our Early American, Spanish colonial heritage in the form of irreplaceable historical fabric, architectural details, objects, and decorations increases with each new earthquake. In particular, California's historic adobe structures, which include missions and secular buildings, have been subjected to devastating earthquakes. Even after rebuilding or repair, a number of these structures have retained much of their authenticity and still carry the scars that demonstrate their toughness and survivability.

Although a good deal is now known about the behavior of some unreinforced masonry buildings during earthquakes, very little was known until recently about the factors that determine how adobe buildings respond to seismic forces. In 1990, the Getty Conservation Institute undertook a research project to study methods for retrofitting historic adobe structures—minimally intrusive methods that would be consistent with maintaining the architectural, historic, and cultural values of the buildings. Since that time, the Getty Seismic Adobe Project (GSAP) has carried out earthquake simulation tests on model adobe buildings, both retrofitted and unmodified. In the process, it has accumulated a wealth of information on how adobe buildings respond to simulated earthquakes and how retrofitting can prevent the occurrence of catastrophic damage.

As in all research that involves simulation of the effects of natural processes on modeled test specimens, some element of doubt exists concerning the extrapolation of laboratory results to the real world. The occurrence of the Northridge Earthquake of January 1994, which measured 6.4 on the Richter scale, provided an unusual opportunity to study, at first hand, the effects of severe shaking on historic adobe buildings. As an extension of GSAP, project personnel, including seismic engineers, an historical architect, and a conservator/historian, surveyed nineteen adobe buildings in the affected area to determine the extent and type of earthquake-related damage. During the survey, observations were made on conditions existing prior to the earthquake, the presence of previous retrofitting, and actual structural details of the building—all factors that bear on the response of the building to seismic stress. This information, together with an analysis of the earthquake characteristics at each site and GSAP findings on failure modes from model studies, are correlated in this report and provide the basis for comparison between simulated and real effects and how effective retrofitting of historic adobe structures can be used to preserve what remains of our adobe architectural heritage.

Further work involving implementation of GSAP retrofitting concepts to actual adobe buildings is planned, but again, only after exposure to a real earthquake of major proportions can the success of the remedial measures be determined conclusively. This survey also serves as a benchmark that documents the conditions of a number of historic adobe buildings in the Los Angeles area, an accomplishment that should prove of value to historians, architects, and all those interested in early California culture.

William S. Ginell
Head, Monuments and Sites Conservation Research
Director, Getty Seismic Adobe Project
The Getty Conservation Institute

Acknowledgments

The survey team wishes to acknowledge the contributions of the following individuals who assisted in gaining access to the earthquake damaged adobe buildings, several of which were red-tagged Mr. and Mrs. Robert Lorenz of Rancho Camulos, Piru; Glen Thornhill of the Andres Pico Adobe, San Fernando; Carolyn Riggs of the Lopez Adobe, San Fernando; Ray Phillips and Phyllis Jones of the Leonis Adobe, Calabasas; Helen Nelson of Mission San Gabriel; Jeanne Ekstrom of the Pio Pico Adobe, Whittier; and Russel Kimura of the Los Encinos State Historic Park. The helpful assistance of these individuals was an essential part of the success of this survey.

We would also like to thank Ellen Peterson, who was so helpful in integrating the four authors' comments into this report; and Steve KeKoch, who prepared many of the drawings of the damaged adobe buildings. We would also like to thank Dinah Berland of the Publications department at the Getty Conservation Institute and consultants Anita Keys and Alison Dalgity for their editorial and formatting assistance.

The survey team would like to express special thanks to William S. Ginell and Neville Agnew of the Getty Conservation Institute for their contributions and encouragement. Bill Ginell accompanied the team in the site inspections that were held two weeks after the survey, assisted in formulating the plan for the formal survey conducted in June 1994, and was instrumental in gaining support for this work. Neville Agnew was especially understanding of the importance of this work and in encouraging the team to undertake this important project.

Chapter 1

Background Information

Introduction

The Northridge earthquake of January 17, 1994 resulted in tragic losses to a number of California's earliest existing structures: its historic adobe buildings. They suffered more damage from this earthquake than any other since the 1925 Santa Barbara earthquake. However, this earthquake also provided a rare opportunity for understanding and assessing the damage that can occur as a result of a large earthquake in a major metropolitan area.

Historic adobe buildings - Spanish colonial missions, Mexican rancho and pueblo adobe structures — are the only above-ground remains of the state's initial settlement by Spain and Mexico in the eighteenth and nineteenth centuries. They are invaluable reminders of a time past when California was sparsely populated by Native Americans, who, at the direction of the first Hispanic colonizers, constructed the majority of these buildings. Native American mission-trained adobe makers, masons, and carpenters continued to comprise the bulk of the labor force throughout the Hispanic era in California.

California's historic adobe buildings are the state's earliest and most vulnerable structures. They are subject to damage by the elements, perhaps most dramatically by earthquakes. Continued preservation of California's Hispanic-era adobe architecture represents a significant challenge given the severity and frequency of earthquakes in recent years and the susceptibility of unreinforced adobe masonry to earthquake damage.

A wide range of opinions exist concerning the performance of historic adobe buildings during large earthquakes. There are those who consistently underestimate the potential of earthquakes to damage historic adobe buildings because these structures are thought to have successfully stood the test of time. There are others who overestimate the hazards posed, believing that historic adobe buildings are weak and incapable of withstanding earthquakes under any circumstance. While adobe buildings are undeniably vulnerable to seismic events, some have survived major earthquakes, which points up the fact that their performance in earthquakes is not widely understood, nor is the dramatic effect of well-designed retrofit measures.

The Northridge earthquake of January 17,1994 had a Richter magnitude of 6.4 and a maximum local Modified Mercalli Intensity (MMI) of IX. It presents an opportunity to examine a significant number of such buildings affected to various degrees by severe ground shaking, to document actual damage in depth, and to dispel the myths about the historical performance of adobe buildings in earthquakes.

The intent of this study was to survey the damage to historic adobe buildings and make an informed evaluation of their seismic performance in order to better protect such buildings in the future. The study presents documentation of the damage and evaluation of the seismic performance of the subject buildings. The performance of the buildings observed and documented in the field represents the reality with which all other observations, from laboratory testing or whatever source, must be reconciled. The ultimate goal is to use the lessons learned from the Northridge earthquake and other retrofit research results to better safeguard historic adobe buildings from the effects of strong ground shaking.

Background

The Northridge earthquake historic adobe damage survey was commissioned by the Getty Conservation Institute (GCI), as part of its long-term commitment to researching conservation measures appropriate for these buildings. The Getty Conservation Institute provided survey funding in conjunction with its ongoing research project, the Getty Seismic Adobe Project (GSAP)

The Getty Seismic Adobe Project began in 1990 with the objective of developing effective seismic retrofit measures with a minimal and reversible effect upon historic fabric. The project includes laboratory research in which model buildings (both retrofitted and unretrofitted) are tested upon a seismic simulator. The results of this survey report will be utilized by GSAP to correlate and evaluate the results of that research. The GSAP final report is scheduled for availability during the second half of 1996.

A preliminary survey of historic adobe buildings damaged by the Northridge earthquake was conducted during February 2-4,1994. The survey was organized in response to a request for assistance received by the Getty Conservation Institute from the acting State Historic Preservation Officer, Steade Craigo. A multidisciplinary team of earthquake engineers, a historical architect, an architectural conservator/historian and a materials scientist, all experienced with earthen architecture, spent three days in the field. The team visited thirteen sites utilizing still photography for recording purposes.

At the end of this brief survey it was clear that a more thorough investigative and recording effort was merited, given the magnitude and number of severe losses encountered. Accordingly, an in-depth survey was proposed as a logical supplement to the Getty Seismic Adobe Project. This survey was conducted from June 12–16, 1994, and became the subject of this report.

Audience

This survey publication is intended to assist owners, building officials, and cultural resource managers of historic adobe buildings to understand the earthquake threat to such buildings and the necessity of taking considered action to limit it. The report is also provided for architects and engineers designing seismic retrofit strategies for historic adobe buildings as a context into which to place their projects. As the Executive Director of the Seismic Safety Commission, Tom Tobin, observed in the *Los Angeles Times* on March 13, 1994: “The earthquake-damaged building is the best lab we have... If the information is not brought forth, the rest of the community can’t learn from it.”

Goals

The primary goal of the survey was to document the damage to historic adobe buildings caused by the Northridge earthquake, including historic fabric affected and existing conditions such as deterioration or structural changes that might affect seismic performance. This report presents the highlights of that documentation.

A secondary goal was to analyze the seismic performance of the buildings by assessing the nature of the damage, its cause and severity, and the effects of preexisting conditions on performance. Such information is essential in order to develop a reasonable estimate of the true vulnerability of historic adobe buildings to large seismic events, based upon the reality offered by the Northridge earthquake damage. A third and related goal was to correlate the damage levels to the intensity of the ground shaking at each site.

Scope of Work

The challenge of improving the seismic performance of historic adobe buildings is to ensure adequate life safety while protecting historic fabric and cultural value. While there are those who view these as mutually exclusive objectives, recent GSAP research demonstrates that both may be achieved simultaneously. A key factor in designing such seismic retrofit strategies for historic buildings is an understanding of which physical conditions require mitigation or intervention and which do not. Important to making such distinctions is: (1) an understanding of the specific historical aspects that are at risk in earthquakes; and (2) identification of specific structural conditions that lead to heightened or lessened vulnerability. Within this context the following are the tasks specified in the scope of work for the survey.

Task One: Identifcation and Selection of Subject Adobe Buildings

Following the format established for the preliminary survey, the multidisciplinary team considered information about prospective new or previously unvisited sites and set priorities for site visitation. The team identified historic adobe buildings that were subject to strong ground motions during the Northridge earthquake as candidates for more thorough investigation. Selection was made based upon results of the earlier survey and reports of other earthquake damaged adobe buildings not previously surveyed. Historic buildings of a variety of sizes and footprints were selected for more intensive study, including some with preexisting seismic retrofit measures in place. Table 1.1 is a listing of all historic buildings surveyed. The bold-faced entries were selected for in-depth study.

Table 1.1. *Listing of all historic adobe buildings examined by the survey team or individual members of the survey team (listed alphabetically).*

Name	Location	Nat'l / State Register	Date(s) surveyed
Andres Pico Adobe	**Mission Hills**	**NR CA Ldmk**	**Feb. 2, 1994 June 13, 1994**
Centinela Adobe	Winchester	NR	June6, 1994
De la Osa Adobe	**Encino**	**NR**	**Feb. 2, 1994 June 16, 1994**
Leonis Adobe	**Calabasas**	**NR CA Ldmk**	**Feb. 3, 1994 June 14, 1994**
Lopez Adobe	**San Fernando**	**NR**	**Feb. 2, 1994 June 13, 1994**
Lopez-Lowther Adobe	**San Gabriel**	**NR**	**Feb. 4, 1994 June 15, 1994**
Miguel Blanco Adobe	San Marino	local designation	Feb. 4, 1994
Pio Pico Adobe	**Whittier**	**NR**	**Feb. 4, 1994 June 15, 1994**
Purcell House (Las Tunas Adobe)	San Gabriel	local designation	Feb. 2, 1994 June 14, 1994
Rancho Camulos	**Piru**	**CA Ldmk**	**Feb. 2, 1994 June 12, 1994**
Reyes Adobe	Agoura Hills	local designation	Feb. 3, 1994
Rocha Adobe (La Brea or Gilmore Adobe)	Park La Brea	local designation	June 6, 1994
San Fernando Mission Convento	Mission Hills	CA Ldmk	Feb. 3, 1994
San Gabriel Mission Convento	**San Gabriel**	**NR**	**Feb. 4, 1994 June 15, 1994**
San Rafael Adobe (Casa Adobe de San Rafael)	Glendale	NR CA Ldmk	June 6, 1994
Sepulveda Adobe	Calabasas	undesignated	Feb. 3, 1 994
Simi Adobe	Simi Valley	NR	Feb. 2, 1994
Verdugo Adobe	Glendale	CA Ldmk	Aug. 16, 1994
Vicente Sanchez Adobe	Los Angeles	local designation NR eligible	June 6, 1994

Bold-faced entries were selected for the detailed survey conducted from June 13-16, 1994.

Task Two: Documentation

Selected historic adobe buildings were documented with an emphasis on features and conditions that potentially affect seismic performance, including preexisting seismic retrofit measures. Documentation of existing conditions consisted of: (1) scaled black-and-white photography of interior and exterior walls of candidate structures: (2) video with narrative commentary; (3) drawings and annotations of existing drawings when available. Project personnel identified and photographed features thought to influence earthquake resistance of the structures and copied historical photographic documentation of preexisting damage where available. This documentation was used for comparison with documentation of preevent conditions and also serves as baseline data for future comparisons.

The immense volume of documentary material produced about certain buildings far exceeded the scope of this volume. All documentary materials require archiving in a suitable repository for use by future researchers of adobe earthquake performance and by designers or managers concerned with these particular buildings. This report includes the above materials as appropriate.

Task Three: Earthquake Characterization

Site and ground motion characteristics of the Northridge earthquake at the location of the selected adobe structures were estimated using available ground motion data provided by the California Division of Mines.

Task Four: Damage Characterization

For the most severely damaged buildings, the project team used perspective drawings of the buildings to plot the damage for interpretation and analysis. Scaled rectified photographic views of the long wall elevations were assembled for these buildings to assist in the comprehensive visualization of the damage and were used with field notes to plot crack patterns on the perspective drawings. The project team used videotape to record damage to historic fabric and character-defining features of the subject buildings. Historic American Building Survey (HABS) drawings were annotated to reflect such preexisting conditions as alterations to the buildings, deterioration, and the location and nature of earthquake damage. This information was used in preparing descriptions of the architecture and damage.

Report Organization

This report is divided into thirteen chapters. The first two provide background information on the survey, the earthquake, and the types of damage observed in the field. Chapter 3 is a summary of observed damage typologies and is critical to understanding the seismic performance of adobe buildings.

Chapters 4 through 11 present individual case studies of those buildings that were studied in depth. They are organized with historical background, followed by building and site descriptions, including preexisting conditions, estimates of local earthquake intensity, description of earthquake damage, and discussion of structural performance.

Chapter 12 is an overview of those adobe buildings that were briefly examined but not selected for in-depth study. Chapter 13 concludes with a summary of findings and general recommendations.

Chapter 2

The Northridge Earthquake: Characteristics and Measurement

Introduction

The Northridge earthquake of January 17,1994 was one of the most damaging earthquakes to strike the Los Angeles metropolitan area since it was first inhabited by Europeans. Recent seismic events such as the 1971 San Fernando earthquake, the 1987 Whittier earthquake, and the 1992 Landers earthquake caused considerably less damage. Extensive damage occurred in the San Fernando Valley, Santa Clara Valley, and Los Angeles Basin and adjoining areas, although injuries were confined mainly to the epicentral area.

This chapter presents a general overview of the Northridge earthquake and characteristics that are of importance to the overall pattern of damage to buildings and structures in general and to historic adobes in particular.

Characteristics of Earthquakes

Accurately describing the severity of the Northridge or any other earthquake is a difficult task. There are several scaled quantities used to describe earthquakes; the two most common are the Richter magnitude and the Modified Mercalli Intensity. However, for engineering purposes, strong-motion acceleration records are more useful in describing the ground motion at specific sites since forces in a structure are directly related to these accelerations. Duration is also an important characteristic; the longer the strong-motion duration, the greater the damage will be. Finally, geologic and soil conditions can amplify the ground motion, making buildings on soft soils more susceptible to earthquake damage than those on stiff soils or rock.

Richter magnitude

The most commonly used measure of earthquake severity is the Richter (or local) magnitude. The Richter magnitude, developed by Charles Richter in 1935 to describe the local magnitude (M_L) of Southern California earthquakes, is popular because it quantifies the size of an earthquake in a single number. It is defined on a logarithmic scale as the measurement of the maximum seismographic wave amplitude at 100 kilometers from the epicenter. Because the scale is logarithmic to the base 10, there is a factor of 10 difference in the wave amplitudes between units on the Richter scale. However, the amount of energy released during an earthquake increases by a factor of about 30 for each unit of increase on the Richter scale. For example, a magnitude M_L=7 earthquake releases about 30 times more energy than one with a magnitude M_L=6. It is difficult for humans to sense earthquakes with Richter magnitudes less than M_L=3, and the largest earthquakes recorded this century have been about M_L=8.9. Other common magnitude measures include the surface wave magnitude (M_S) for shallow earthquakes, and seismic moment (M_W) which accounts for the amount of fault slip, rock rigidity, and area of faulting.

The problem with the Richter magnitude, or any of these other magnitude measures, is that they describe the size of the earthquake in a single number but do not describe the variation in intensity of shaking at different sites. However, for engineers, this problem is overcome by using other measures such as the Modified Mercalli Intensity and strong-motion acceleration records that describe the local site intensities for a given earthquake.

Modified Mercalli Intensity scale

The Modified Mercalli Intensity (MMI) scale is a ground-motion intensity scale based upon human observations of human reaction and structural damage resulting from earthquake motions. The MMI scale ranges from I to XII. A brief description of each of these scale values is provided in Table 2.1. The MMI scale is used to give a human sensitivity to determining the severity of ground shaking in an area. Generally, the

Table 2.1. ***The Modified Mercalli Intensity scale.***

The severity of an earthquake is described by the Modified Mercalli Intensity scale, introduced in 1931 by American seismologists Harry Wood and Frank Neumann. They established twelve catagories of intensity. The following is a condensed version.

I. Not felt except by a very few under favorable circumstances.

II. Felt only by a few persons at rest, especially on the upper floors of buildings. Suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of office buildings, but not necessarily recognized as an earthquake. Standing cars may rock slightly. Vibration similar to that of a passing truck.

IV. If during the day, felt indoors by many, outdoors by few. If at night, few awakened. Dishes, windows, and doors rattle, walls creak. A sensation such as a heavy truck striking the building. Standing cars rock noticeably.

V. Felt by nearly everyone, many awakened. Some dishes and windows broken, some plaster cracked, unstable objects overturned. Disturbance to trees, poles, and other tall objects. Pendulum clocks may stop.

VI. Felt by all; many people run outdoors. Fallen plaster, minor chimney damage. Movement of moderately heavy furniture.

VII. Everyone runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings. Panel walls thrown out of frame structures. Chimneys, factory stacks, monuments, walls, and columns fall. Heavy furniture overturned and damaged. Changes in well water. Sand and mud ejected in small amounts. Persons driving in cars are disturbed.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great damage in substantial buildings, which suffer partial collapse. Buildings shifted off foundations, ground noticeably cracked, underground pipes broken.

X. Some well-built wooden structures destroyed, most masonry structures destroyed, foundations ruined, ground badly cracked. Rails bent. Considerable landslides from steep slopes and river banks. Water splashed over banks. Shifted sand and mud.

XI. Few, if any, masonry structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipes out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Total damage. Waves are seen on ground surface. Lines of sight and level are distorted. Objects thrown into the air.

Wood, H.O., and Frank Neumann, 1931. Modified Mercalli Intensity scale of 1931: ***Bulletin of the Seismological Society of America*, vol. 20, p. 277-83.**

ground-motion intensity is greatest near the epicentral region and diminishes at greater distances from the epicenter.

Because of its subjective nature, the MMI scale is difficult to translate into quantities that can be used by engineers for purposes of analyzing stresses or forces in individual buildings, although attempts have been made to correlate the MMI scale with maximum horizontal ground accelerations. A map of the earthquake area is shown in Figure 2.1 with areas of equal MMI values in different shades. Boundaries between the shaded areas are called isoseismal contours.

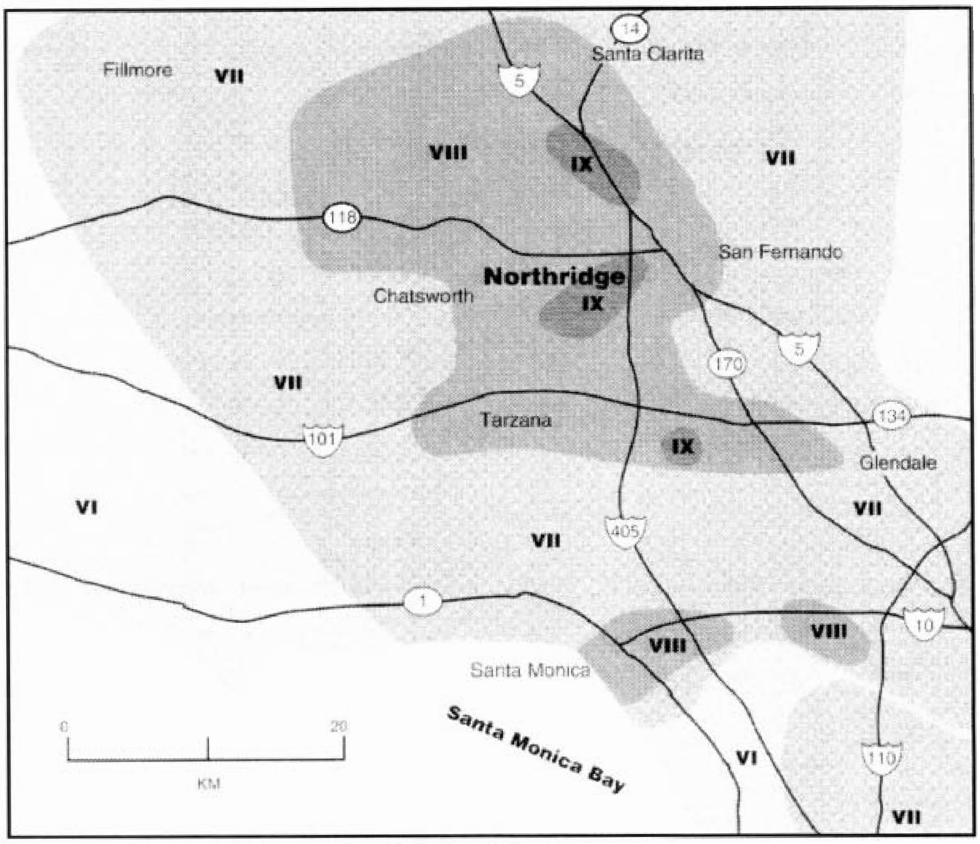


Figure 2.1. ***Map of earthquake intensity, scale I-XII (Source: The Continuing Challenge by the Seismic Advisory Board, 1994.)***

Strong-motion acceleration records

Strong-motion instrumentation is used to record the ground-motion accelerations at individual sites and in some cases the response of individual buildings. The Northridge earthquake was the most instrumented earthquake in history.

There are several different networks of strong-motion instrument arrays in the Southern California region. The California Department of Conservation, Division of Mines and Geology, obtained strong-motion records from 116 ground-response stations and 77 extensively instrumented structures that are part of their California Strong Motion Instrumentation Program (CSMIP). In addition, the University of Southern

California maintains a network of approximately 80 ground-response stations in the Los Angeles Basin. There are also a number of strong-motion instruments that are privately owned. Approximate locations of CSMIP strong-motion stations in the affected area are indicated on the maps in Figures 2.2 and 2.3.

Most strong-motion recording stations record three directions of acceleration as a function of time: two perpendicular horizontal and one vertical. Specification of the peak ground accelerations (PGAS), the maximum accelerations recorded in each of the three directions, is a common method of simplifying the description of ground-shaking severity at a given location. The set of PGA values at a site can be a good estimation of the intensity of motion at that location.

A contour map of maximum horizontal ground accelerations in terms of “g” values (lg=980 cm/sec2, or the acceleration due to gravity) is shown in Figure 2.4 and is based on the records of the CSMIP, USGS, and USC strong-motion recording stations. This map also shows the approximate surface projection of the fault rupture plane, which extends upward toward the northeast from the focal point. The fault rupture did not break the ground surface, so there was no surface trace.

The map shows that the strongest motions over large areas occurred near the epicenter and to the north, although there were smaller pockets of strong ground shaking in other locations such as Santa Monica. Records from a few localized sites with very high ground accelerations were also obtained but were not included in the development of the contour map so as not to distort the surrounding contours. In Tarzana, for example, record peak ground accelerations were 1.82g horizontal and 1.18g vertical with a duration of acceleration peaks of 1g or greater of over 8 seconds. These values are higher than any previously recorded ground-level strong-motion records. However, they are thought to be anomalous to the site conditions and not indicative of the surrounding area. Indeed, the values of the contours on the map should be taken as approximate because they are based on a limited set of recording stations that are scattered unevenly over the area and do not include local site effects.

Earthquake duration

The duration of strong motion also affects the amount of damage that occurs during an earthquake. Structural damage will continue to worsen as the duration increases. In addition, the longer the duration the greater the amplification of motion due to resonance of the soil and/or structure.

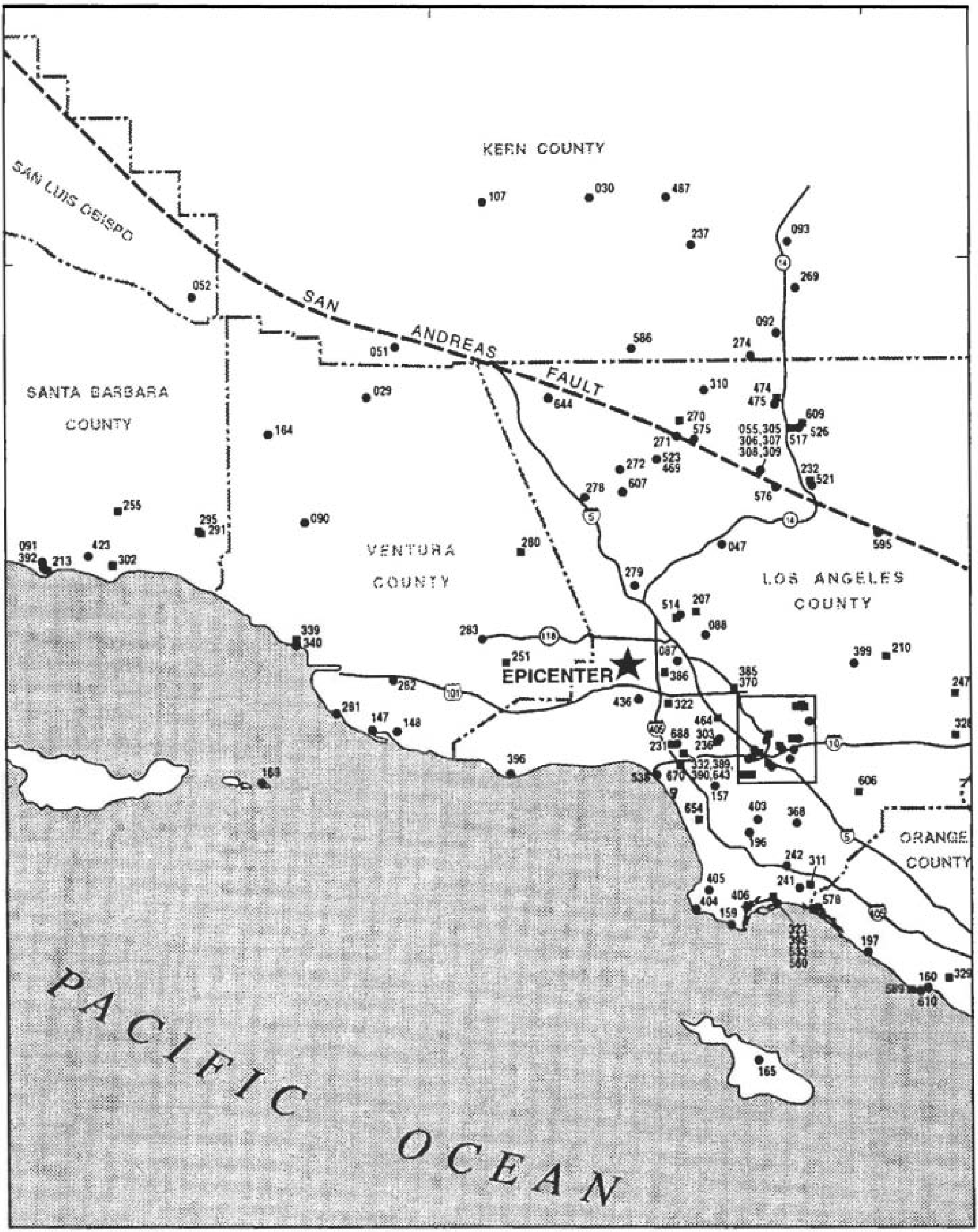


Figure 2.2. *Index map showing* CSMIP *stations that recorded the Northridge earthquake of January 17, 1994. The San Andreas Fault zone is shown for reference. The downtown Los Angeles area* CSMIP *stations are shown in more detail in Figure 2.3. (California Department of Conservation, 1994.)*

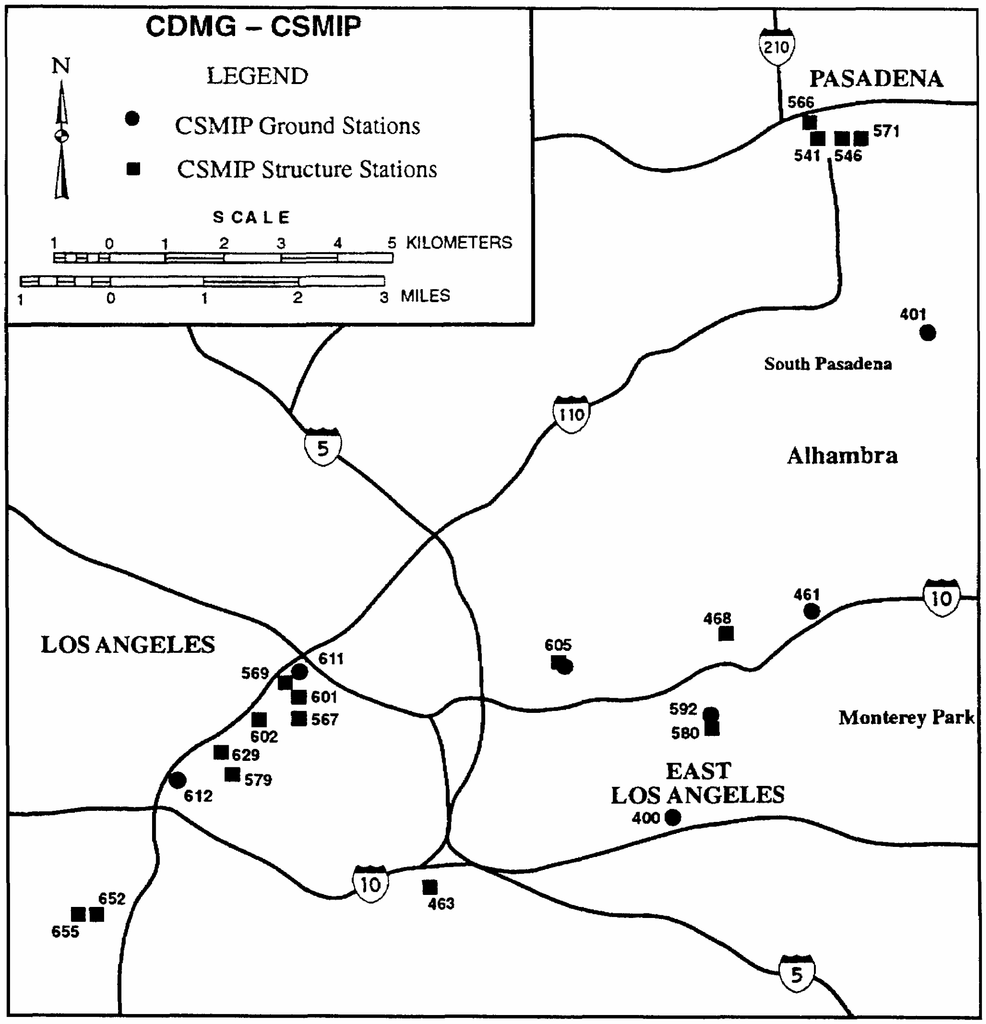


__Figure 2.3.__ Inset section of Figure 2.2 for downtown Los Angeles and Pasadena. (California Department of Conservation, 1994.)

Strong-motion duration is determined by that portion of the record which is greater than some specified amplitude, commonly taken as 0.05g. The recorded length of time in which the peaks are above this value is known as the bracketed duration. Generally, earthquakes with larger Richter magnitudes have longer bracketed durations. For example, earthquakes with a Richter magnitude $M_L=6$ produce strong motions that last anywhere from 5 to 15 seconds, while those with a Richter magnitude $M_L=7$ may last 15 to 30 seconds. The longer the duration at a given level of shaking, the greater the damage.

Local soil conditions

As in previous earthquakes, damage patterns indicate that surficial geology contributes significantly to severity of ground shaking and the resulting damage. Local soil conditions can amplify the motions of an earthquake. Sites with soft soils, such as alluvial deposits and unconsolidated sediments, are generally more hazardous than sites located on rock. The most severe damage is usually concentrated in areas with soft soil. A plot of red-tagged (unsafe) structures in the earthquake area as of April 1994 is shown superimposed on a generalized geologic map in Figure 2.5. As indicated on this map, many of the areas of concentrated damage are underlain by Holocene deposits and alluvial basins.

Description of the Northridge Earthquake

The Northridge earthquake had a Richter magnitude of M_L=6.4, a surface wave magnitude of M_S=6.8, and a seismic moment of M_W=6.7. The rupture initiated approximately 12 miles below the San Fernando Valley (a shallow earthquake) and propagated upward toward the northeast. The location of the epicenter was approximately 1 mile southwest of the community of Northridge and is indicated on the maps in Figures 2.2 through 2.5.

Although the local Richter magnitude of this earthquake was only M_L=6.4, the intensity of shaking in several areas was very strong. In the epicentral region, as well as one other area to the north, the maximum intensity on the Modified Mercalli scale was IX (see Figure 2.1). The duration of the strong motions was about 10 to 15 seconds and is comparable to the duration of the 1971 San Fernando event but significantly shorter than the 1992 Landers earthquake which lasted approximately 30 seconds.

Damage was concentrated in the epicentral region, as expected, but several other areas were hard hit as well, including Sherman Oaks and Encino, central Los Angeles just south of Highway 1-10, Santa Monica, and the Santa Clara Valley. Most of the historic adobes included in this survey were located in these soft-soil areas.

Estimate of Intensities at Historic Adobe Sites

Estimates of MMI and PGA at each of the historic adobe sites in the survey were determined based on the MMI contour map provided in Figure 2.1, individual strong-motion CSMIP recording station data, and the maximum ground acceleration map in Figure 2.4.

Table 2.2 lists the nineteen historic adobe buildings included in the survey and their locations, along with the closest CSMIP recording stations. For each station the PGAS in the three principal directions are given. Locations of the CSMIP stations are shown in Figures 2.2 and 2.3. The estimates of MMI and PGA at each of the historic adobe sites are listed in the last two columns of Table 2.2.

Table 2.2. *Local CSMIP recordings and estimates of PGA and MMI values at historic adobe sites.*

Name **Location**	**Closest recording station and PGA values (g)**				**PGA est.**	**MMI est.**
	Station(s)	**N-S**	**E-W**	**Vert.**		
Andres Pico Adobe	087 088 541	0.29 0.44 0.91	0.35 0.30 0.61	0.59 0.19 0.60	0.5g	VIII
Centinela Adobe	157	0.17	0.24	0.10	0.2g	VII-VIII
De la Osa Adobe	436 386 322	>1.06 0.41 0.46	1.82 0.47 0.24	1.18 0.30 0.18	0.4g	VIII
Leonis Adobe	251	0.22	0.21	0.17	0.3-0.4g	VII-VIII
Lopez Adobe	087 088 541	0.29 0.44 0.91	0.35 0.30 0.61	0.59 0.19 0.60	0.4-0.5g	VIII
Lopez-Lowther Adobe	401 461	0.16 0.09	0.12 0.12	0.09 0.07	0.2g	VI-VII
Miguel Blanco Adobe	401 571	0.16 0.16	0.12 0.19	0.09 0.12	0.1-0.2g	V1-VII
Pio Pico Adobe	606 368	0.18 0.23	0.11 0.17	0.10 0.14	0.1-0.2g	VI-VII
Purcell House (Las Tunas Adobe)	401 461	0.16 0.09	0.12 0.12	0.09 0.07	0.2g	VI-VII
Rancho Camulos	280	0.21	0.27	0.18	0.3-0.4g	VII-VIII
Reyes Adobe	251	0.22	0.21	0.17	0.2-0.3g	VI-VII
Rocha Adobe (La Brea or Gilmore Adobe)	303	0.41	0.24	0.19	0.3g	VII
San Fernando Mission Convento	087 088 541	0.29 0.44 0.91	0.35 0.30 0.61	0.59 0.19 0.60	0.5g	VIII
San Gabriel Mission	401 461	0.16 0.09	0.12 0.12	0.09 0.07	0.2g	VI-VII
San Rafael Adobe (Casa Adobe de San Rafael)	370	0.24	0.30	0.15	0.3-0.4g	VII
Sepulveda Adobe	396	0.10	0.13	0.10	0.2-0.3g	VII
Simi Adobe	251 283	0.22 0.30	0.21 0.19	0.17 0.15	0.4g	VII
Verdugo Adobe	370	0.24	0.30	0.15	0.3-0.4g	VI-VII
Vicente Sanchez Adobe	157	0.17	0.24	0.10	0.2-0.3g	VI-VII

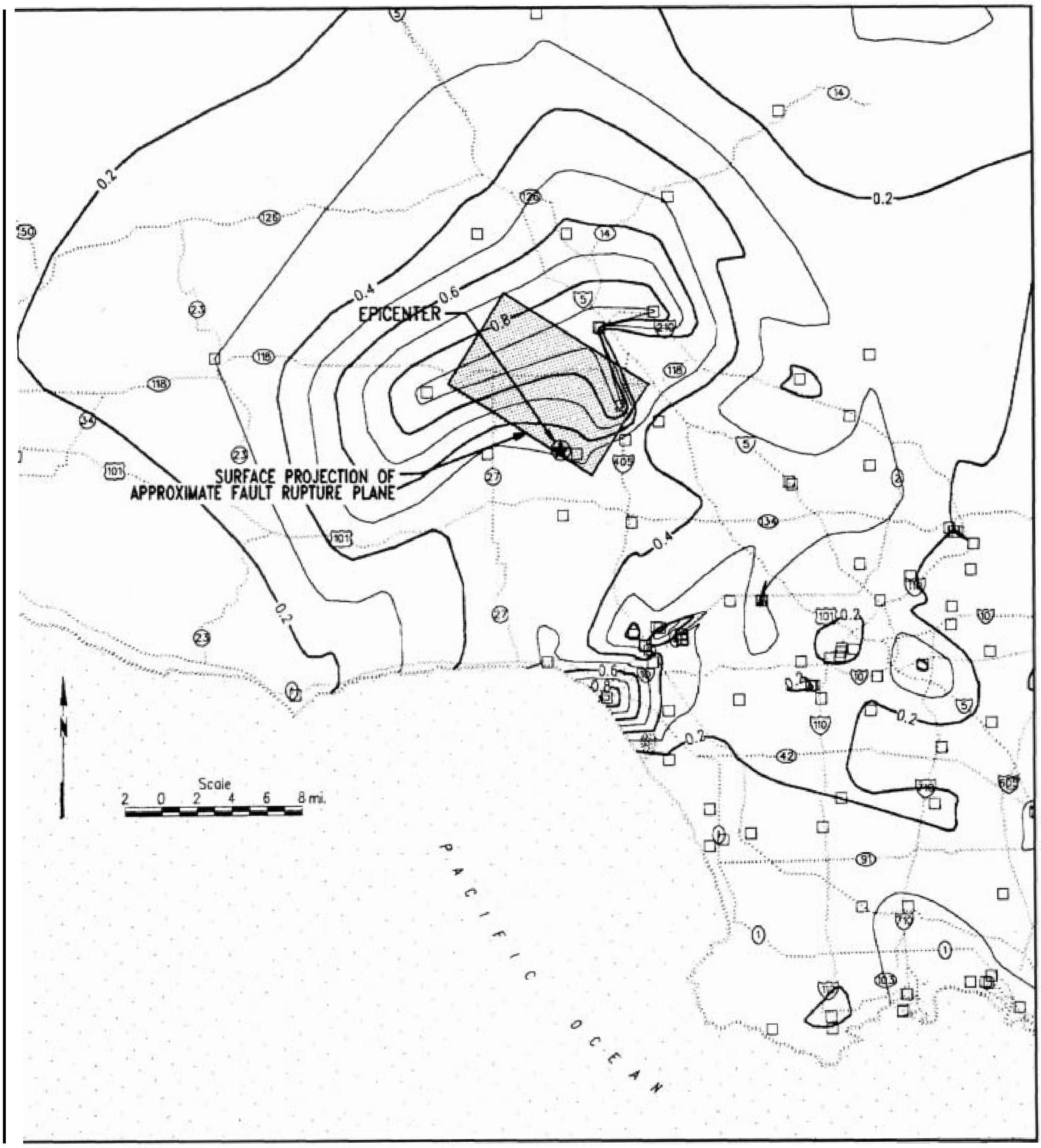


Figure 2.4. ***Contours of maximum acceleration based on recordings at rock and soil sites. (Source: J.P. Stuart, et. al., 1994.)***

Five of the nineteen historic adobes were subjected to very strong ground motions of 0.4g or greater. Four of these buildings (Andres Pico Adobe, San Fernando Mission convento, De la Osa, and Lopez Adobes) are located in the San Fernando Valley where the ground motion was very strong. The fifth, the Simi Adobe, is in the Simi Valley west of the San Fernando Valley.

Another five of the adobes, scattered in the San Fernando Valley, the Los Angeles Basin, and the Santa Clara River area, experienced ground motions in the 0.3g to 0.4g range. In the San Gabriel Valley the ground motion was significantly lower. The PGA values were approximately 0.2g or less at the Lopez-Lowther Adobe, San Gabriel

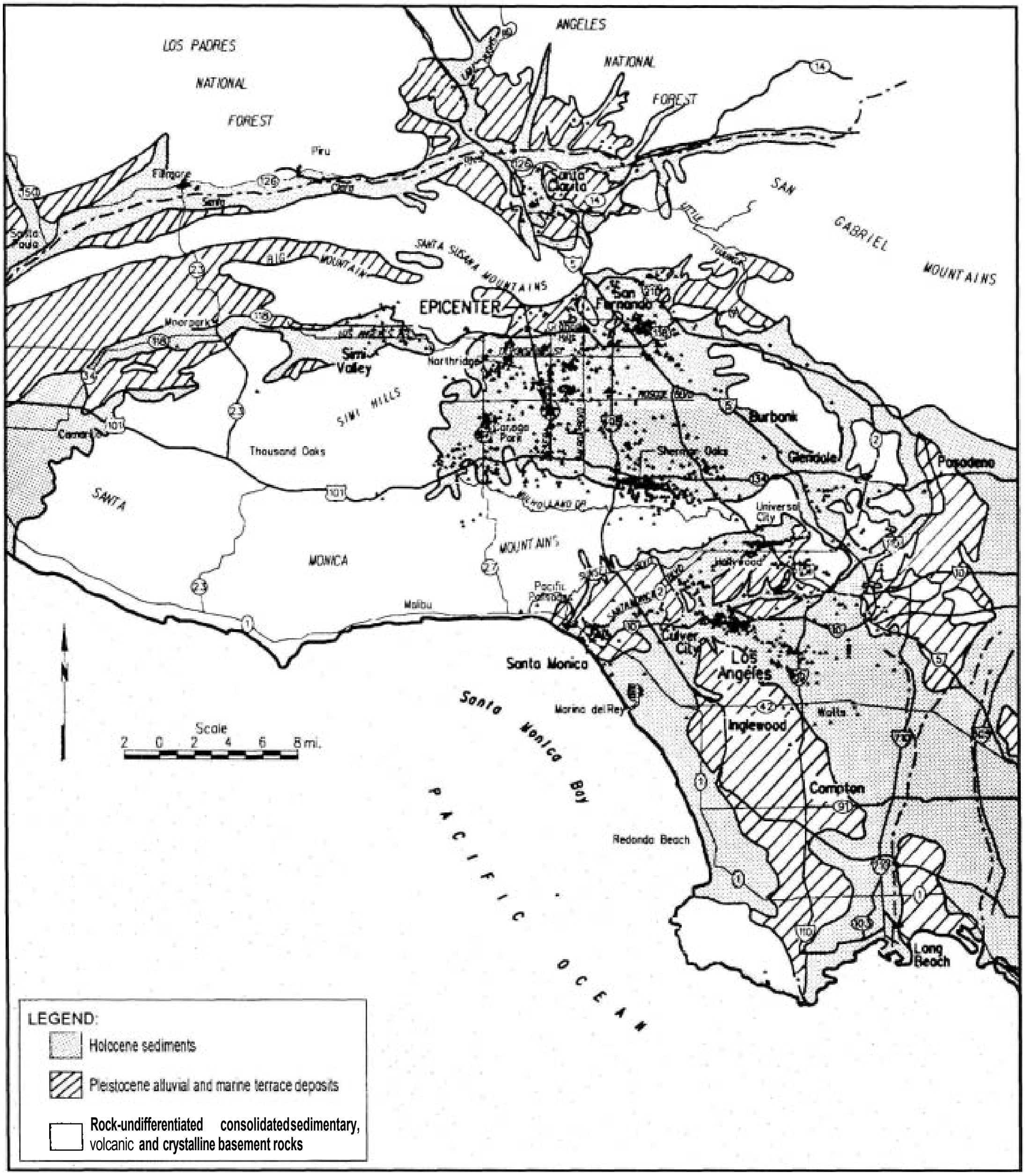


Figure 2.5. ***Damage patterns from the . 1994 Northridge earthquake and generalized geologic conditions in the Los Angeles Area. (Source: Governor's Office of Emergency Services, 1994; Los Angeles County, 1990; California Divisions of Mines and Geology, 1969.)***

Mission convento, and Purcell House, while they were between 0.1 g and 0.2g at the Pio Pico Adobe and Miguel Blanco Adobe.

Damage descriptions for the surveyed adobes are given in Chapters 4 through 12 and are summarized in the concluding Chapter 13. A plot of damage level versus estimated horizontal peak ground acceleration is also developed in that chapter.

Chapter 3

Damage Typologies and Assessment

Introduction

This chapter presents information useful in characterizing earthquake damage to historic adobe buildings. Damage typologies are described, including detailed descriptions and graphic examples from the surveyed buildings. Knowledge of the different types of damage will enhance understanding of the condition and damage assessments of the individual buildings discussed in Chapters 4 through 12. The description of each typology includes the likely cause or causes of the damage and the expected hazard posed by each.

The effects of preexisting conditions, including water damage, earthquake damage, and installed retrofit measures, are also discussed as well as descriptions of standardized earthquake damage states used to make overall assessments of building damage and a discussion of the relative seriousness of each damage type. Finally the selection process by which eight of the nineteen historic adobes were chosen for more in-depth study is discussed.

Damage Typologies

Adobe is a low-strength building material, and the walls of adobe buildings are thick and massive. The stresses in the adobe masonry during an earthquake can easily exceed the tensile strength of the material, and cracks will develop. The extent of damage to an adobe structure subjected to an earthquake is, in simple terms, a function of (a) the severity of the ground motion, (b) the geometry of the structure, i.e., the configuration of the adobe walls, roof, floors, openings, and foundation systems, (c) the existence and effectiveness of seismic retrofit measures, and (d) the condition of the building at the time of the earthquake.

Geometry plays an important role in how an adobe building will respond to seismic ground motions. A thin adobe wall with a slenderness (height-to-thickness) ratio greater than 10 will perform differently than a thick wall with a slenderness ratio of 5. A freestanding adobe wall will perform quite differently from one buttressed by perpendicular walls. A solid wall with no openings will develop failure patterns that are quite different from a wall with numerous windows and doors. All of these are elements of building geometry that affect building response and damage during an earthquake.

Installed seismic retrofit measures generally have a positive effect on the seismic performance of an adobe building. Bond beams, buttresses, tie-rods, and other structural elements that add resilience and/or continuity to a structural system are beneficial. Roof and mid-height flooring/ceiling systems can significantly affect the overall performance. Structurally sound connections between adobe walls and the roof and floor can greatly improve the seismic performance by providing continuity and lateral support at critical locations. Negative effects can also result from seismic retrofit measures by creating stress concentrations leading to other types of damage.

The condition of a building at the time of an earthquake plays a significant role in its performance. Preexisting cracks, perhaps resulting from previous earthquakes, may isolate a wall section, causing it to act as a freestanding wall; other walls may be leaning, affecting their stability. Water damage is perhaps the most important existing condition that affects the performance of an adobe building: it can alter the strength of adobe to such an extent that a wall may be unable to support its own weight.

The integrity of the adobe masonry also can have an impact on seismic performance. Masonry integrity is a function of the bonding pattern and the cohesion or bonding between the adobe blocks and mortar. When there is poor bonding the walls may not behave monolithically as well-constructed adobe walls typically do.

Following are descriptions, figures, and photographs of the damage types observed in historic adobe buildings after the Northridge earthquake. These damage types are listed in Table 3.1, and many of the typical ones are illustrated in Figure 3.1.

Out-of-plane wall damage

Adobe walls are very susceptible to cracking from flexural stresses caused by out-of-plane ground motions. The cracks caused by out-of-plane flexure usually occur in a wall between two transverse walls. The cracks often start at each intersection, extend downward vertically or diagonally to the base of the wall, and then extend horizontally along its length. The wall rocks back and forth out of plane, rotating about the horizontal crack at the base.

Although cracks from out-of-plane forces occur easily, the extent of damage is often not particularly severe as long as the wall is prevented from overturning. The principal factors that affect the out-of-plane stability of adobe walls are:

- wall thickness and the slenderness or height-to-thickness ratio (S_L) of the wall;
- the connection between the walls and the roof and/or floor system:
- whether the wall is load bearing or nonload bearing;
- the distance between intersecting walls:
- the condition of the base of the wall.

The Slenderness ratio of a wall is fundamental to its overturning stability. A very thick, stout wall $(S_L \leq 3.5)$ is virtually impossible to overturn and will slip horizontally

Table 3.1. *Historic adobe earthquake damage typologies.*

Type		Description
Out of plane	gable end failure[1]	Gable-end walls suffer severe cracking that often leads to instability. Gable-end walls are tall, poorly attached to the building, have large slenderness (height-to-thickness) ratios, and carry no vertical loads.
	flexural cracks and collapse	Flexural cracks begin as vertical cracks at transverse walls, extend downward vertically or diagonally to the base of the wall, and extend horizontally to the next perpendicular wall. **The existence of cracks does not necessarily mean that a wall is unstable.** Walls can rock without becoming unstable. After cracks have developed, the out-of-plane stability of a wall is dependent on the slenderness ratio, connection to the structure, vertical loads, and the condition of the wall at its base.
	mid-height cracks	Long, tall, and slender single-wythe walls, or long, tall, double-wythe walls with no header courses interconnecting the wythes are susceptible to mid-height horizontal cracking from out-of-plane ground motion.
In plane		Classic X-shaped or simple diagonal cracks are caused by in-plane shear forces.
Corner damage	vertical	Vertical cracks can develop at corners in one or both planes of intersecting walls.
	diagonal	Diagonal cracks that extend diagonally from the bottom to the top of a wall at a corner may be caused by in-plane shear forces or out-of-plane flexural forces.
	cross	A diagonal crack extending from the bottom corner can combine with a diagonal crack from the top corner forming a wedge-shaped section.
Cracks at openings		Cracks often begin at the tops of doors and openings and propagate upward vertically or at a diagonal. Cracks can also develop at the lower corners of windows. These cracks may be caused by in-plane or out-of-plane motion.
Damage at intersection of perpendicular walls		Perpendicular walls can separate from each other and cause damage by pounding.
Slippage between walls and wood framing		Roof, ceiling, and floor framing often slips at the interface with the adobe walls. Wood framing is often not or inadequately attached to the adobe walls in historic adobe buildings.
Damage at anchorage and cross-ties		Crack damage often propagates from structural anchorage and cross-ties. It is difficult to avoid stress concentrations at these locations which generally lead to cracks and other damage such as crushing of material.
Local section instability		Local wall sections can become unstable as the result of cracks that develop at corners of buildings and/or window and door openings.
Horizontal upper-wall cracks		Horizontal cracks may develop near the tops of walls when there is a bond beam or the roof is anchored to it. These cracks are caused by the combination of horizontal forces and the small vertical compressive stresses near the top of the wall.
Moisture damage contributions to instability		Moisture damage at the base of a wall can result in wall instability. In some cases, the wall may collapse out-of-plane because one side of the wall has been weakened or eroded. In other cases, saturation or repeated wet/dry cycles can weaken the lower adobes causing weakened slip-planes at the base of the wall along which the wall can slip and collapse.

[1] Gable-end wall collapse is specified because, where they exist, gable-end walls are the most susceptible part of a building to collapse.

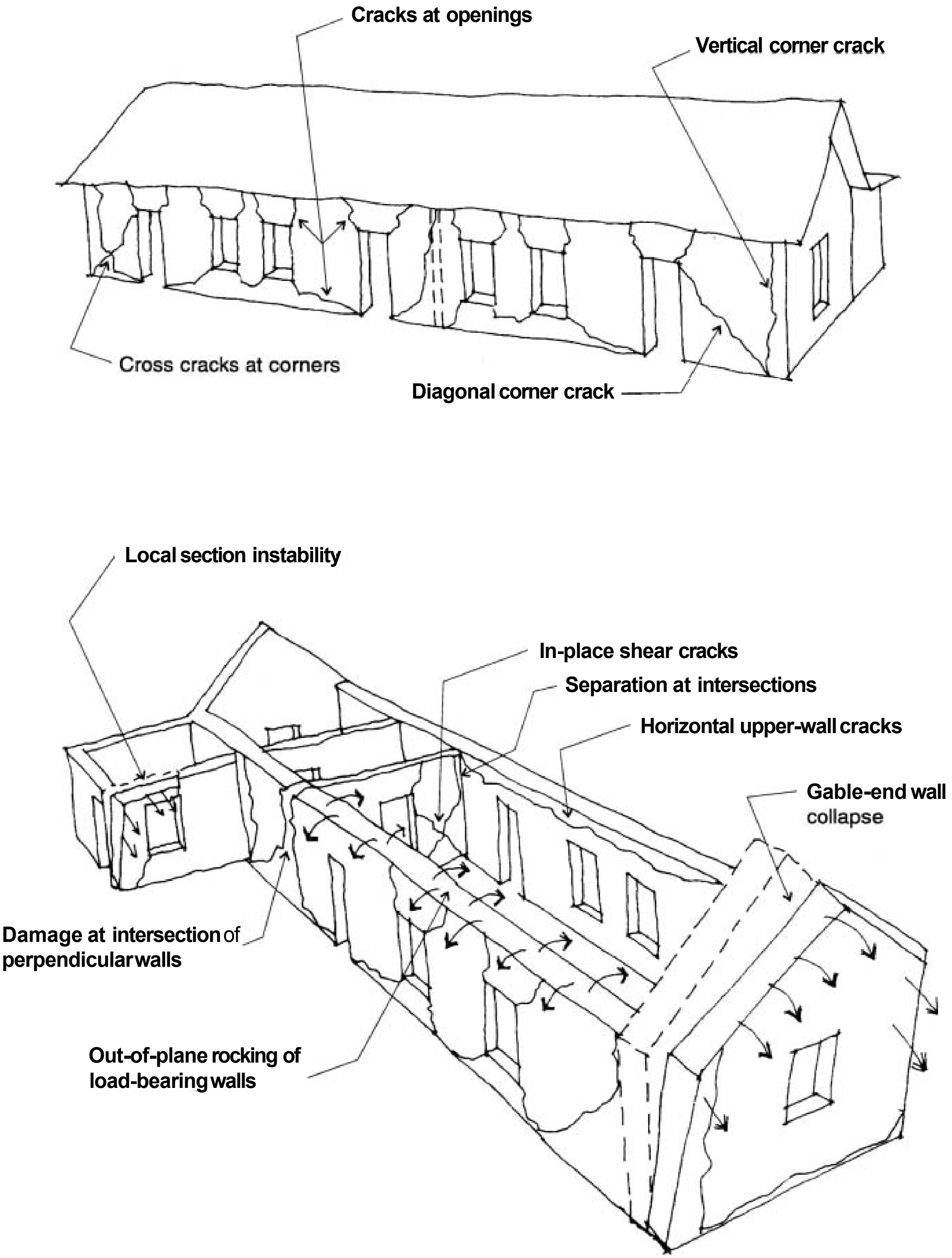


Figure 3.7. Typical failure typologies observed in historic adobe buildings after the Northridge earthquake.

at the base before it will overturn. On the other hand, slender walls ($S_L>10$) are very susceptible to overturning or possibly buckling at mid-height.

Connections between the walls and the roof and/or floor systems can greatly improve the out-of-plane stability of a wall. It is not necessary for the floor or roof to be a complete diaphragm system for these connections to greatly improve the out-of-plane stability. A bond beam or partial plywood diaphragm may be sufficient to stabilize the out-of-plane motions of walls. Even anchoring a wall to a roof or floor system without strengthening the diaphragm can have a significant positive effect on the out-of-plane stability.

The vertical loads at the tops of thicker, load-bearing walls also act to stabilize the walls. As the wall rocks out of plane, the load shifts to the edge of the wall that is rocking upward and resists the overturning by bearing down on the raised corner.

The condition of the base of an adobe wall may also affect its out-of-plane stability. Conditions that lead to out-of-plane instability or heighten the susceptibility to overturning include: basal erosion, which reduces the bearing area; excessive moisture content, which reduces the strength; or repeated wet-dry cycles, which may also weaken the adobe.

The collapse of any wall is obviously a very serious failure that results in a loss of historic fabric and a large cost of reconstruction as well as the possibility of serious injury.

Gable-end wall collapse

Overturning of gable-end walls is a specific case of out-of-plane failure that needs specific discussion because these walls are typically the most susceptible part of an adobe building. The walls are tall and thin, are usually not well connected to the structure at the floor, attic, and/or roof levels, and are not load-bearing walls.

The severe cracking or collapse of gable-end walls is the most commonly observed serious damage type. Examples include:

- overturning of the entire end wall, as occurred at the De la Osa Adobe (Figure 3.2);
- partial collapse of the upper level of the gable-end, as occurred at the Andres Pico Adobe (Figures 3.3–3.5);
- severe cracking without collapse, as occurred at Rancho Camulos.

The principal damage to gable-end walls, overturning, is caused by ground motions that are perpendicular (out of plane) to the walls. Instability problems can also result from in-plane ground motions when sections of the wall slip along diagonal cracks.

The De la Osa Adobe suffered the most complete collapse of any of the gable-end walls observed in the survey. The entire east end wall, starting at the base, overturned outward in one piece. The survey team was told that the window in the middle of the wall was still in the same relative position in the wall after the wall had collapsed.

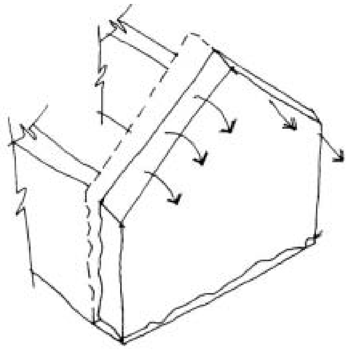


Figure 3.2. *Diagram of complete collapse of gable-end wall.*

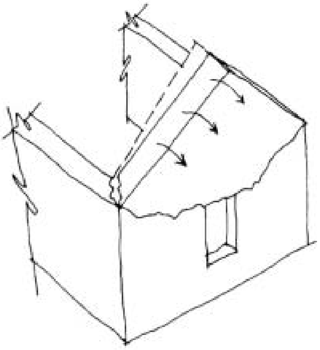


Figure 3.3. *Diagram of the collapse of the upper portion of a gable-end wall.*

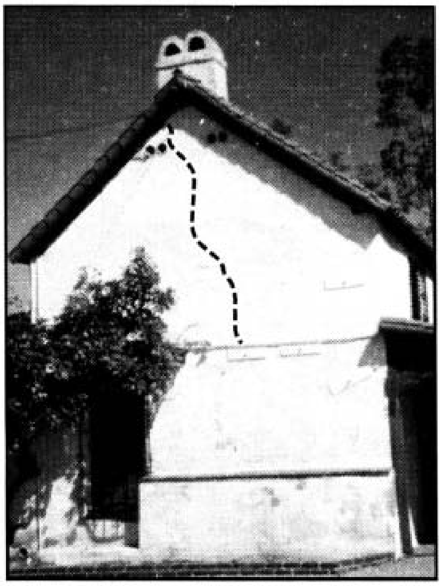


Figure 3.4. *Andres Pico Adobe. Gable-end wall in 1991 before the Northridge earthquake. Preexisting cracks are indicated by dotted line.*

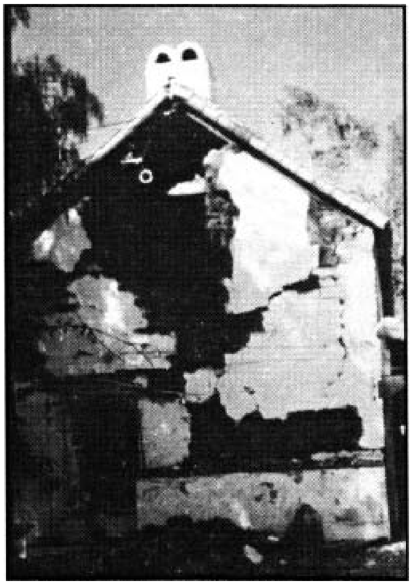


Figure 3.5. *Andres Pico Adobe. Gable-end wall after the Northridge earthquake.*

The gable-end of the Andres Pico Adobe also suffered severe damage as a pie-shaped section above the second floor collapsed outward. The east side of this section was defined by a vertical chimney flue that was chased through the center of the wall thickness. The west side of the collapsed section was defined by a preexisting crack that was observed during an earlier survey conducted by the GSAP team in 1991.

Out-of-plane flexure cracks and collapse

Out-of-plane flexural cracks are one of the first crack patterns to appear in an adobe building during a seismic event. This damage type and the associated rocking motion is illustrated in Figure 3.6.

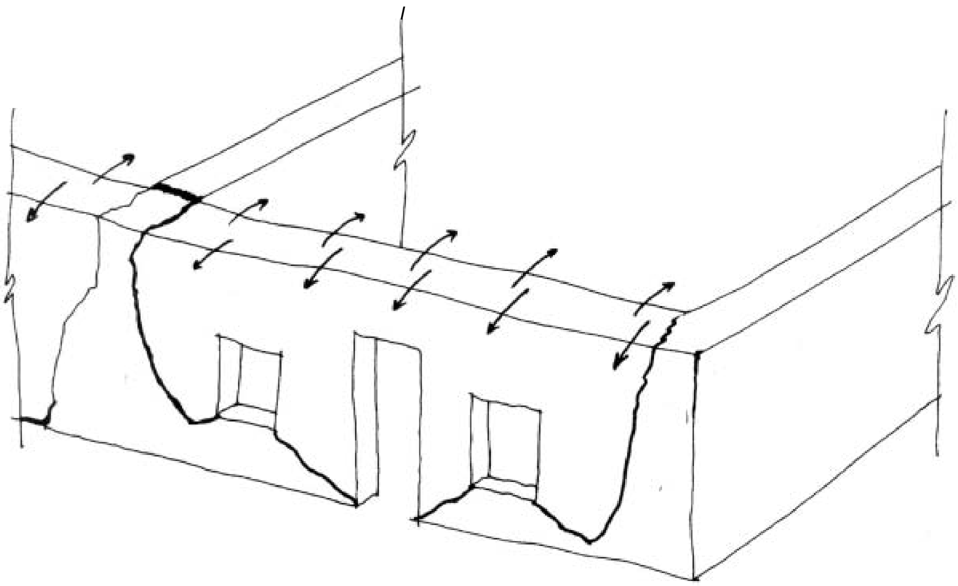


Figure 3.6. *Out-of-plane flexure of load-bearing walls.*

Freestanding walls are the most vulnerable to overturning. Freestanding walls have no horizontal support along their length such as that provided by cross walls or roof or floor systems. Garden walls are examples of freestanding walls susceptible to overturning. Intersecting walls will improve the stability of freestanding walls. A garden wall on the north side of the convento at the San Fernando Mission collapsed (Figure 3.7). This wall was made with stabilized adobe bricks and had a slenderness ratio of 5.

Numerous examples of out-of-plane flexural damage were observed during this survey. The clearest examples of flexural crack patterns were observed at the Andres Pico Adobe (Figure 3.8) and the Leonis Adobe (Figure 3.9). Load-bearing walls are much more resistant to out-of-plane collapse than nonload-bearing walls due to the resistance provided by the roof or floor framing system as well as the stabilizing effect of the roof weight.

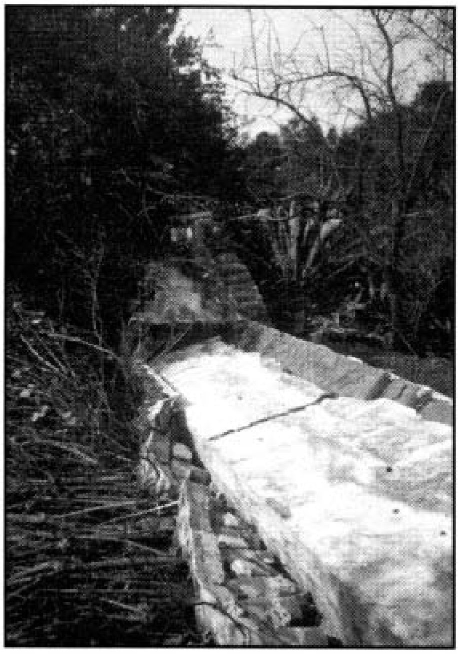


Figure 3.7. *Overturning collapse of garden wall outside of the convento at Mission San Fernando ($S_L=5$).*

Mid-height, out-of-plane flexural damage

For the most part, historic adobe buildings are not susceptible to mid-height, out-of-plane flexural damage because the walls are usually thick, having low slenderness ratios. However, horizontal cracks may develop when load-bearing walls are long and slender and the top of the wall is restrained by a bond beam or connection to the roof or ceiling system

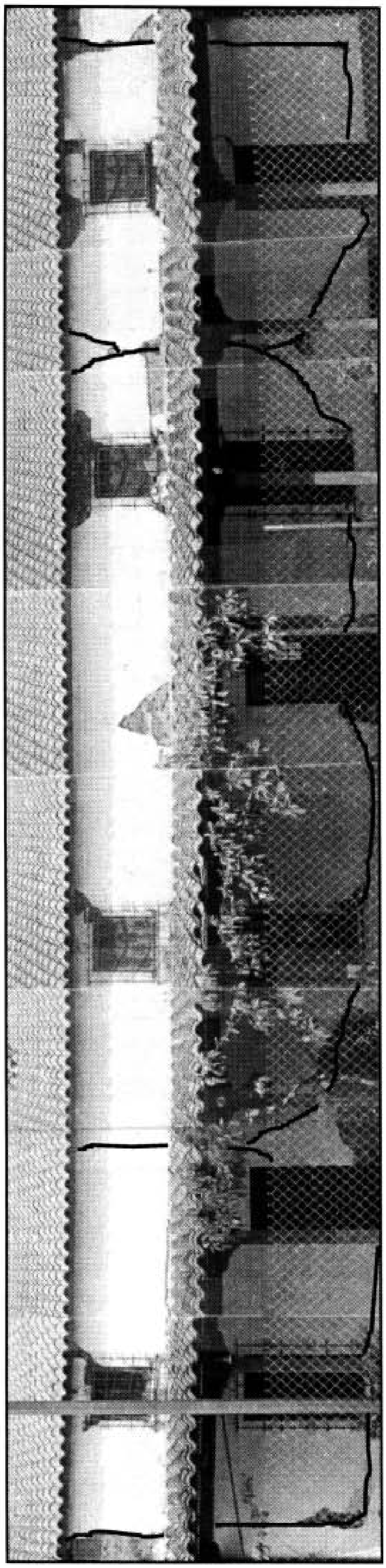


Figure 3.8. *Andres Pico Adobe. Cracks caused by out-of-plane flexure are highlighted by darkened lines.*

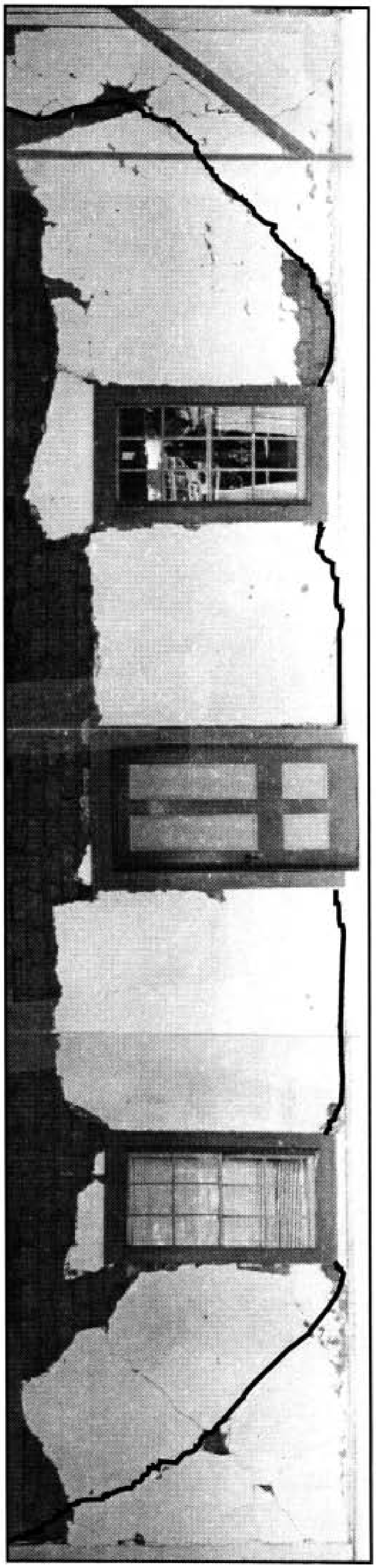


Figure 3.9. *Leonis Adobe. Cracks caused by out-of-plane flexure are highlighted by darkened lines.*

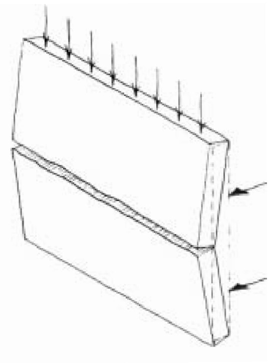


Figure 3.10. ***Diagram of mid-height, out-of-plane flexural damage.***

(Figure 3.10). This is a damage and potential failure mechanism usually observed only in thin-walled brick buildings.

Although the exterior longitudinal walls of the convento at the San Fernando Mission are reasonably thick, the walls are comprised of two wythes that are poorly bonded together and have no header courses interconnecting them. Although the inner wythe is anchored to the second-floor joists, the outer wythe is not attached and effectively acted as a tall, thin, two-story wall. A mid-height crack developed in the exterior wythe on both sides of the building (Figures 12.2 and 12.3).

In-plane shear cracks

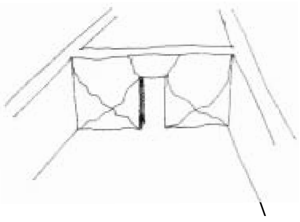


Figure 3.11. ***Diagram showing X-shaped shear cracks in a interior wall.***

Diagonal cracks, as shown in Figures 3.11 through 3.13, are typical results of in-plane shear forces. The cracks are caused by horizontal forces in the plane of the wall that cause tensile stresses at approximately 45 degrees to the horizontal. The X-shape occurs when the sequence of ground motions causes the shear forces to go in one direction and then reverses and the shear forces go in the opposite direction (Figure 3.14). These cracks often occur in walls between openings.

The severity of in-plane cracks is judged by the amount of permanent displacement between the adjacent sections of the walls after ground shaking ends. More severe damage to the structure may occur when an in-plane horizontal offset occurs in combination with a vertical displacement (i.e., when the crack pattern follows a more direct diagonal line and does not stair-step along mortar joints). Diagonal shear cracks can continue to worsen

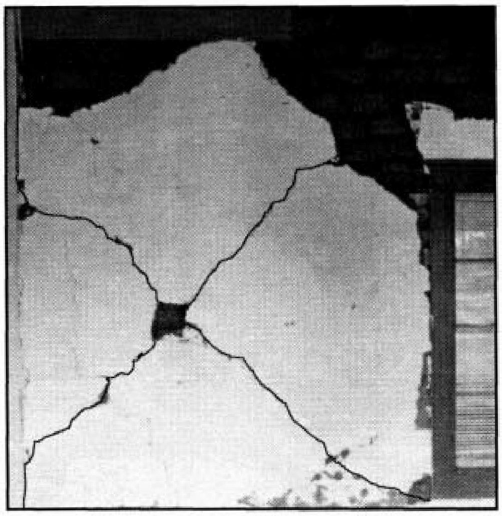


Figure 3.12. ***Leonis Adobe. Shear cracking in typical X-pattern (cracks highlighted).***

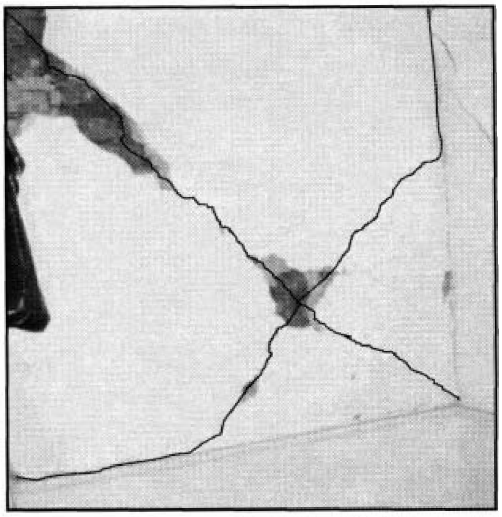


Figure 3.13. ***De la Osa Adobe. Shear cracking in typical X-pattern (cracks highlighted).***

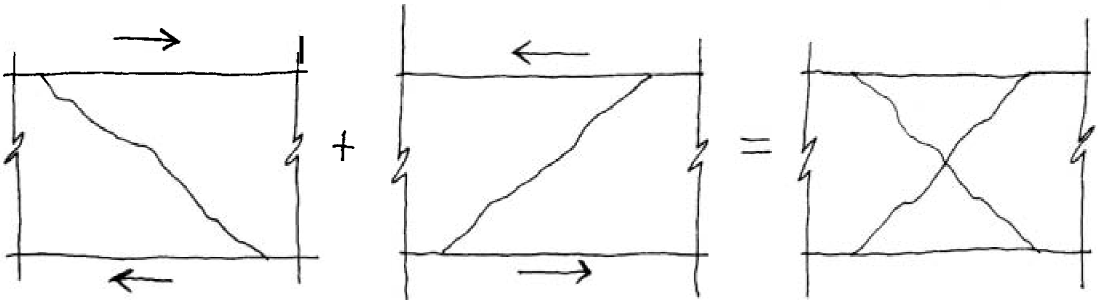


Figure 3.14. ***X-shaped cracks result from a combination of shear cracks that have been caused by ground motion in two opposite directions.***

during prolonged ground motions because gravity is constantly working in combination with earthquake forces to exacerbate the damage.

Corner damage

Damage often occurs at the corners of buildings due to the stress concentrations that occur at the intersection of perpendicular walls. Instability of corner sections often occurs because two sides of the corner are unrestrained and, therefore, the corner section is free to collapse outward from the building.

Diagonal cracking at corners

Diagonal cracks that start at the top of a wall and extend downward to the corner are caused by in-plane shear forces. This type of crack results in a wall section that can move laterally and downward during extended ground motions. This type of damage is difficult to repair and may require reconstruction. Illustrations of this damage type are shown in Figures 3.15 and 3.16.

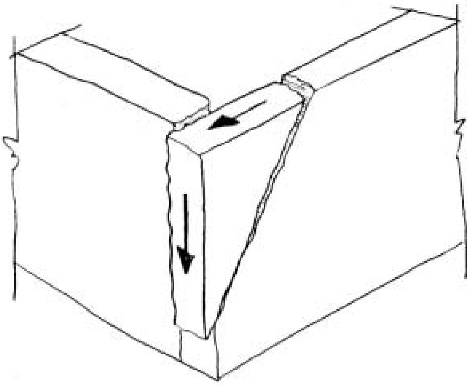


Figure 3.15. ***Diagram showing vertical and horizontal displacement of a wall section at a corner.***

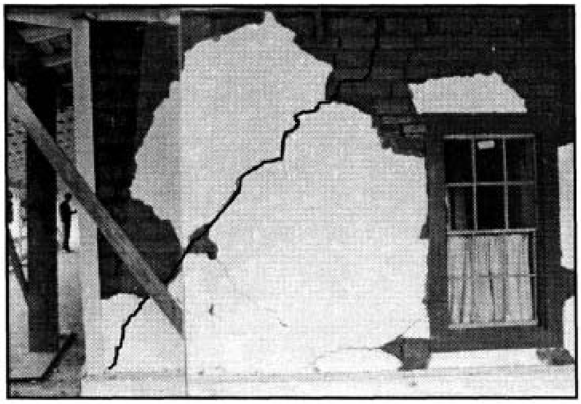


Figure 3.16. ***Leonis Adobe. Diagonal crack at the southeast corner on the second floor (crack highlighted).***

Vertical cracks at corners

Vertical cracks often develop at corners during the interaction of perpendicular walls and are caused by flexure and tension due to out-of-plane movements. This type of damage can be particularly severe when vertical cracks occur on both faces allowing collapse of the wall section at the comer, illustrated by Figures 3.17 through 3.19.

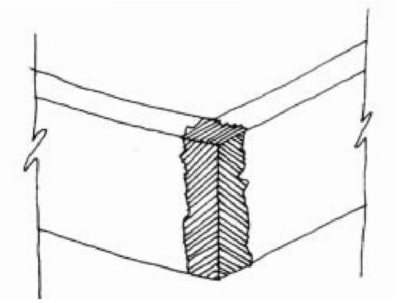


Figure 3.17. ***Diagram showing how vertical cracks at a corner can lead to instability of the corner section of the wall.***

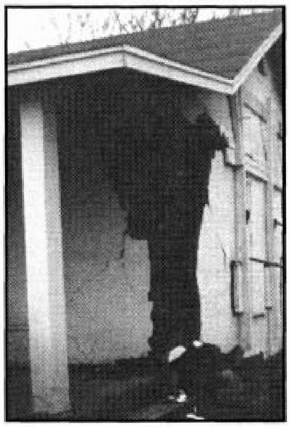


Figure 3.18. ***Sepulveda Adobe. Vertical cracks at this comer lead to collapse of the corner section.***

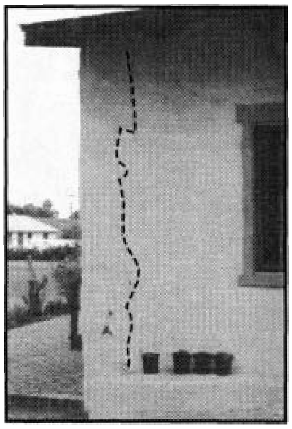


Figure 3.19. ***Pio Pico Adobe. Initiation of a vertical crack (dotted line along crack).***

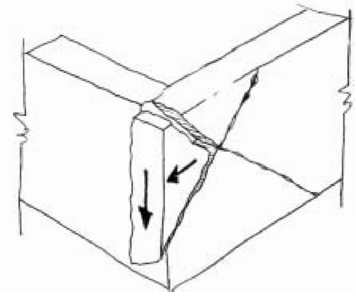


Figure 3.20. ***Diagram showing a combination of shear and flexural cracks that can lead to the instability to a portion of a wall after cracks have developed.***

Combinations with other cracks or preexisting damage

The combination of diagonal cracks and vertical cracks can leave an adobe wall severely fractured with several sections of the adobe wall susceptible to large offsets and/or collapse. An example of a wall section that is very vulnerable to serious damage is shown in Figure 3.16 and illustrated in Figure 3.20. The diagonal cracking at that location is at the southwest corner of the buildings leaving the cracked wall sections free to move outward.

Comers may be more susceptible to collapse if vertical cracks develop and the base of the wall has already been weakened by previous moisture damage.

Cracks at openings

Cracks occur at openings more often than any other general location in a building. They are caused by earthquakes, foundation settlement, or slumping of a wall due to moisture intrusion at the base. Cracks at openings develop because stress concentrations are high in these locations. These cracks start at the top or bottom comers of openings and extend on a diagonal or vertically to the tops of the walls as shown in Figures 3.21 and 3.22.

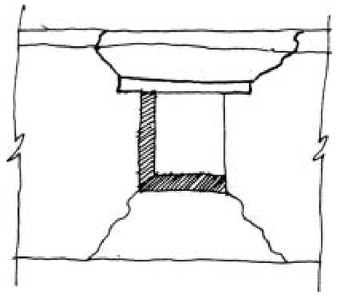


Figure 3.21. ***Diagram of cracks that occur first at the upper corners of window openings and then at the lower corners.***

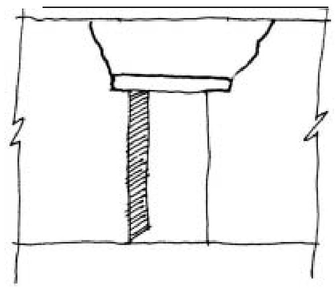


Figure 3.22. ***Diagram of cracks at the upper corners of a doonvay.***

Cracks at openings are not necessarily indicative of severe damage. Wall sections on either side of openings usually prevent these cracks from developing large offsets. However, in some cases, these cracks may result in cracked wall sections over the openings that may be hazardous to occupants if they are dislodged.

Intersection of perpendicular walls

Damage often occurs at the intersection of perpendicular walls. One of the walls rocks out of plane while the perpendicular wall remains very stiff in plane. Resulting damage at these locations is inevitable during large ground motions.

Damage of this type can either result in gaps developing between the in-plane and the out-of-plane walls (Figures 3.23 through 3.25) or vertical cracks may occur in the out-of-plane wall. The damage may be significant when large cracks open and associated damage occurs to the roof or ceiling framing. Anchorage to the horizontal framing system or other continuity elements can greatly reduce the severity of this damage type.

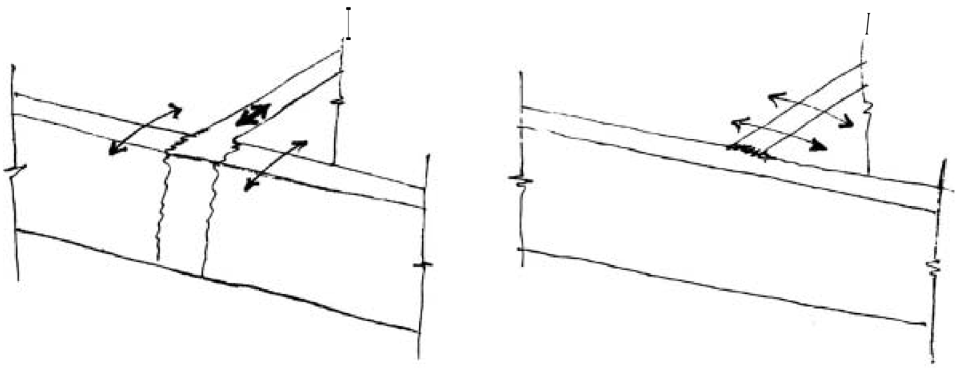


Figure 3.23. ***Vertical cracks often develop at the intersection of perpendicular walls.***

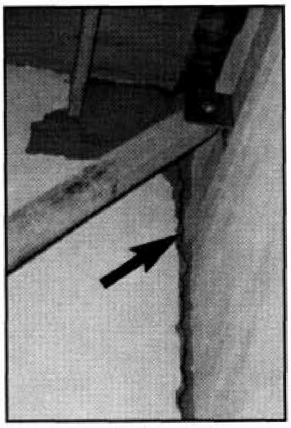


Figure 3.24. *Convento at the San Gabriel Mission. Separation between two interior walls.*

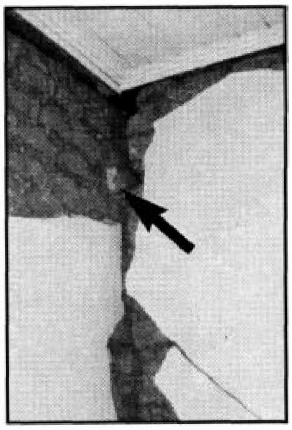


Figure 3.25. *De la Osa Adobe. Separation between interior wall (right) and exterior wall (left).*

Slippage between adobe walls and the roof, ceiling, or floor framing

Slippage often occurs between horizontal framing of second floors, ceilings, or roofs and adobe walls. Typically in historic adobe buildings, there is little attachment between the walls and the framing. Second-floor or ceiling joists are sometimes set in pockets in the walls. Ceiling or roof framing is often set directly on tops of the walls, with or without wall plates. Permanent offsets between ceiling framing and adobe walls are shown in Figures 3.26 and 3.27.

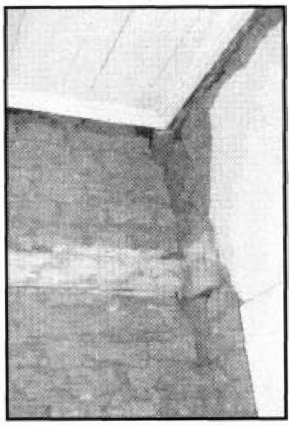


Figure 3.26. *Sepulveda Adobe. Slippage of ceiling relative to supporting walls.*

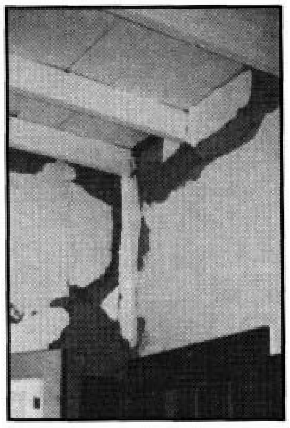


Figure 3.27. *Pio Pico Adobe. Slippage of tapanco floor joists relative to supporting wall.*

Failure of this type ranges from cosmetic to severe as the adobe walls may slip out from under the framing, and the wall, ceiling, and roof may collapse. This condition has also been observed in newer adobe buildings with bond beams where there has been no mechanical attachment between the adobe and the bond beam. The adobe wall pulls out from underneath the bond beam.

Damage at wall anchorage

Wall anchors (or tie rods) are intended to hold a wall snugly against a perpendicular wall or diaphragm. Many wall anchors were probably installed in response to previous earthquake or settlement damage. Damage to walls can occur at wall anchorages because of the stress concentrations that are created during ground motions. Anchors are very difficult to attach to adobe walls successfully because the adobe material is weak in shear and tension.

To understand the performance of adobe buildings with these tie rods and to design more effective anchorage, it is important to understand the behavior of the material around these anchors.

An anchorage at the De la Osa Adobe pulled into the wall and was ineffective in adequately restraining the out-of-plane motion of the wall (Figure 3.28). At another location in the De la Osa Adobe, cracks initiated at the anchorage location. However, there is little question that, regardless of the poor design of the tie-rod anchors at the De la Osa Adobe, they were effective in preventing more severe damage. At the Pio Pico Adobe, a few of the recently installed anchors attaching the attic (tapanco) floor to the exterior north wall were partially pulled out of the wall (Figure 11.4).

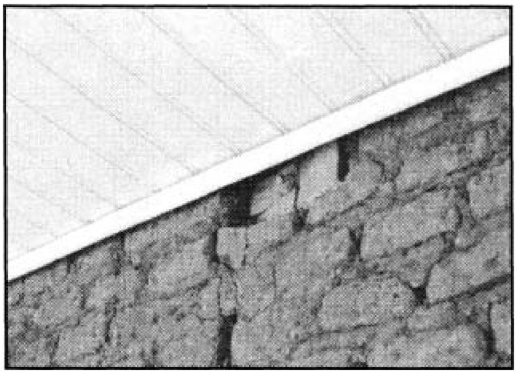


Figure 3.28. ***Anchorage failure of steel tie rods. Anchor has pulled into wall allowing tie rod to sag and become ineffective.***

Local section instability

Sections of an adobe building may become unstable after cracks have developed. This is particularly true for sections of a wall that become isolated from the building because openings are located too close to the corners. An example of this problem occurred in the garage of the Andres Pico Adobe. The collapsed corner is shown in Figure 3.29 and an explanation of the general problem is presented in Figure 3.30.

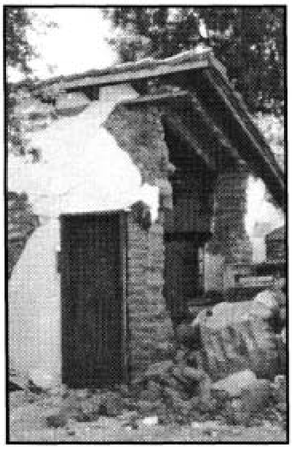


Figure 3.29. ***Andres Pico Adobe garage structure. Failure was defined by cracks at the door and window openings. Also see Figure 3.23.***

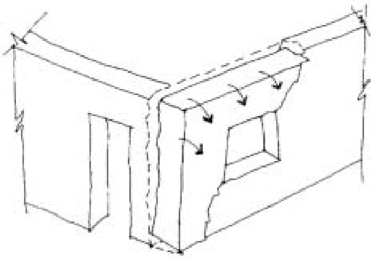


Figure 3.30. ***A localized section of a adobe building may become unstable when the cracking pattern permits isolated wall sections to form which can lead to collapse.***

The susceptibility to local section instability can be foreseen by predicting the general crack pattern in a building that may result from an earthquake. Cracks at openings and corners are very predictable. The wall sections defined by the crack pattern can then be examined to determine if any of these sections might become unstable during ground motion.

Horizontal cracking in upper section of walls

Horizontal cracks may occur in the upper section of walls when the walls are anchored to the roof system and/or when a bond beam has been installed. The cracks develop horizontally at or near the juncture of the wall and the bond beam or roof framing from either out-of-plane or in-plane movement (Figure 3.31). An example of this type of cracking occurred at the Lopez Adobe where a crack developed at the bottom of a concrete bond beam (Figure 3.32). The damage was not severe and the bond beam appears to have worked effectively.

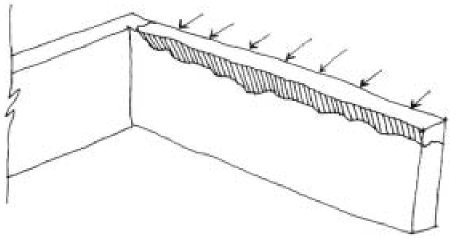


Figure 3.31. ***When a roof or bond beam is attached to a wall, the lateral forces can create a horizontal crack in the upper section of the wall.***

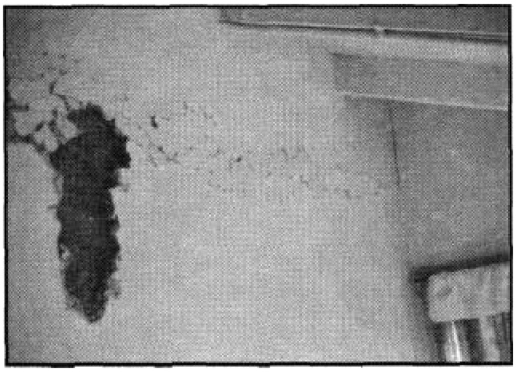


Figure 3.32. ***Horizontal cracking at the bottom of the bond beam, Lopez Adobe.***

Another example occurred in the upper section of the walls at the Andres Pico Adobe (Figure 3.33). From the evidence of this cracking, there appears to be some anchorage of the roof to the wall. Typically with no attachment, the roof or ceiling framing slips relative to the top of the wall before horizontal cracking develops.

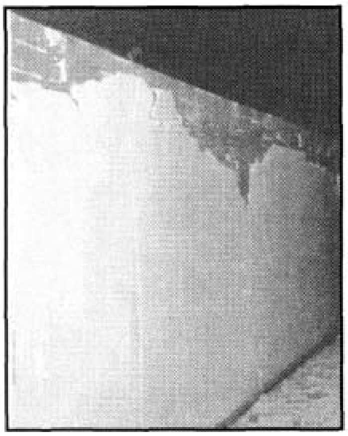


Figure 3.33. ***Horizontal cracking in the upper section of the second story wall at the Andres Pico Adobe.***

Moisture damage contributing to instability

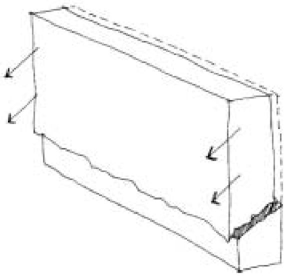


Figure 3.34. ***Moisture damage can result in a weak plane developing along which a wall can slide and collapse.***

When the adobe at the base of the wall is weakened by moisture damage, a weak plane can develop along which the upper section of the wall can slip and collapse (Figure 3.34). The negative effects of water and their causes are discussed in the following section on preexisting conditions.

This condition is most clearly shown in Figure 3.35 where a corner of the kitchen wall at the Andres Pico Adobe failed. The adobe at the base of the wall has been weakened by repeated exposure to moisture causing the weak failure plane to develop. It appears that the wall slipped along this plane and collapsed.

A similar failure mode is the probable cause of failure for several walls at Rancho Camulos shown in Figure 3.36. When a wall fails by overturning, the location of the rubble will be representative of rotation about the base. By contrast, the wall shown in Figure 3.36 appears to have collapsed down upon itself. The top of the wall is in the pile of rubble very near to the original wall line. There is extensive moisture damage to many walls at Rancho Camulos; other collapsed walls at Rancho Camulos may have failed for the same reason.

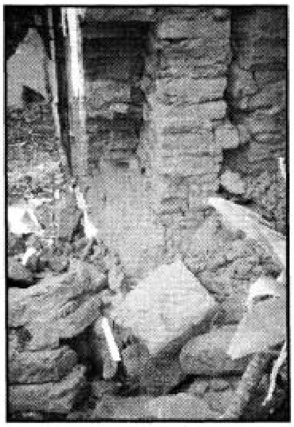


Figure 3.35. ***Moisture damage in this kitchen wall at the Andres Pico Adobe contributed to the collapse of the corner of the building.***

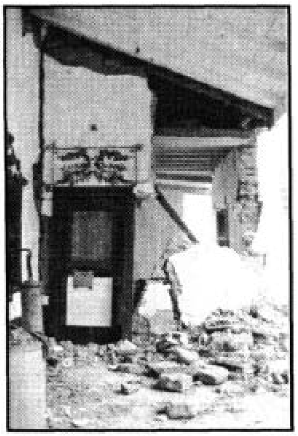


Figure 3.36. ***Collapsed wall of Ramona's room at Rancho Camulos. This thin, 12-inch-thick wall collapsed downward rather than falling outward. Moisture damage at the base of the wall contributed to the failure.***

Effect of Preexisting Conditions

Preexisting conditions may have a profound influence on the seismic performance of an adobe building. In the Andres Pico Adobe, the collapsed gable-end wall was susceptible to damage because of preexisting cracks. The failure of several walls of the Del Valle Adobe at Rancho Camulos was the result of extensive water damage at the base of the walls in combination with the earthquake. The converto at the San Gabriel Mission was susceptible to additional damage because of the extensive cracks caused by recent earthquakes and the fact that no repairs or shoring had been undertaken prior to the Northridge earthquake. An assessment of the condition of any historic adobe building before an earthquake can help determine the potential extent and types of problems that may occur during an earthquake.

Moisture damage

Water is the most prevalent threat to adobe buildings in areas of both high and low seismicity. It damages an adobe wall by eroding away portions of the wall and by reducing the strength of the adobe material.

Basal erosion is the eroding away of a portion of an adobe wall at its base. It can be caused by surface runoff or by water falling from the roof and splashing up against the base of the wall. It can also be caused by water being drawn or wicked up into a wall by capillary action and then diffusing to the wall surface to evaporate. Water can carry soluble salts that will then crystallize near the surface when the water evaporates. In crystallizing, the salts expand and fracture the adobe. The continuing deposition and recrystallization of the soluble salts will slowly erode the surface. The extent of the basal erosion can also be increased by abrasive actions of animals, plants, and wind.

Regardless of the cause of basal erosion, the area of the wall that has to carry the loads imposed on it is reduced. When the loads surpass the compressive strength of the material, failure occurs. It is also conceivable that a wall could actually become unstable and subject to overturning if enough material eroded from one side.

The difference between adobe and other masonry materials, such as brick or stone, is the dramatic reduction in strength when it becomes wet. Brick or stone can become saturated and still retain most of its strength. Long before adobe has reached saturation its compressive and tensile strength may have been reduced by 50 to more than 90 percent. This magnitude of reduction can result in a material which can fail even under normal loads.

Depending upon the loads on the wall and the reduction in strength, the adobe will first begin to deform slowly and then will increase as the adobe becomes wetter. A bulge at the base of an adobe wall is most often attributed to this settling or slumping.

Repeated wet/dry cycles can also significantly reduce the strength of the adobe. When a clay material is repeatedly cycled from a wet to a dry state, the bonding between the clay particles breaks down. The bonding of the clay fraction gives adobe its strength and can greatly influence the extent of earthquake damage.

It is not necessary for an adobe wall to be wet at the time of an earthquake for water to be a primary cause of failure. The reduced strength of the adobe makes a wall more susceptible to damage or collapse. Spalling, resulting from the combination of earthquake motions and a weakened adobe material, is shown by the examples in Figures 3.37 and 3.38. If an entire wall section becomes equally wet or weakened by wet/drycycles, the wall could fail suddenly as depicted in Figure 3.34.

Figure 3.37. *Spalling of exterior stucco and adobe in a water-damaged section of wall at the Andres Pico Adobe.*

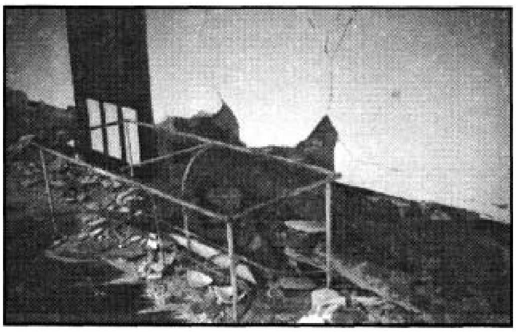


Figure 3.38. *A similar spalling of adobe and stucco on the exterior wall at the Del Valle Adobe at Rancho Camulos.*

Out-of-plumb walls

Wall overturning is the most severe problem that can occur to an adobe building because of the life-safety hazard, the loss of historic fabric, and the cost of building repair. If an adobe wall is already out-of-plumb, it will be more susceptible to collapse than a wall that is vertical. For walls that are 20 to 24 inches thick, 1 or 2 inches out of plumb is not particularly significant. But a wall that is 6 inches out of plumb is likely to be highly susceptible to collapse.

Walls at the Andres Pico Adobe, the Del Valle Adobe at Rancho Camulos, and De la Osa Adobe were measured to determine how far from plumb they were. The gable-end walls at Andres Pico were approximately 3 inches out of plumb. The walls at Rancho Camulos and the De la Osa Adobe were only 1 to 2 inches from vertical. The most out-of-plumb wall that the survey team encountered was one of the exterior walls at Pio Pico. This wall was approximately 6 inches out of plumb at mid-span. The exterior walls at Pio Pico are 24 inches thick and approximately 13 feet high.

Preexisting cracks

The presence of preexisting cracks increases the susceptibility of a building to earthquake damage during moderate ground motions. These cracks may have been caused by previous earthquakes, wall slumping, or foundation settlement.

An adobe building is likely to suffer extensive damage when the ground motion is intense (PGA=0.4g), independent of the condition of the building before the event. Where ground motions are moderate (PGA=0.2g) the extent of damage is heavily influenced by the condition of the building before the earthquake. Damage will become more extensive during moderate ground shaking if preexisting cracks are present.

In the San Gabriel Valley during the Northridge earthquake, PGA values ranged from .015g to 0.20g. The performance of the historic adobe buildings in the San Gabriel Valley is indicative of the effect of preexisting cracks. The Las Tunas Adobe had few preexisting cracks and suffered slight damage. The Miguel Blanco Adobe had no known preexisting cracks and a visual exterior inspection revealed no damage. By contrast, the convento at the San Gabriel Mission had a significant number of preexisting cracks and suffered extensive damage. The existing cracks were widened and some walls suffered permanent offsets.

Seismic retrofit measures

Seismic retrofit measures can have a profound influence on the performance of an adobe building. The measures observed in some of the surveyed buildings included bond beams, tie rods, anchorage to roof and floor beams, and the application of wire mesh to the exterior walls. The effectiveness of the applied measures varied depending upon how well they were implemented.

Evaluation of the Severity of Earthquake Damage

Up to this point, the discussion of damage to adobe buildings has been primarily objective and has emphasized the specifics of actual damage types and the events which may have caused the damage. The purpose of this section is to define in subjective terms the level of damage that occurs to these buildings by describing damage states for the overall structure and making an assessment of the relative severity of each damage type.

Damage states

To evaluate, describe, and compare relative damage levels among buildings, it is useful to have a defined set of categories that describes the severity of damage. For this purpose, the standardized damage states developed by the Earthquake Engineering Research Institute (EERI) will be used in this report. In addition to the EERI description of each damage state, an interpretation of the description for use with historic adobe buildings is also provided in Table 3.2.

Table 3.2. *Standardized damage states.*

Damage state	EERI description	Commentary on damage to historic adobe buildings
A None	No damage, but room contents could be shifted. Only incidental hazard.	No damage or evidence of new cracking.
B Slight	Minor damage to nonstructural elements. Building may be temporarily closed but could probably be reopened after minor cleanup in less than one week.* Only incidental hazard.	Preexisting cracks have opened slightly. New hairline cracking may have begun to develop at the corners of doors and windows or the intersection of perpendicular walls.
C Moderate	Primarily nonstructural damage; there also could be minor but nonthreatening structural damage; building probably closed for two to twelve weeks.*	Cracking damage throughout the building. Cracks at the expected locations (opening, wall intersections, slippage between framing and walls). Offsets at cracks are small. None of the wall sections is unstable.
D Extensive	Extensive structural and nonstructural damage. Long-term closure should be expected due either to amount of repair work or uncertainty of economic feasibility of repair. Localized, life-threatening situations would be common.	Extensive crack damage throughout the building. Crack offsets are large in many areas, cracked wall sections are unstable, vertical support for the floor and roof framing is hazardous.
E Complete	Complete collapse or damage that is not economically repairable. Life-threatening situations in every building of this category.	Very extensive damage. Collapse or partial collapse of much of the structure. Due to extensive wall collapse, repair of the building requires reconstruction of many of the walls.
* Times are difficult to assign because they are largely dependent on the size of the building.		

Assessment of the relative severity of damage types

The most important aspect of identifying the various damage types is to understand their relative severities as they relate to life safety and the protection of historic fabric. An understanding of the relative severity of each type of damage is the most important factor in prioritizing stabilization, repairs, and seismic retrofits. If a particular damaged component is likely to worsen quickly if it is not repaired, then that damage becomes a higher priority than damage that is not likely to worsen. If damage leaves a major structural element, such as a roof or an entire wall, susceptible to collapse, then it becomes an even greater priority because of the threat to life safety. Original adobe walls are critical to the authenticity and definition of a historic adobe structure; the loss of an entire wall compromises the historic integrity of the entire structure. Consequently, damage that could result in the loss of a major feature, such as a wall, is more critical than damage that would result in partial failure, but no loss.

The most common severe damage type is the gable-end wall damage. It is the most likely to result in the collapse of an entire wall, thus destroying extensive amounts of historic fabric as well as posing a very serious threat to life safety. Out-of-plane flexure may or may not be severe depending on the extent of cracking and permanent displacement. Of particular concern is a section of wall that is independent of the rest of the structure by virtue of the crack pattern. The instability of such a section is considered serious because, without restraint, it may collapse during even moderate additional ground motion.

Slippage between walls and ceiling or roof framing is normally not serious as it relates to impact on historic fabric. However, in some cases, the bearing of ceiling joists is not adequate, and slippage will create a serious life-safety threat. Even if the slippage is extensive enough to prevent a roof system from bearing on a wall, it is unlikely that the roof will collapse, unless other parts of the system have failed as well. Of course, if both the walls that support the roof have moved outward, then the situation is extremely critical as the entire roof could collapse completely.

Damage at the intersection of perpendicular walls is normally not serious from a life-safety perspective. However, similar to corner damage, adjacent walls can become isolated and behave as freestanding walls. When they reach this state, the possibility of collapse or overturning is greatly increased and a serious life-safety threat is created. In addition, if significant permanent offsets occur, repair may be difficult.

In-plane shear cracking, damage at wall and tie-rod anchorage, and horizontal cracks are relatively low-risk damage types. However, while in-plane shear is not considered severe from the perspective of life safety, it is often costly in terms of the loss to historic fabric. In-plane shear cracks often cause very severe damage to important historic fabric such as plasters and stuccos.

The least serious type of damage is cracks that often are seen radiating out from the corners of openings. These cracks are normally the first to form in an adobe wall following slight to moderate ground movements. These cracks are the result of movement that is either perpendicular or parallel to the plane of the wall.

Table 3.3 provides details of the life safety and historic fabric concerns for each of the damage types. As noted in the table, some damage types are usually not serious initially but may become serious if the structure is subjected to greater load, loads of longer duration, or repeated earthquakes without intermittent corrections and repairs.

It should be noted that in most situations, different types of damage do not act separately but rather together. In fact, several of the damage types are actually caused by other types of damage. In some cases, the specific relationship of the different damage types is simple while in others it may be extremely complex.

The information presented is intended primarily to assist in prioritizing decisions related to the repair and correction of different types of damage. Elements of a building that may suffer collapse should be protected first. Collapse typically represents serious damage that results in the loss of a section of a building and poses a life-safety threat. The first priorities are to provide for life safety and the protection of historic fabric.

Table 3.3. *Severity of the different damage types in terms of their effect on both life safety and the historic fabric of the building.*

Type		Life safety and historic fabric
Gable-end wall failure		Collapse of gable-end walls is a serious life-safety threat and causes extensive loss of historic fabric.
Out-of-plane flexure		When walls only develop cracks and are stabilized at the top to prevent overturning, this damage type is not severe. Many load-bearing walls in extensively damaged adobe building were stable throughout the Northridge earthquake. In the case of overturning, the life-safety danger is serious because not only do the walls collapse, but the roof or ceiling structure may collapse.
Mid-height out-of-plane		Damage represented by mid-height horizontal cracking is not serious in and of itself. However, the potential for much greater damage is significant. During further ground shaking, out-of-plane movement of the wall could make the upper or lower sections of the wall unstable and collapse, thus becoming a life-safety threat.
In-plane shear		In-plane shear cracks generally do not constitute a life-safety hazard. Nevertheless, this type of damage can cause extensive damage to the walls and the attached plaster which may be historic. When large horizontal and vertical offsets occur at these cracks repair costs may be significant, and result in a loss of historical integrity.
Corner damage	vertical	Life-safety hazard is minimal. The collapse of an entire corner can occur when vertical cracks occur in both planes of a corner, resulting in loss of historic fabric and a costly repair.
	diagonal	Life-safety hazard is minimal. Slippage can occur along diagonal cracks that slant downward toward a corner. If much vertical slippage occurs, the wall may be very difficult to repair, compromising historical integrity.
	cross	Life-safety hazard is minimal. A complex pattern of cracks can lead to significant offsets of sections of the walls. Damage may be difficult to repair if these offsets occur, compromising historical integrity.
Cracks at openings		Life-safety hazard is minimal. The cracks that occur at the tops and bottoms of openings are typically not severe except to the extent that they affect the plaster over and around the cracks, which may be historic.
Damage at intersection of perpendicular walls		Life-safety hazard is minimal, unless other problems occur as a result of this damage. Damage to historic fabric is minimal, unless historic renderings spall.
Slippage between walls and wood framing		If the slippage between the walls and wood framing is not large, then the life-safety hazard is minimal. It may still be costly to repair. If the slippage is large, it may indicate the walls were approaching instability, which is a very hazardous life- safety condition. Normally, historic fabric is little compromised.
Damage at wall or tie-rod anchorage		Life-safety hazard is minimal, unless the local damage leads to other more significant problems. Damage to historic fabric is localized.
Local section instability		In the immediate area, life-safety hazards and loss of historic fabric may be significant.
Horizontal cracks		Life-safety hazard is minimal. These cracks occur when there is a bond beam or the roof is anchored to the walls. If the bond beam is not anchored to the walls, they may slip out from underneath partially or completely. Otherwise, there is usually only a horizontal crack at the interface, which is not particularly significant.

Selection of Buildings for the Detailed Survey

There was a wide range in the amount and types of damage suffered by the adobe buildings in the greater Los Angeles area after the Northridge earthquake. Several buildings suffered extensive damage while others suffered only slight damage. The three most severely damaged buildings were the Del Valle Adobe at Rancho Camulos, the De la Osa Adobe, and the Andres Pico Adobe. Each of these buildings had extensive crack damage in most walls and one or more partially or completely collapsed walls. The fourth building studied in the area of strong ground motion was the Leonis Adobe, where the second story was extensively damaged. Each of these buildings, except for Rancho Camulos, is located in the San Fernando Valley where the ground motion was very strong. Rancho Camulos is located in the Santa Clara Valley over the mountains to the north of the San Fernando Valley, where the ground motion was also strong.

In the San Gabriel Valley, the damage to the Las Tunas and Miguel Blanco Adobes was slight but was moderate to extensive to the convento of the San Gabriel Mission and the Lopez-Lowther Adobe. The susceptibility to damage of the two latter structures was primarily a function of the preexisting condition of the buildings.

The locations of the selected buildings with respect to the earthquake epicenter and estimated contours of maximum accelerations are shown in Figure 3.39. The buildings selected for the in-depth survey were chosen primarily to illustrate as many of the damage types as possible. Many of the damage types were identified in the initial survey but some of the damage types were not recognized until after the data were analyzed. The detailed study of these eight adobe buildings represents an important source of information on the performance of historic adobe buildings during large seismic events.

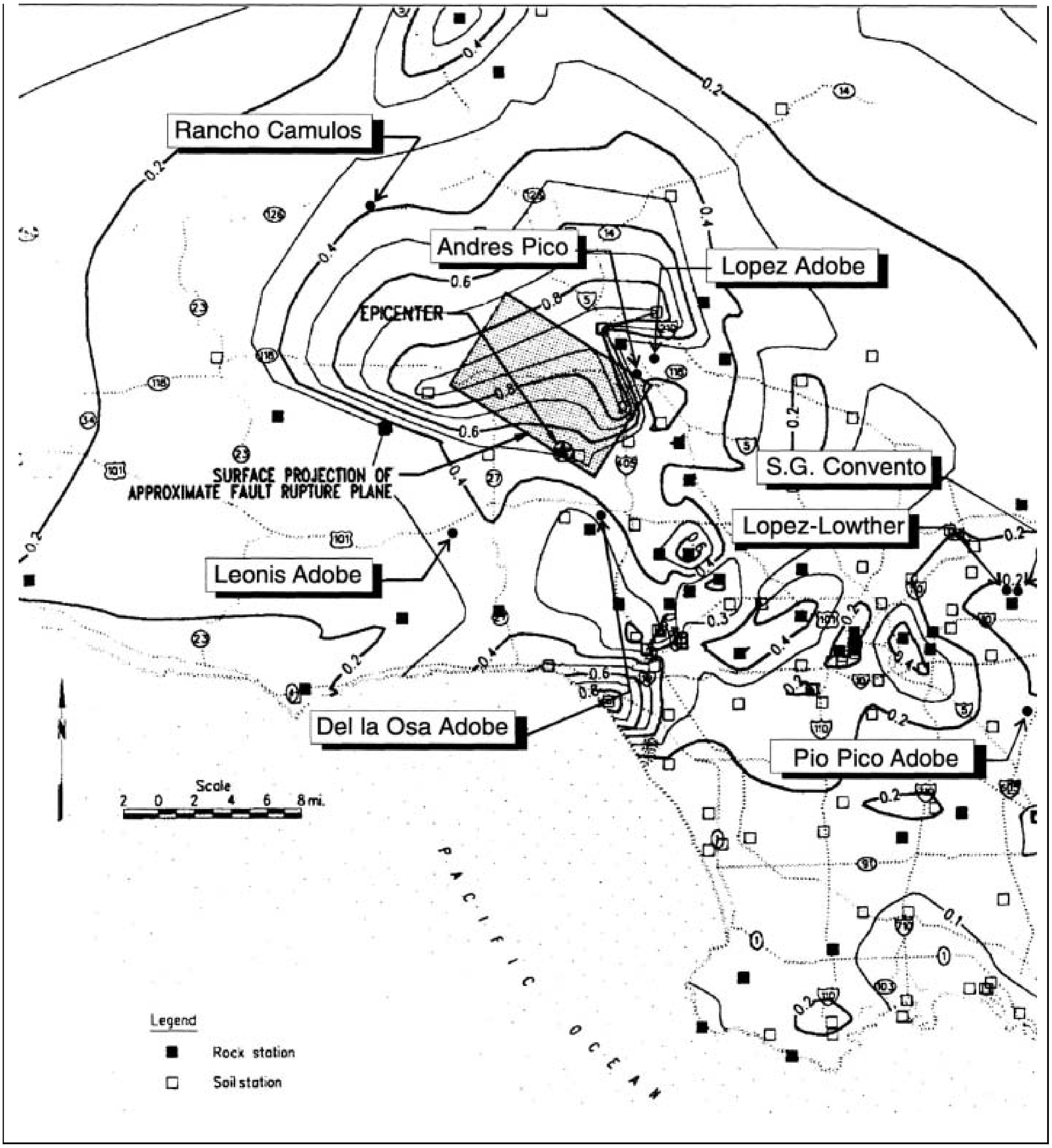


Figure 3.39. *Locations of historic adobe buildings selected for in-depth study Contours of maximum acceleration based on recordings at rock and soil sites.*

Chapter 4

Rancho Camulos

Historical Background

Social history

The Del Valle Adobe at Rancho Camulos, originally Rancho San Francisco, a ranch of Mission San Fernando, evolved through the years into a U-shaped complex with a central courtyard or patio. The Historic American Building Survey dated the earliest portion of the building to 1841 and the additions to about 1846; however, a recent publication provides contradictory information (Delong 1980:163; Smith 1977:passim). The Rancho Camulos Del Valle Adobe complex is considered one of the most representative of California's old ranchos since so many typical elements have survived, including the cocina, chapel, and winery. It is undoubtedly the most famous, having been featured as the home of Ramona in the romance novel by Helen Hunt Jackson. Its significance as a national symbol of the idyllic, pastoral days of early California is difficult to overstate.

Architectural history

The earliest portion of the Del Valle Adobe consists of three rooms, one-and-one-half stories in height, and a one-story, one-room extension. It was also reported to be a four-room building as early as 1853 (Smith 1977:101). This original portion constitutes the majority of the south wing of the U-shaped complex. The room known as Ramona's room to the southeast is the one-story original extension. According to the most trustworthy secondary source available, the building was expanded in 1857 with the addition of three rooms in the garret or tapanco (Smith 1977:110). In the 1860s, six more rooms and a detached kitchen to the north were purportedly constructed. A wine cellar under the most southwesterly bedroom and sala was added during this construction period. The wooden ceiling of the southwest comer bedroom is covered with brea, suggesting that it may have been the finished roof, perhaps temporarily. Flat brea roofs are consistent with early building traditions in Ventura and Los Angeles counties.

Later in the 1870s, more rooms were added to the north end of the western wing of the building (Smith 1977:110). The east corredor (portal or veranda) was extended to the comer of the kitchen after 1895 when A. C. Vroman photographed the open, unconnected northwest comer of the complex (Smith 1977:192). Also, at an unknown time, the northernmost room of the west wing was enlarged with stone and, perhaps at the same time, a stone room was added to the north side of the southwest comer bedroom. Supposedly, a granary and storeroom were added to the kitchen at this time. A plan of the Del Valle Adobe by Rexford Newcomb published in 1925 shows the kitchen building was configured very differently than it is today, or as it was drawn by the Historic American Building Survey (HABS) in 1934, suggesting that major changes were made between 1925 and 1934 (Smith 1977:102). Apparently, the northeast room of the kitchen building (the granary perhaps?) was sacrificed in order to convert the original cocina, as indicated on the 1925 plan, into a garage.

Greek revival detailing of fireplaces, chair railings, or corredor posts can be seen throughout the earlier parts of the building. Wrought-iron wall decorations and fixtures of various types can be observed throughout the building, the handiwork of a German metalsmith, Carl Peters, who came to the present owners' family from the Del Valles early in this century. The continuity of use and tradition is striking, as only two families have ever owned and managed the rancho: the Del Valles and the Rubels.

Rancho Camulos is privately owned and a registered California Historical Landmark but is not listed in the National Register of Historic Places.

Building and Site Description

The principal adobe structure at the Rancho Camulos is U-shaped in plan, covered by hipped roofs, with the exception of the south wing that is gable-roofed at the east end. The overall dimensions are 178 feet, north-south, by 116 feet, east-west. The north wing is connected to the west wing by a breezeway; the west and the south wings are integrated and together form an L-shape; and the open part of the U-shape faces east. The original portion of the structure, which is 18 feet by 68 feet, includes most of the south wing and has a finished half story above.

The site slopes from the north to the south with the difference in elevation between the north side of the north wing and the south side of the south wing being approximately 5 feet. The surrounding soil is alluvium consisting of unconsolidated flood plain deposits of silt, sand, and gravel of up to 100 feet in depth.

The foundation is stone, and there is a stone wall basement located at the southwest corner that encompasses approximately 1,400 square feet.

The present kitchen is another addition adjacent to the original adobe building on the north. A screened and open porch, or corredor, extends around the inside of the U-shaped area, with the main roof extending out over it. A partial corredor is located on the south side of the original portion of the building. The main adobe walls are 24 inches thick and vary in height from 12 feet to 14 feet.

The main floor of the structure is on three levels; the north wing and the north room of the west wing are the highest. The west wing and the west room of the south wing are on the intermediate level but only approximately a foot below the north wing. The south wing, consisting primarily of the original portion of the structure, is approximately 3 feet below the west wing. Steps on the corredors and from the drawing room down into the library make the elevation transition from the west wing to the south wing.

The ceiling systems consist of joists that span the shorter distances between walls. Typical joist size is 2 1/2 x5 inches spaced 20 inches on center. Size varies, as do the on-center distances. In some cases the joist ends rest on wooden plates; in others, they do not. The bearing of the joists varies as well. The majority of joists appear to extend 6 to 12 inches into the adobe walls. In Ramona's room, however, the joists only extend 2 to 3 inches into the walls. Roof rafters are generally full-dimension 2x4s spaced approximately 30 inches on center and rest on wall plates at the outer edge of the walls. Presently the roof is composition shingle over skip sheathing, and in some areas the skip sheathing is overlaid with plywood.

Three major physical conditions influenced the performance of the Del Valle Adobe during the earthquake of January 17, 1994. These include water damage, preexisting cracks, and material weakness. The most significant is moisture damage. There has been water damage to the lower adobe walls and foundation in several locations throughout the building. Repeated wet/dry cycling has resulted in deteriorated and weakened adobe at the base of many walls. The walls around the southeast and southwest bedrooms have been damaged as well as the east and west elevations of the west wing. In many areas, the lower section of the adobe walls has been covered with large concrete patches that hide the moisture-damaged adobe and force the water to rise even higher in the walls.

The adobe material used at Rancho Camulos is a silty, sandy soil with a relatively small amount of clay. As a result, the walls crack at relatively low levels of earthquake excitation.

The building also has many cracks throughout the structure that occurred prior to the Northridge earthquake. From the nature of these cracks, it is likely that many occurred during previous earthquakes. The larger cracks had been filled with concrete and covered with plaster.

Also notable is the fact that no seismic retrofitting had been done to the building prior to the earthquake. Although there are three stone buttresses at the southeast corner bedroom (Ramona's room) and one on the west elevation of the west wing at the north end, it is likely that these were constructed to stabilize the walls for other reasons, such as lower wall moisture damage. There is also a pair of wooden pilasters anchoring a tie rod across the south wing that was probably installed in response to wall leaning. For the most part, there is a lack of elements in the structure that would tie the walls together or tie the roof-ceiling system to the walls.

Estimate of Local Earthquake Intensity

Rancho Camulos is located approximately 18 miles northwest of the epicenter of the Northridge earthquake. The closest CSMIP strong-motion earthquake recording station to the Rancho Camulos site is located approximately 4 miles further to the north at

Lake Piru. The peak ground accelerations (PGAS) downstream from the Santa Felicia Dam were 0.21g (21% of gravity) in the north-south direction, 0.27g in the east-west direction, and 0.13g in the vertical direction. Given the observed minor damage to the wood-frame portions of the complex, these moderately strong ground motions appear to be consistent with what was felt at the site, estimated to have been between 0.3g and 0.4g (see Figure 2.4). The estimated MMI value was between VII and VIII.

Damage Description

The damage to the Del Valle Adobe at Rancho Camulos was very extensive. Two walls of the southeast bedroom (Ramona's room) collapsed. The south wall of the bedroom at the southwest corner of the building collapsed, and the damage to the west wall is irreparable. The gable-end wall at the southeast corner was severely damaged but did not collapse. The stone walls at the north end of the west wing have suffered severe crack damage in the comers.

Crack damage occurred throughout the building. There was damage at building comers in the form of pounding and separation gaps between walls at intersections, spalling of interior and exterior plaster, and spalling of adobe in areas that had been weakened by previous and repeated exposure to water. In many locations, the walls have pulled away from the ceiling joists, and damage to the walls has reduced their ability to support the joists.

Exterior walls

North end, west wing

The stone-masonry north end of the west wing sustained major vertical separation cracks at the comers and a horizontal crack across the north wall at the window sill level, indicating out-of-plane rocking. However, at the east end of the wall, the crack pattern is complicated by a major diagonal crack that runs from above the window lintel down to the base of the northeast comer. Damage to the northeast and northwest comers of this west wing are shown in Figures 4.1 and 4.2, respectively.

Figure 4.1. ***Northeast corner of west wing. Damage at the corner of the stone wall and at the interface between the stone and the adobe.***

West wing

The west wall of the west wing has a crack pattern that indicates out-of-plane rocking, with long horizontal cracks at the base of the wall that turn vertical at some of the interior cross walls (Figure 4.3). This wall is very long with almost no restraint against outward out-of-plane motion except for a buttress near the north end of

Figure 4.2. ***Northwest corner of the west wing. Damage at the corner of the stone wall.***

the adobe wall (Figure 4.4). There is a 3/4-inch separation between the wall and the top of the buttress at the top plate level. Several interior cross walls abut this long wall and provide restraint against inward motion. At a few locations, the horizontal crack pattern turns vertically, indicating the resistance of inward motion provided by the interior walls. The base of the wall has suffered severe moisture damage over a long period of time and has been patched with concrete, brick, and mortar. Much of the plaster along the base of the wall has spalled as a result of compressive stresses during rocking.

At the south end of this long west wall is a stone-masonry bathroom addition that extends out toward the west. There is a separation gap at the intersection of the stone wall with the long adobe wall. Little damage was observed in the stone-masonry walls. However, an old vertical crack does exist at the interface between the west-facing stone wall and the adjacent west-facing adobe wall of the southwest corner bedroom.

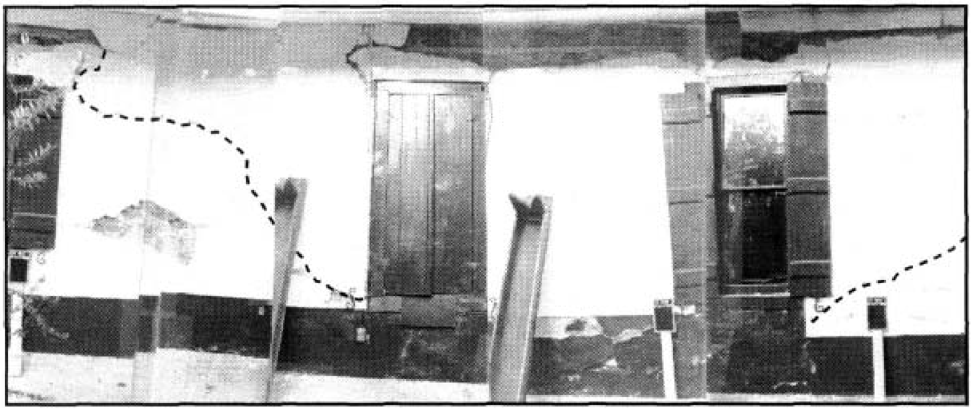


Figure 4.3. ***West wall of west wing. Flexural crack extends from upper left diagonally to the base of the wall and along base (dotted line along crack).***

Southwest corner bedroom

The west wall of the bedroom has a severe diagonal crack that runs from the rafter level at the northwest corner of the room down and across to the southwest corner, through the window at the sill level (Figure 4.5). The in-plane horizontal offset of this crack is approximately 2 inches. This wall also had out-of-plane flexural damage as evidenced by a vertical crack at the northwest corner that transitions into a horizontal crack at the base.

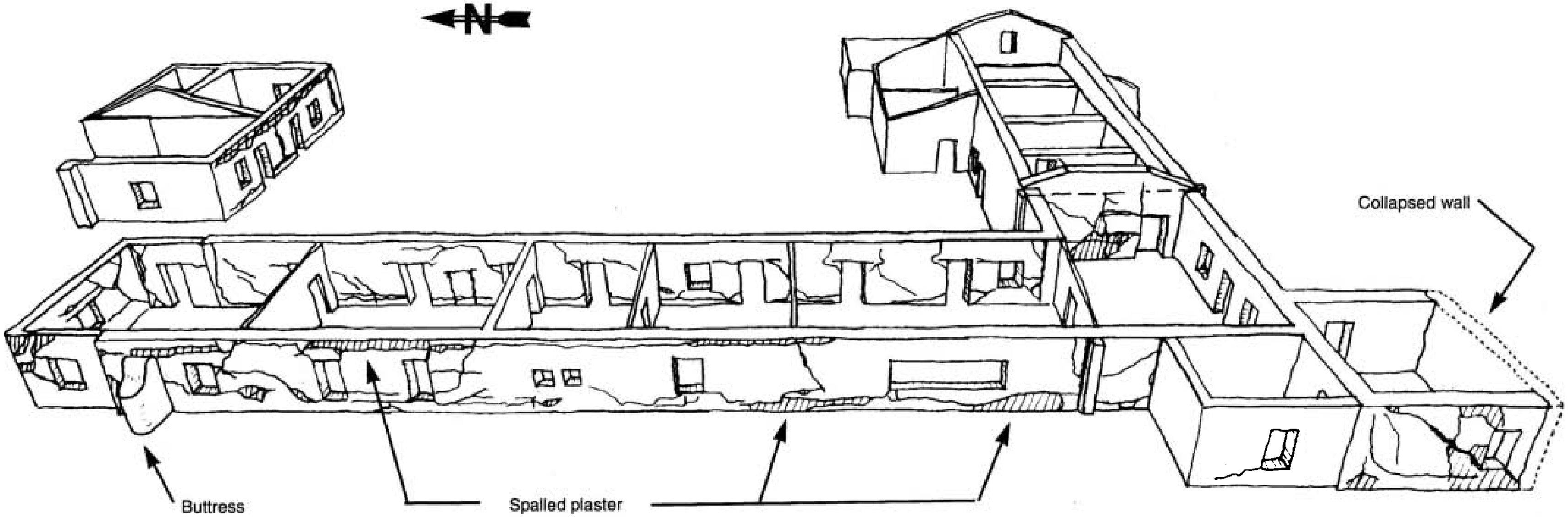


Figure 4.4. *Drawing of Del Valle Adobe at Rancho Camulos, viewed from the west.*

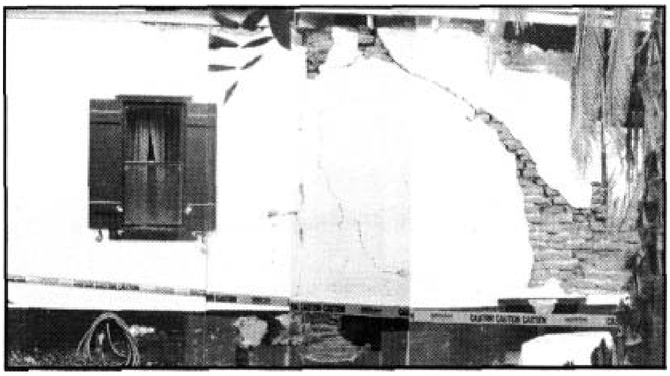


Figure 4.5. ***Exterior elevation of the west wall of the bedroom at the southwest comer of the residence. The diagonal crack is a shear crack with a permanent offset of approximately 2 inches.***

The south adobe wall of the southwest corner bedroom completely collapsed (Figures 4.4, 4.6, and 4.7), bringing down the ceiling joists and leaving nearly vertical interfaces at the abutting east and west walls. The roof remains intact as this south wall was not a primary load-bearing wall.

The east wall of this bedroom is also damaged, although not nearly as seriously as the west wall. There is some separation damage at the interface with the south wall of the drawing room.

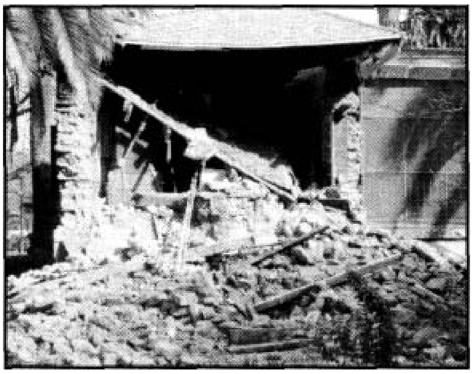


Figure 4.6. ***Southwest corner bedroom. The south wall collapsed and the east and west walls of this room were also seriously damaged with large cracks and permanent offsets.***

South wall, south wing

The south wall of the south wing changes elevation between the drawing room and the library. There is also a wooden pilaster at this juncture that anchors a steel tie rod that spans between the exterior long walls. Damage to the south wall appears to be mostly related to out-of-plane rocking with horizontal cracks and plaster spalling extending along the base of the wall at the lintel level and at the top plate level as well as vertical cracks at the cross walls and at mid-span between them (Figure 4.7). Adobe cross walls provide restraint against movement to the inside. However, except for the tie rod at the library west wall, there is very little restraint to outward leaning, which is exactly what happened along this portion of the south wall. There are separation gaps of approximately 2 inches at the cross wall interfaces, with resultant pullout of the ceiling joists. At the central wall sections between the two doorways there is evidence of in-plane shear cracking.

Ramona's room

At the east end of the south wing is a bedroom known as Ramona's room. It is built of 12-inch-thick adobe walls. There have apparently been problems over the years as the south and east walls are buttressed and concrete wainscoting has been used on the interior, all of which are earlier attempts to address either earthquake or moisture damage.

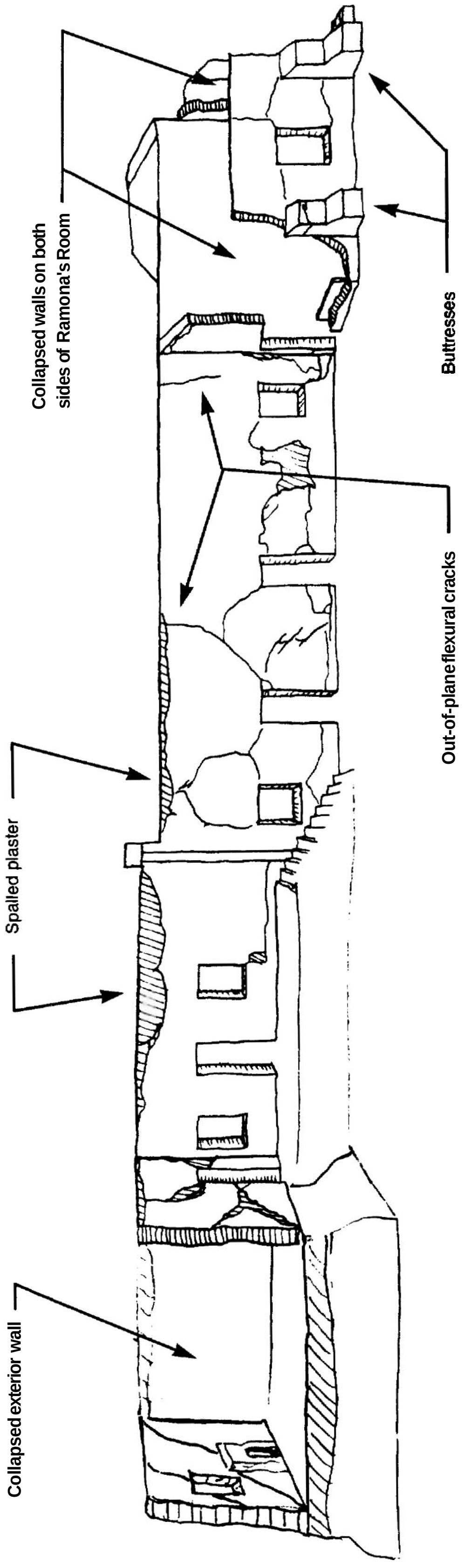


Figure 4.7. Drawing of Del Valle Adobe at Rancho Camulos, south elevation.

Partial collapse of the west and south walls and complete collapse of the east wall occurred (Figures 4.7 through 4.9) during the Northridge earthquake. However, because the central portion of the south wall was supported by two buttresses, the ceiling did not collapse. It appears that much of the collapse mechanism was the result of through-wall shear failure of the water-damaged adobe cross-section at the base, as seen in Figure 4.8. This failure mechanism contrasts with overturning failure in which the entire wall collapses by falling outward perpendicular to the plane of the wall.

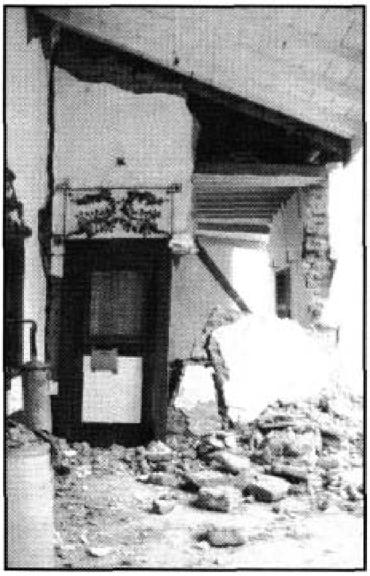


Figure 4.8. ***West wall of Ramona's room. The majority of this wall collapsed leaving only the section of wall that is above the door.***

Figure 4.9. ***Southeast corner of Ramona's room. The buttresses on the south wall prevented collapse of that wall. The east wall of Ramona's room collapsed during the earthquake. The gable-end wall did not collapse but suffered serious damage (more details are shown in Figure 4.10).***

East gable-end wall, south wing

The east gable-end wall suffered severe crack damage (Figures 4.10 and 4.11) but did not collapse. The cracks in this wall extend upward from the top of the door, upward from the bottom of the door, between the door and windows, and horizontally from the top of the window. This section of wall is partially restrained by the roof rafter at the top edge of the wall.

There is a separation crack of 1 1/2 to 2 inches at the top of the buttress on the east wall and a horizontal crack at the base of the buttress, indicating that it rocked outward away from the east wall. The crack pattern in this wall suggests a mixture of out-of-plane flexure at the upper floor level and in-plane racking of the entire wall.

The extension of the south wing at the northeast comer, including the kitchen and dining room, are wood-frame construction and suffered only minor crack damage in the stucco, primarily at the corners of doorways and window openings.

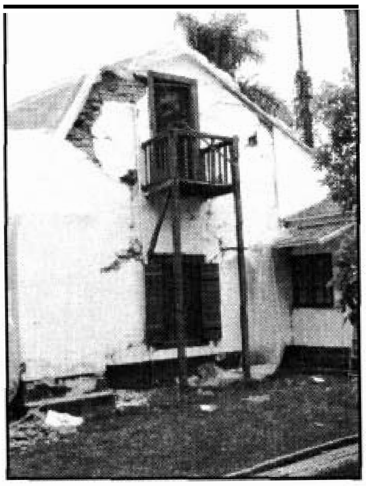


Figure 4.10. *Gable-end wall of the south wing. The crack damage to this wall was extensive with cracks emanating from the corners of the door and window Some restraint is provided on the inside of the wall by interior paneling.*

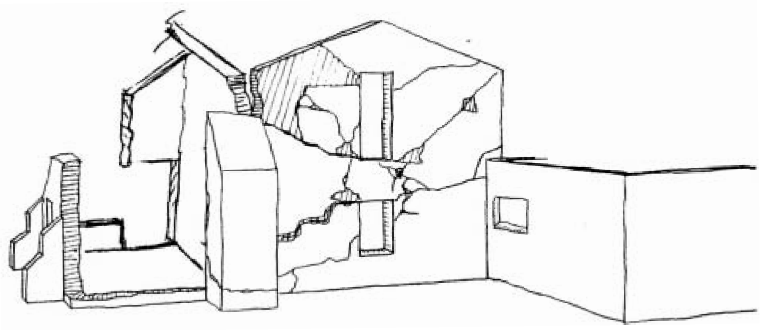


Figure 4.11. *Drawing of damaged gable-end wall on the east end of the south wing.*

North wall, south wing

On the north wall of the south wing the crack damage is primarily vertical and horizontal, indicating out-of-plane flexural modes (Figures 4.12 and 4.13). Vertical cracks line up with interior cross walls and mid-span in the upper portion of the wall. Horizontal cracks were observed again at the base of the wall, extending upward at the cross walls.

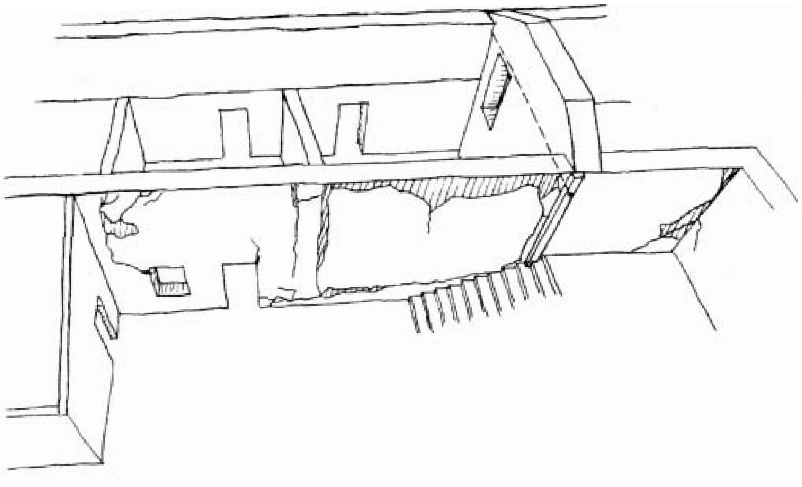


Figure 4.12. *Drawing of damage to the north wall of the south wing, similar to that shown in Figure 4.13.*

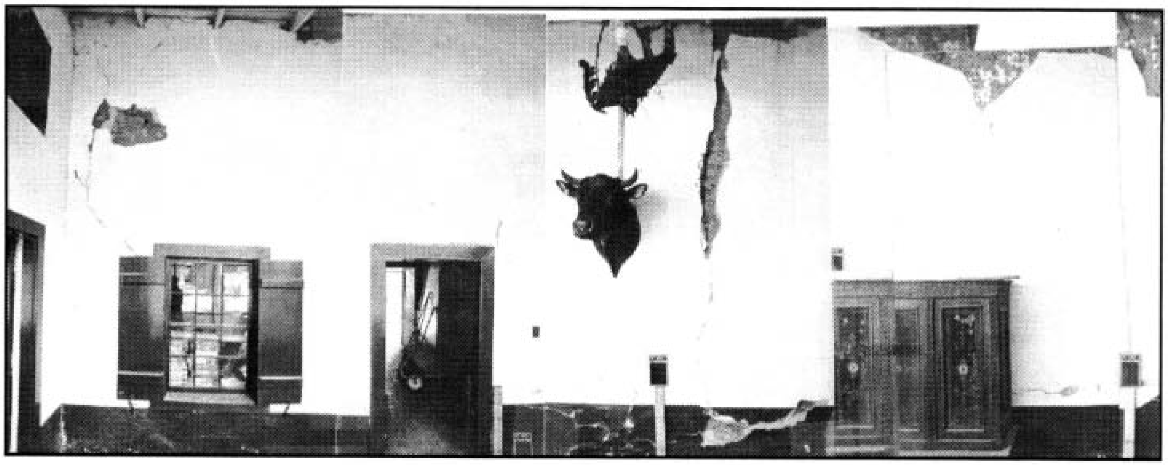


Figure 4.13. ***North wall of the south wing. This photograph shows the flexural cracking that has developed vertically at perpendicular walls and along the base of the wall between perpendicular walls. Despite the cracking, the wall is only slightly out of plumb.***

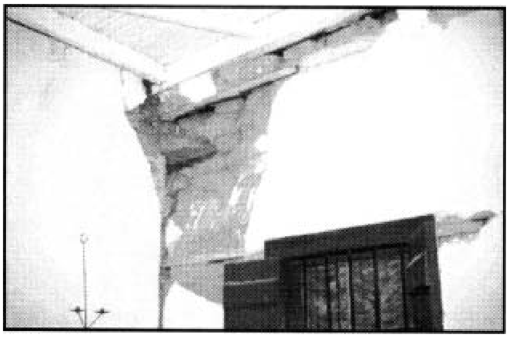


Figure 4.14. ***Damage to the adobe at the reentrant corner of the L-shaped main residence. The adobe at this intersection was severely broken and some of the adobe spalled.***

At the west end of this wall is a reentrant comer where it abuts the east wall of the west wing. Damage to the adobe at this location is severe (Figure 4.14), showing the effects of separation, pounding and out-of-plane rocking.

East wall, west wing

The east wall of the west wing is long and, like the west wall, has almost no out-of-plane support except for a few interior wood-frame and one adobe cross wall (Figure 4.15). The crack damage along this wall includes diagonal shear cracks in most of the wall sections, usually starting at the lintel level and proceeding downward to the base of the wall. A couple of the wall sections with both door and window openings show evidence of in-plane pier rocking.

This wall also shows signs of rocking out of plane, with horizontal cracks along the base of the wall and at the top plate level (Figure 4.16). Pullout of the ceiling joists and separation gaps of as much as 1.5 inches at the interface with the cross walls were observed. The horizontal cracks at the base of the wall are also accompanied by severe spalling of plaster and adobe resulting from moisture damage.

The adobe wall abuts a stone-masonry addition at the north end, and a significant vertical separation crack exists at this juncture. Another significant separation crack exists at the northeast comer of the north end room (Figure 4.1).

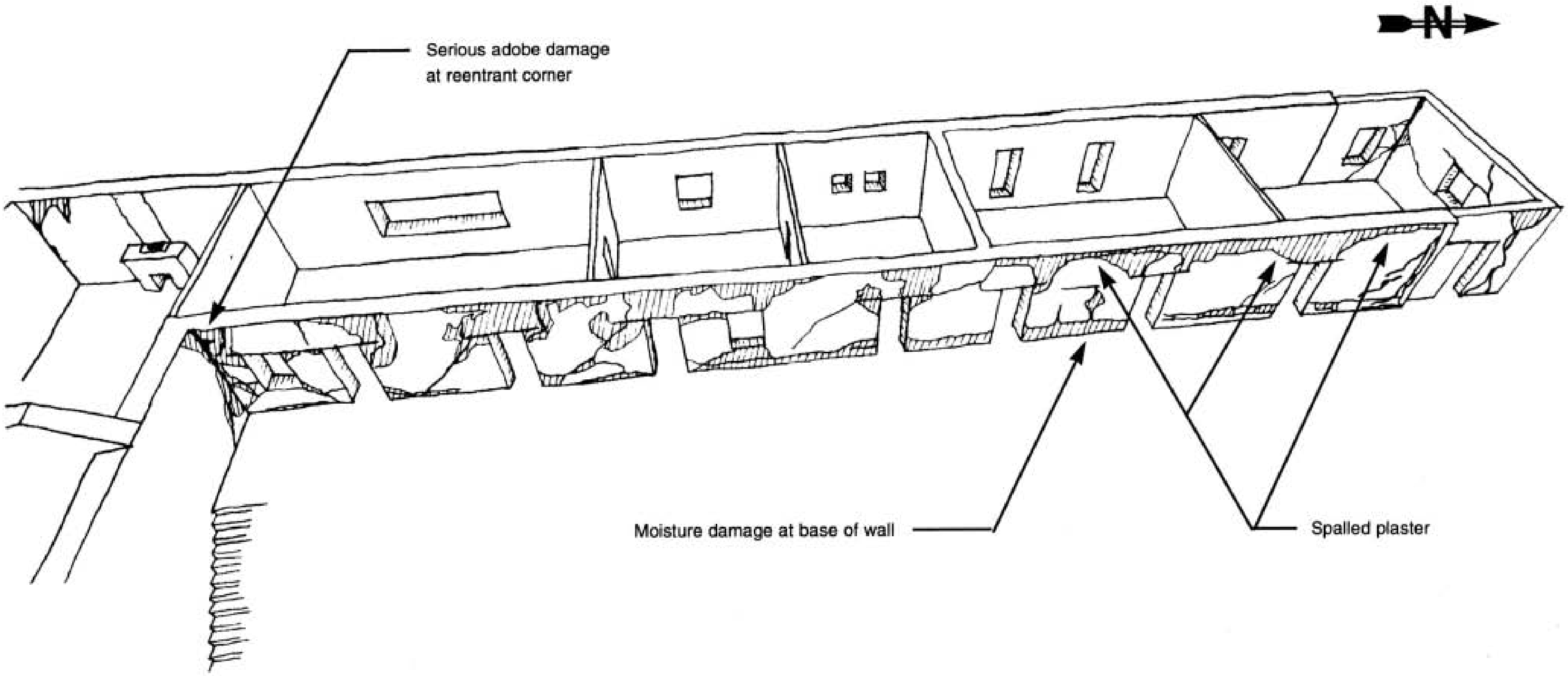


Figure 4.15. *Drawing of Del Valle Adobe at Rancho Camulos. West wing viewed from the east.*

Interior walls

The interior walls are adobe in the south and north wings and adobe and wood-frame in the west wing. Except for the steel tie rod across the south wing at the west wall of the library, these interior cross walls are not adequately anchored into the longitudinal exterior walls. This has resulted in varying degrees of separation from the long walls at their interfaces.

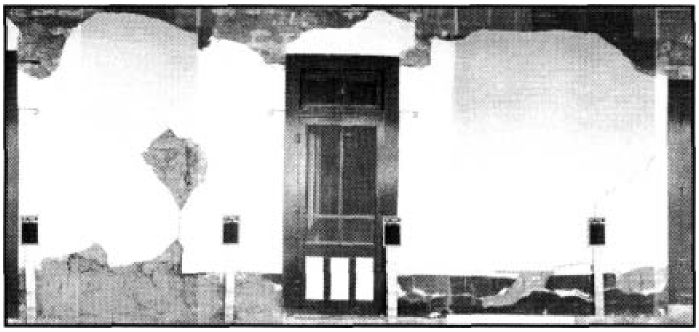


Figure 4.16. ***East wall of west wing. Flexural crack extends from upper left diagonally to the base of the wall and along the base.***

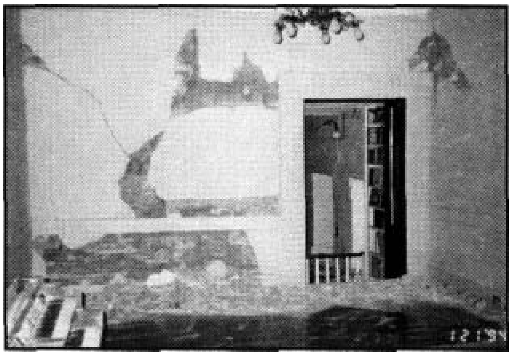


Figure 4.17. ***Interior cross wall on west side of library. Diagonal shear cracks start at upper left and a gap between this wall and the exterior wall opened as shown on the right. The damage in the center of the wall reveals infilled openings, one above the other.***

Of particular note are the east and west cross walls of the library. In addition to the 2-inch separation gaps at the south longitudinal wall, there are significant diagonal cracks starting at the upper north corners and extending downward and across toward the south. In the west library wall the crack pattern is complicated by the presence of infilled door and/or window openings, one above the other. This was formerly the west exterior wall of the original adobe structure with a tapanco (loft) access high in the wall (Figure 4.17).

The only adobe interior cross wall in the west wing suffered damage in an area where large chases were cut into it for heating vents. There is little damage at the intersection of this interior wall and the exterior walls.

Other damage

The major damage to the north wing, or servants' quarters, consisted of out-of-plane rocking and flexural cracking of the south wall, where a horizontal crack was observed to extend across the entire length, and vertical cracks formed at the location of the interior cross wall and where the east end wall abuts the south wall. Plaster damage at the top of the south wall was heavy, where it appears that the through-wall ceiling joists pushed on the exterior plaster and popped it off the adobe surface. Ceiling joists in several locations slid on top of the walls, causing adobe and plaster damage (Figure 4.18). Other damage was moderate but greatly influenced by preexisting conditions such as possible moisture damage to the east end wall and previously patched crack damage on the north wall.

Overall Structural Performance

The behavior of the Del Valle Adobe at Rancho Camulos demonstrates many aspects of historic adobe construction that are vulnerable to damage. The collapse of the wall on the south side of the building is largely attributed to preexisting moisture damage. The gable-end wall on the east end of the south wing was severely cracked but did not collapse. The long, tall north and south walls of the south wing rocked out of plane and caused in-plane damage to the transverse walls. The walls on the west wing appear to have suffered a combination of in-plane and out-of-plane damage.

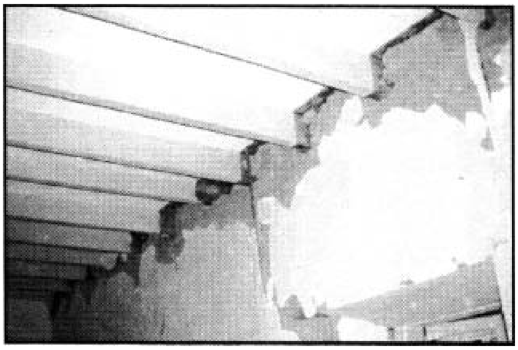


Figure 4.18. *Damage at the interface between the ceiling joists and the adobe walls. This was typical throughout the structure.*

The physical condition of the Del Valle Adobe prior to the Northridge earthquake adversely affected the structural performance of this building during the earthquake. The adobe material is low strength, the lower sections of the walls in many locations had suffered significant and repeated water damage, the structural elements were either not connected or poorly connected, and the building had substantial preexisting crack damage, presumably from prior earthquakes and/or movement caused by moisture problems.

The collapse of the east and west walls of Ramona's room and the collapse of the south wall of the southwest bedroom were largely attributed to the poor condition of the adobe at the base of these walls at the time of the earthquake. Preexisting moisture damage allowed through-wall shear planes to develop that allowed the walls to slip off their foundation supports and collapse on themselves.

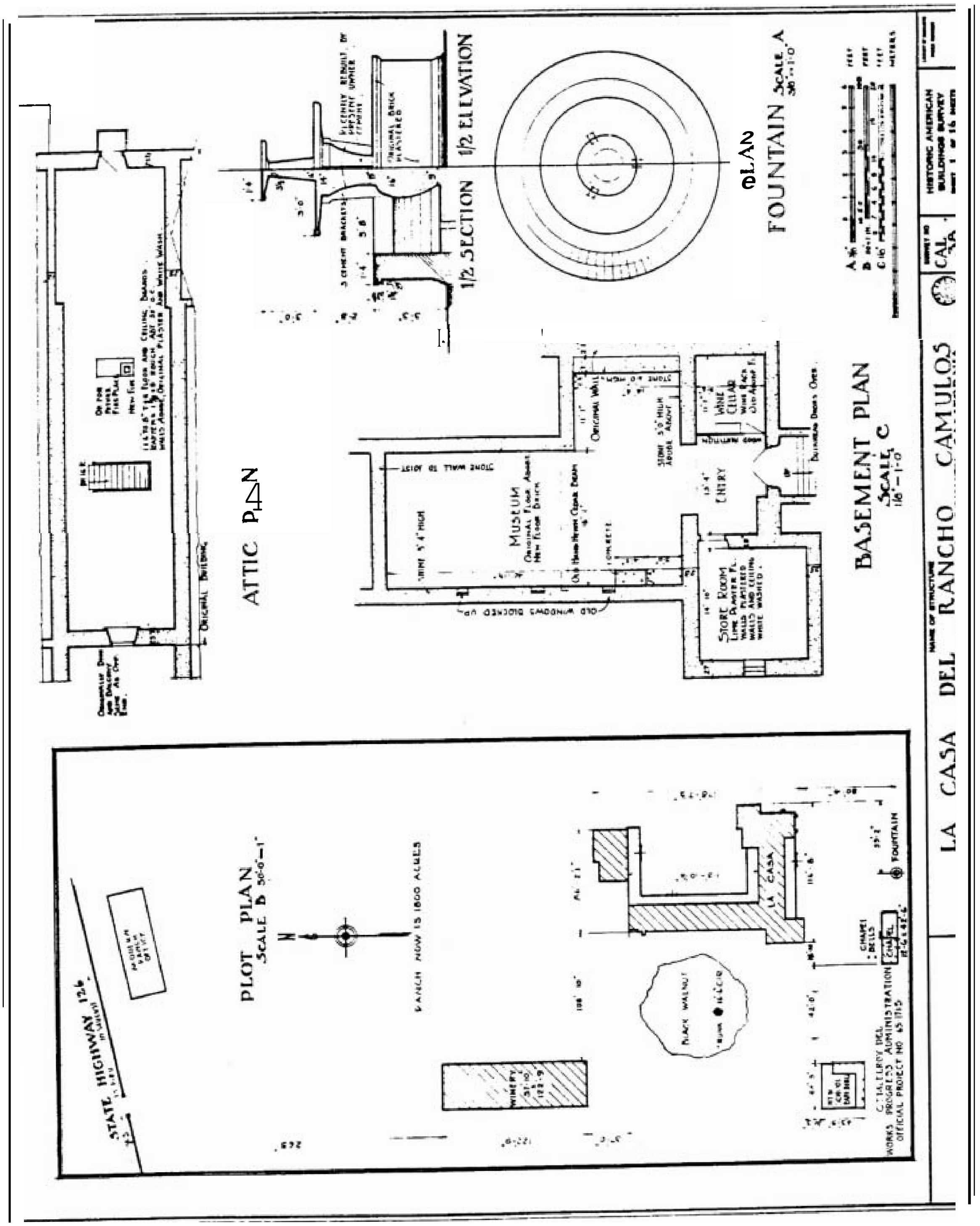
Other damage occurred at comers and at the connection between the walls and ceiling framing. Corners are always susceptible to additional damage because of the large, out-of-plane motions of one wall and the small, in-plane deflections of the transverse wall. In both the south and west wings, the out-of-plane rocking of the longitudinal walls was not well coupled by the floor or roof system and led to deterioration of the adobe around the ceiling joists.

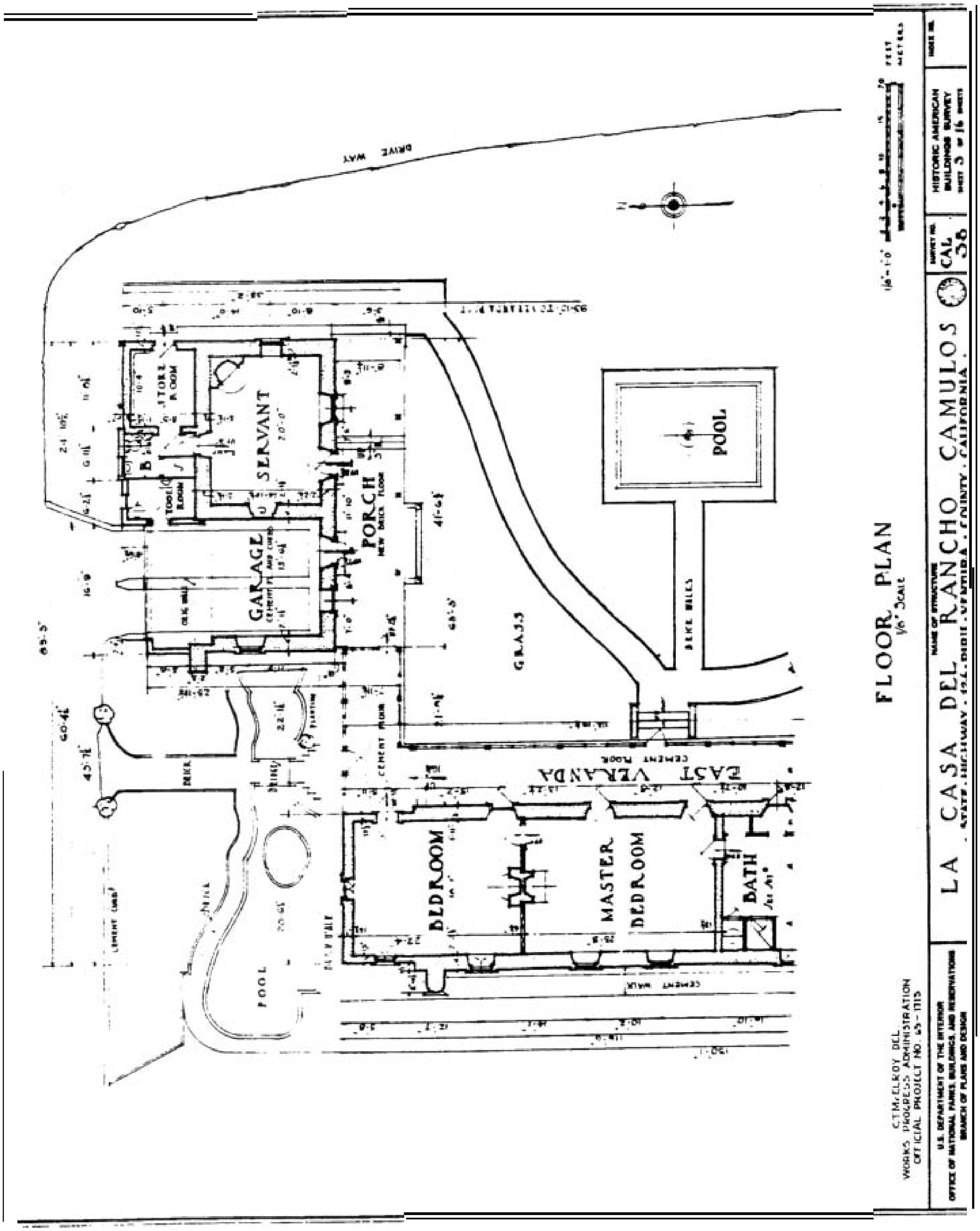
Given these initial conditions and the level of local ground motion, significant damage to the building would be expected. Much of the cracking pattern is the result of the overall configuration of the building, as well as the basic material strength. In addition, the level of damage was exacerbated by the lack of appropriate interconnection of structural elements and poor maintenance. The level of crack damage to the Del Valle

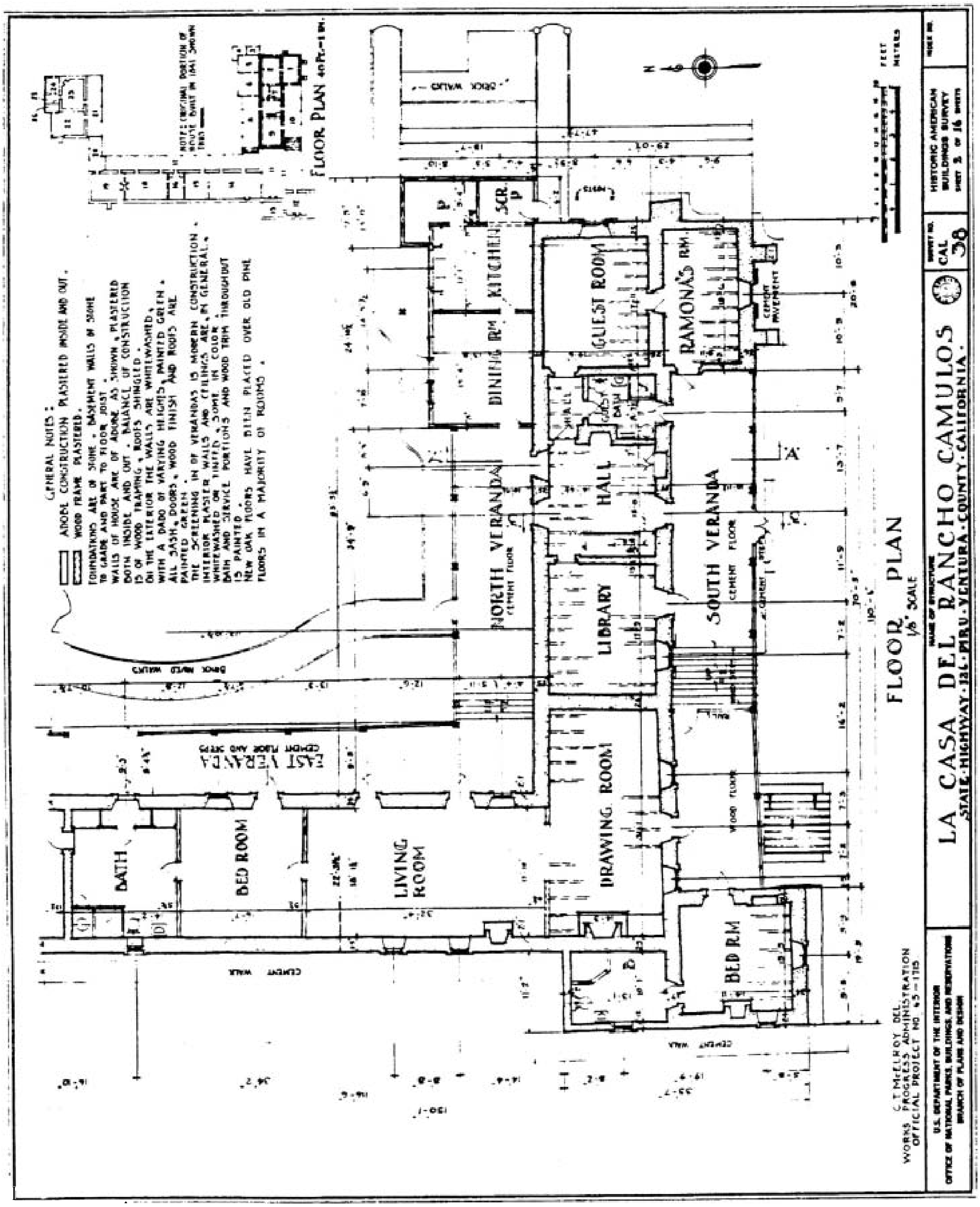
Adobe is considered to be very extensive, with partial and total collapse of some structural elements.

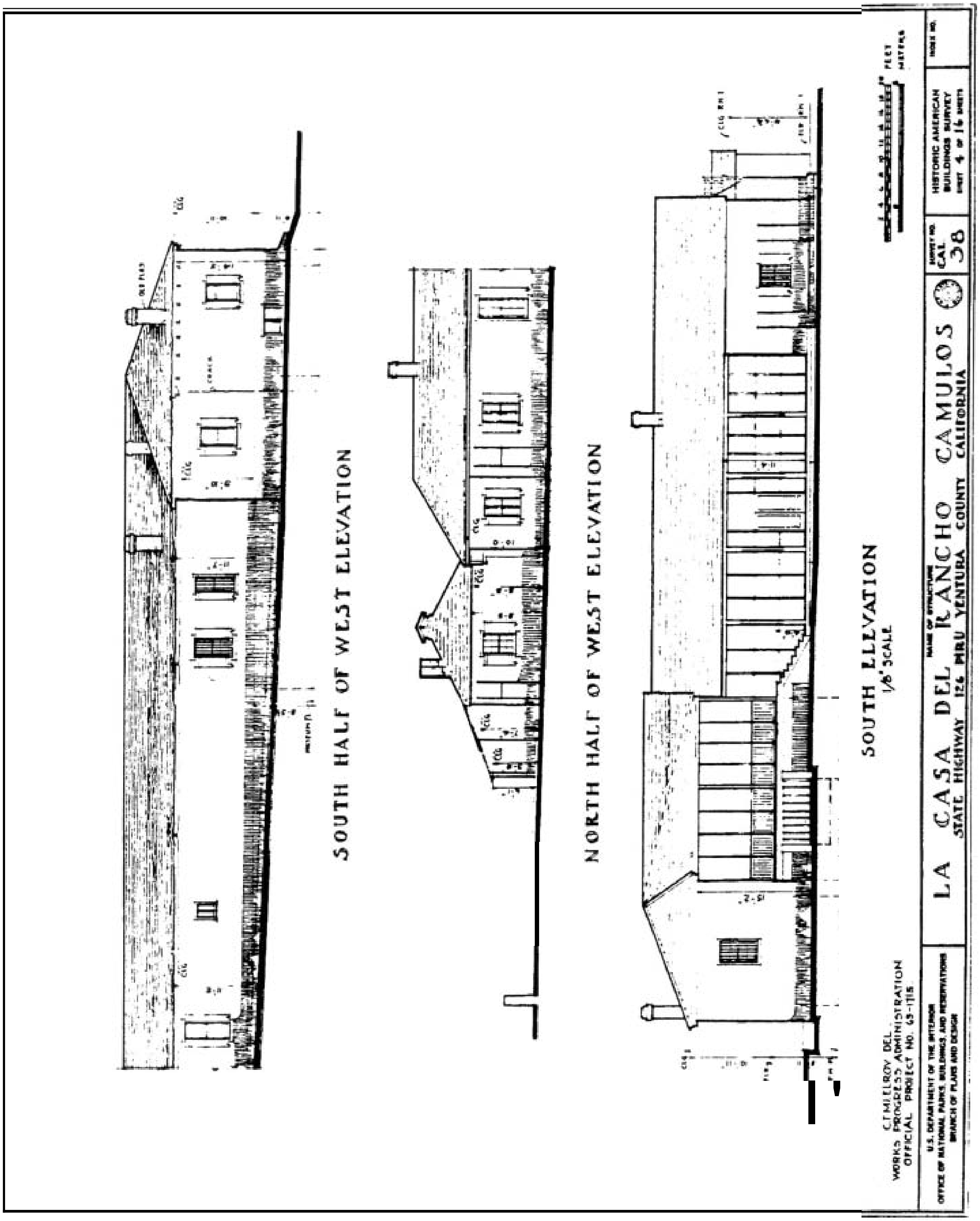
One interpretation of the damage pattern is that the major component of ground motion was in the north-south direction, with at least one large thrust toward the north, resulting in a consistent pattern of shear cracks in the walls that run in the north-south direction. These walls include the east wall of the west wing, the west wall of the southwest corner bedroom, and the east gable-end wall of the south wing. In addition, the out-of-plane rocking and separation damage to the north wall of the west wing, the large separation gaps between the south wall of the south wing and the cross walls, the out-of-plane flexural damage to the north and south long walls of the south wing, as well as the collapse of the south wall of the southwest corner bedroom, are all strong indications of a significant movement to the north.

Motion in the east-west direction also appears to have been strong, but apparently not as strong as in the north-south direction. It did cause out-of-plane rocking of the east and west walls of the west wing, but these walls were quite susceptible to this type of damage, having little or no out-of-plane restraint, weakened wall bases, and little coupling of the two walls from the ceiling or roof structures. The out-of-plane damage to the east gable-end wall also is an indication of this motion. However, there is very little in the way of in-plane shear cracking in the north and south longitudinal walls of the south wing.


ATTIC PLAN
Original Building
1/2 SECTION
1/2 ELEVATION
FOUNTAIN PLAN Scale A 3/8"=1'-0"
Original Brick Plastered
3 Cement Brackets
BASEMENT PLAN Scale C 1/8"=1'-0"
Museum
Store Room
Entry
Wine Cellar
Original Wall
Old Windows Blocked Up
Stone Wall to Joist
PLOT PLAN Scale B 50'-0"=1"
State Highway 126
Ranch Now is 1800 Acres
La Casa
Fountain
Chapel
Bells
Black Walnut
Winery
Works Progress Administration
Historic American Buildings Survey
CAL
LA CASA DEL RANCHO CAMULOS


FLOOR PLAN
1/8" SCALE
LA CASA DEL RANCHO CAMULOS
VENTURA COUNTY . CALIFORNIA
HISTORIC AMERICAN BUILDINGS SURVEY
CAL 38
C.T.McELROY DEL.
WORKS PROGRESS ADMINISTRATION
OFFICIAL PROJECT NO. 65-1315
U.S. DEPARTMENT OF THE INTERIOR
DRIVE WAY
POOL
GRASS
BRICK WALKS
EAST VERANDA
CEMENT FLOOR
CEMENT WALK
BEDROOM
MASTER BEDROOM
BATH
GARAGE
PORCH
NEW BRICK FLOOR
SERVANT
STORE ROOM
TOOL ROOM
POOL


GENERAL NOTES :
ADOBE CONSTRUCTION PLASTERED INSIDE AND OUT.
WOOD FRAME PLASTERED.
FOUNDATIONS ARE OF STONE. BASEMENT WALLS OF STONE TO GRADE AND PART TO FLOOR JOIST.
WALLS OF HOUSE ARE OF ADOBE AS SHOWN, PLASTERED BOTH INSIDE AND OUT. BALANCE OF CONSTRUCTION IS OF WOOD FRAMING, ROOFS SHINGLED.
ON THE EXTERIOR THE WALLS ARE WHITEWASHED, WITH A DADO OF VARYING HEIGHTS, PAINTED GREEN.
ALL SASH, DOORS, WOOD FINISH AND ROOFS ARE PAINTED GREEN.
THE SCREENING IN OF VERANDAS IS MODERN CONSTRUCTION.
INTERIOR PLASTER WALLS AND CEILINGS ARE, IN GENERAL, WHITEWASHED OR TINTED, SOME IN COLOR.
BATH AND SERVICE PORTIONS AND WOOD TRIM THROUGHOUT IS PAINTED.
NEW OAK FLOORS HAVE BEEN PLACED OVER OLD PINE FLOORS IN A MAJORITY OF ROOMS.
NOTE: ORIGINAL PORTION OF HOUSE BUILT IN 1841 SHOWN THUS
FLOOR PLAN 40 FT.=1 IN.
BATH
BED ROOM
EAST VERANDA
CEMENT FLOOR AND STEPS
LIVING ROOM
BRICK PAVED WALKS
CEMENT WALK
NORTH VERANDA
CEMENT FLOOR
DINING RM
KITCHEN
SCR. P
P
BRICK WALKS
DRAWING ROOM
LIBRARY
HALL
HALL
GUEST BATH
GUEST ROOM
RAMONA'S RM.
SOUTH VERANDA
CEMENT FLOOR
WOOD FLOOR
CEMENT PAVEMENT
BED RM
N
A
FEET
METERS
FLOOR PLAN
1/8" SCALE
C.T. McELROY DEL.
WORKS PROGRESS ADMINISTRATION
OFFICIAL PROJECT NO. 65-1715
U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
BRANCH OF PLANS AND DESIGN
NAME OF STRUCTURE
LA CASA DEL RANCHO CAMULOS
STATE HIGHWAY 126 · PIRU · VENTURA · COUNTY · CALIFORNIA ·
SURVEY NO.
CAL 38
HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 2 OF 16 SHEETS
INDEX NO.


SOUTH HALF OF WEST ELEVATION
NORTH HALF OF WEST ELEVATION
SOUTH ELEVATION
1/8" SCALE
CLG
CRACK
FEET
METERS
C.T. MIELROY DEL.
WORKS PROGRESS ADMINISTRATION
OFFICIAL PROJECT NO. 65-1315
U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
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SURVEY NO.
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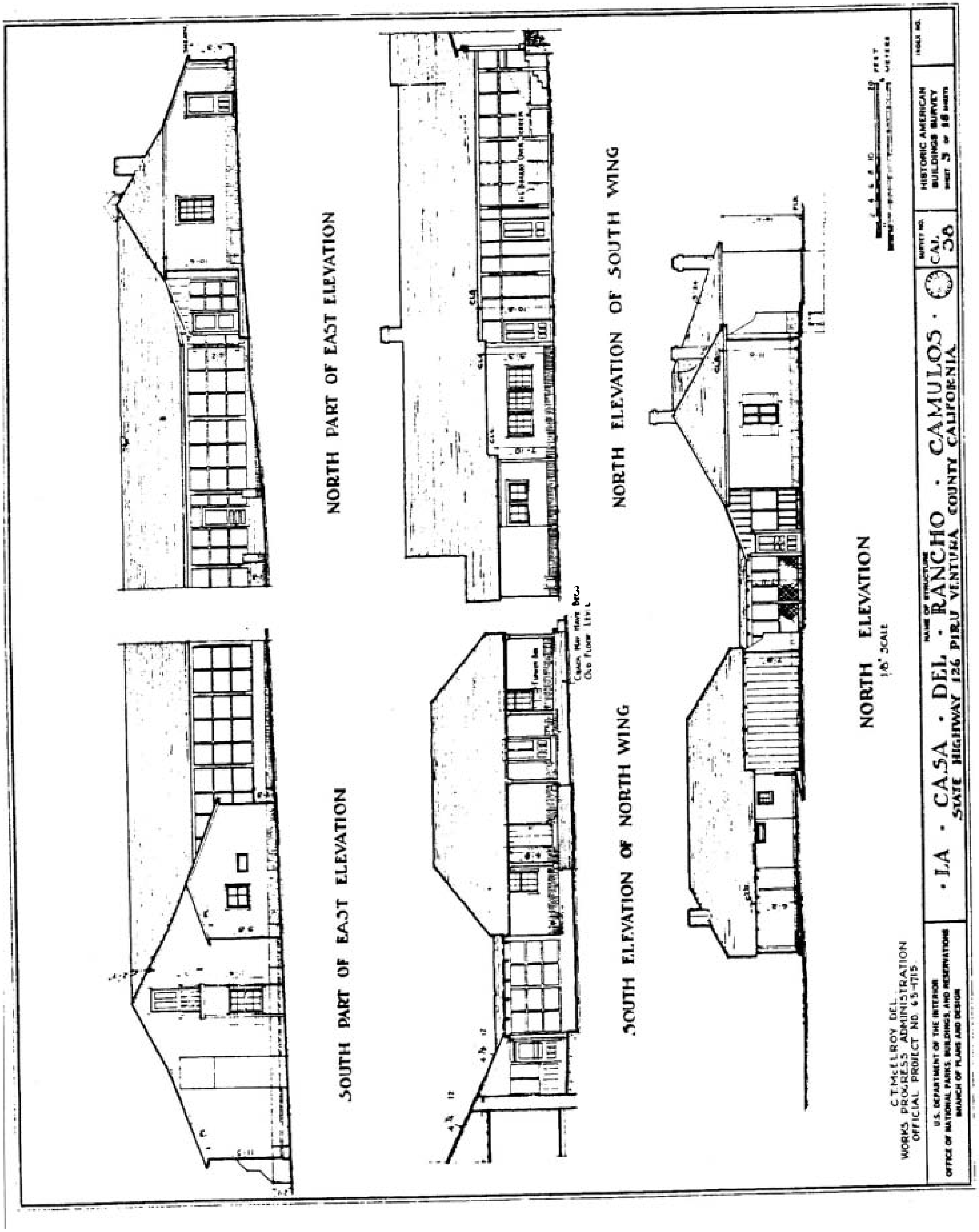
HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 4 OF 16 SHEETS
INDEX NO.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HISTORIC AMERICAN BUILDINGS SURVEY
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INDEX NO.

Chapter 5

Andres Pico Adobe

History and Background

Social history

The earliest portion of the Andres Pico Adobe is thought to have been constructed in about 1834 on the mission grounds by San Fernando Mission Native American neophytes (Harrington 1976:1). It was eventually acquired by Andres Pico in 1853 along with much of the San Fernando Mission estate after the latter was sold by Governor Pio Pico to Eulogio de Celis. Celis is thought to have used the adobe as a country residence and may have been responsible for adding on to the original one-room structure successively (Robinson 1966:10). Andres Pico lived in the mission convento and installed his son Romulo and family in this dwelling. They continued to own this property known as the Pico Reserve after Andres Pico no longer owned the rest of the mission lands (Robinson 1966:14). The building might more appropriately be called the Romulo Pico Adobe.

Architectural history

Between 1816 and 1860 the rooms to the north and south of the sala are thought to have been added to the original one-room structure by the former owner, Celis (Andres Pico Adobe brochure). The adobe was thoroughly remodeled in approximately 1873 by Romulo Pico, who may have added one or both of the one-story adobe wings to the west and installed wooden floors over the earlier ladrillo pavement. The half story is reported to have been added at this time (perhaps to a flat-roofed structure), although tapanco construction was common in the mission era (Harrington 1976:3). Differences in the material composition of the foundations of various rooms of the building suggest that the Andres Pico Adobe was built piecemeal. Ladrillo tile floors of the mission era were uncovered in the northernmost two rooms (library and sala) only (Giffen 1955:16).

The Andres Pico Adobe was substantially rehabilitated by archaeologist Mark Harrington as his family home in 1930 after having fallen into ruins (Figures 5.1 through 5.3). The building was one and one-half stories in height and had an exterior staircase leading to the north gable-end access to the tapanco space. Harrington installed an interior staircase and transformed the former landing into a cantilevered balcony, a modification similar to that made to the Rancho Sausal Castro Adobe in Salinas, but without historical prototype.

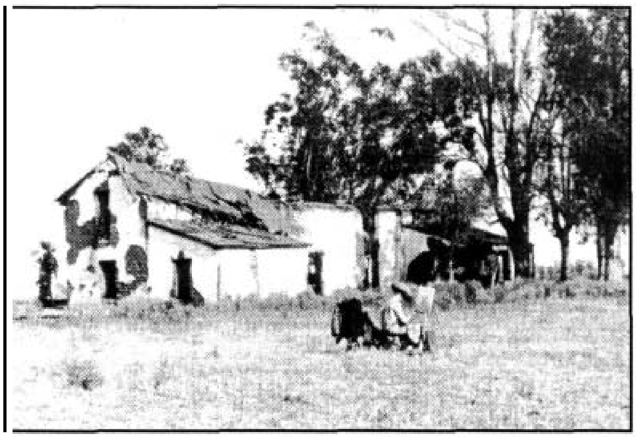


Figure 5.1. *The Andres Pico Adobe from the northwest before reconstruction, approximately 1930 (source: San Fernando Valley Historical Association).*

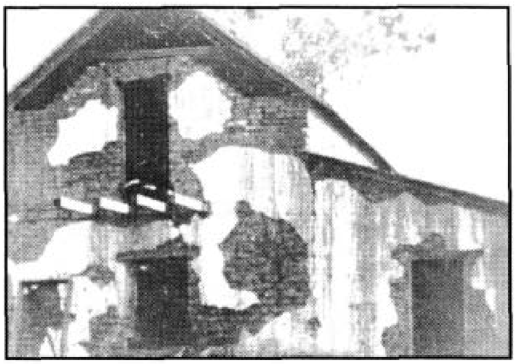


Figure 5.2. *The Andres Pico Adobe north wall before reconstruction, approximately 1930 (source: San Fernando Valley Historical Association).*

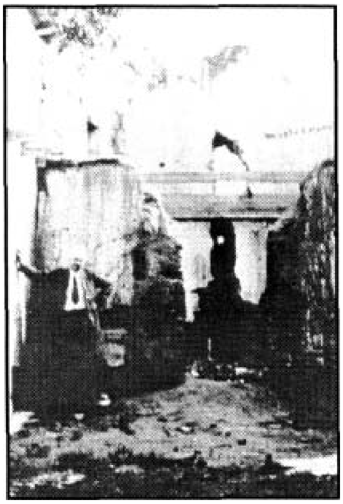


Figure 5.3. *The Andres Pico Adobe south wall before reconstruction, approximately 1930 (source: San Fernando Valley Historical Association).*

Historical photographs taken during the reconstruction process indicate that Harrington replaced the top courses of the half story or tapanco area including the gable ends, possibly raising them. Architectural features dating to the 1870s such as six-over-six window sashes were replaced by Harrington with multiple-pane casement windows he considered more appropriate to the mission era. He made a number of architectural changes in a similar vein, creating a hybrid—perhaps more reflective of Harrington's taste for idealized Spanish colonial revival architecture than architectural historical realities. The fireplace in the living room is a contemporary addition, as is the design of that in the dining room. The building was lime plastered by Harrington’s workers. Harrington designed the patio in the popular revival mode with a Spanish-style fountain and an adobe garage. His wife reported that he uncovered archaeological evidence for the fountain and merely rebuilt the patio walls (Harrington 19765). The dark interior woodwork of the adobe reflects changes made by a later owner who tiled the roof, further intensifying the mission appearance of the building.

Historical photographs show that the south gable-end wall was badly cracked at the time of the Harrington rehabilitation. Cracks in the south gable-end wall were also observed and recorded in 1991 during the initial survey by the Getty Seismic Adobe Project team.

The Andres Pico Adobe is an important document for future understanding of how frontier Americans have participated in re-creating their past—in this instance, a romanticized Spanish California version. Many reintegrated historic adobe buildings exist in California; few have escaped one form or another of idealized restoration or rehabilitation. The Andres Pico Adobe, however, stands out as one that was consciously altered by an academic who was professionally involved in the field of historic preservation.

The Andres Pico Adobe is publicly owned, a registered California Historical Landmark, and listed in the National Register of Historic Places.

Building and Site Description

The Andres Pico Adobe consists of a two-story main structure, one-story additions, a patio wall, and a garage. The two-story portion is approximately 75 feet long and 18 feet wide and is oriented along a north-south axis. A one-story corredor extends along the entire east side and along the central portion of the west side in the patio area.

The site is relatively flat. The surrounding soil is recent alluvium consisting of clay, silt, sand, and gravel, all of which are unconsolidated and poorly to well stratified. There does not appear to be an obvious site drainage problem, although moisture intrusion in some of the walls has been a significant problem in the past.

The foundation is primarily river cobbles, although in some portions of the building fragments of mission tile have also been used.

The walls of the main two-story portion are 2 feet thick up to the second floor and are 20 inches above that. The height of the east and west longitudinal walls is 15 1/2 feet and the height of the gable walls at their apex is approximately 23 feet. The walls of the additions vary between 9 and 11 feet in height. Most of the walls appear to be constructed with adobe headers, or adobes placed with their long side perpendicular to the wall face. All interior and exterior adobe wall surfaces are covered with lime plasters.

The gable roof extends the length of the two-story portion and it, as well as the other roofs of the various additions, is clay tile. The present roof of clay tile replaced the wood shingle that existed at the time of the Historic American Building Survey in the 1930s. The roof structure consists of rafters supported by a ridge beam and wall plates along the longitudinal bearing walls. The rafters also have collar beams for the purpose of making the ceiling flat in the central portion of the second-floor area.

The building has undergone several alterations and rehabilitations during its existence, some of which were in response to decay or damage. A low buttress at the northeast corner existed as early as the 1930s.

Thick vegetation is presently located at the bases of several of the walls, and while watering activity for the vegetation may have caused the moisture problems, the possible extent is not fully known. Severe lower-wall deterioration exists along a portion of the west wall of the main living room; this is the area covered by the corredor now. However, they were exposed and vulnerable to the elements for years previously. Another area where recent lower-wall moisture problems exist is the west wall of the kitchen. The south-end gable wall features a concrete or brick skirt (contrapared) 3 feet high that runs from the southeast comer to the window at the southwest corner. The skirt was probably an earlier attempt to address the moisture problem affecting this wall.

There are other areas with moisture problems as well and some may have contributed to the partial collapse of walls such as the northwest corner of the kitchen, the northeast corner of the garage, and the north patio wall.

One of the more significant structural aspects of this building is the anchorage of the floor joists at the second floor level. Along the exterior length of the east wall, a wooden ledger is lag-bolted into the end grain of each floor joist. A similar ledger is found on the west wall in the patio area. These ledgers support the corredor roofs on the east and west sides of the building.

On the exterior of the south-end gable wall there are large metal bearing plates anchored to the second floor with thru-bolts into the ledger floor joist that runs parallel to the south wall.

Estimate on Local Earthquake Intensity

The Andres Pico Adobe is located approximately 6 miles northeast of the epicenter of the Northridge earthquake. There are three CSMIP strong-motion earthquake recording stations located within 3 to 5 miles of the site. One is at the Nordoff Avenue fire station in Arleta, approximately 3 miles southeast of the site. Another is at the County Hospital parking lot in Sylmar, approximately 4 miles northeast of the site. The third is the Kagel Canyon Station in Pacoima which is 5 miles northeast of the Andres Pico Adobe. The north-south, east-west, and vertical peak ground accelerations recorded at the Nordoff Avenue fire station were 0.29g, 0.35g, and 0.59g, respectively. This was one of the few sites where the recorded vertical PGAS exceeded the horizontal accelerations. The recorded PGAS at the County Hospital parking lot were 0.91g, 0.61g, and 0.60g. The vertical PGA values at these two stations were nearly identical; however, the horizontal PGA values were different by a factor of two or three. The maximum horizontal acceleration at the Andres Pico site is estimated to have been 0.5g. Motion appears to have been strong in both horizontal directions, although the east-west component appears to have been the more significant for this structure, judging from the overall damage pattern. Based on Figure 2.1, the estimated MMI for this site is WI.

Damage Description

Earthquake damage to the Andres Pico Adobe is very extensive, consisting of severe crack damage and partial collapse of some walls. Approximately one third of the south-end gable wall above the second floor collapsed, as did the chimney on the west wall above the roof line, the northwest corner of the kitchen, the northeast corner of the garage, and a section of garden wall along the north side of the patio. The north gable-end wall at the second-floor level is leaning outward approximately 3 inches and a large section of the exterior plaster separated from the adobe surface and fell, causing structural damage to the balcony. The east and west longitudinal walls have permanent out-of-plane damage with mid-span deflections of approximately 4 inches at the second-floor joist level and at the wall top plate level.

There is severe crack damage throughout the structure and evidence of moisture damage along the base of the walls which led to increased levels of adobe and plaster spall damage as well as partial collapse in some locations. The west longitudinal wall (Figure 5.4) and northwest comer of the kitchen (Figures 5.5 and 5.6) are examples of increased spalling of the adobe and partial collapse, respectively. Much of the cracking also resulted in large areas of spalled and delaminated plaster.

Figure 5.4. *West elevation. The chimney collapsed and fell through the porch roof. There is damage to the west wall at the reentrant comers where the lower roofs intersect the west wall.*

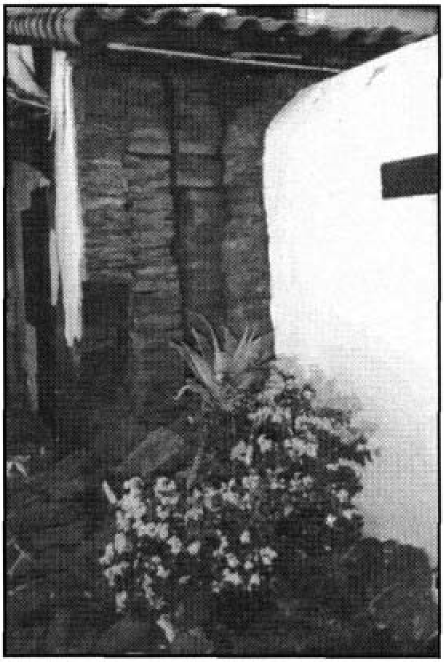


Figure 5.5. *Northwest corner of the kitchen. The layout of the bricks in this area was partially responsible for the collapse at this location. At first glance, it appears that the wall is 3 wythes wide, but the wall on the left of the photograph is only 2 wythes wide. The third wythe is a connecting section between the two walls.*

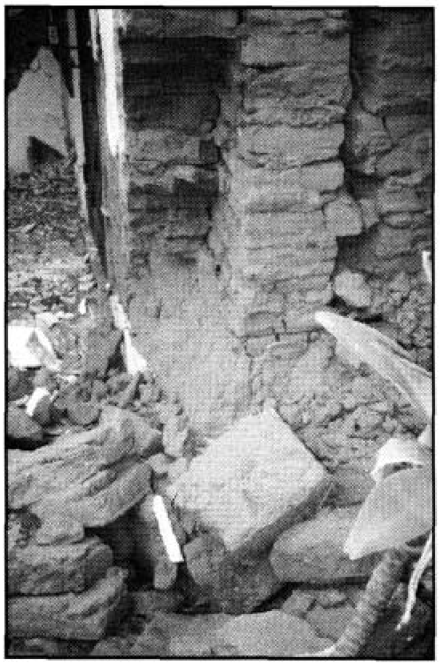


Figure 5.6. *Detail at the base of the northwest corner of the kitchen shown in Figure 5.5. Previous moisture intrusion reduced the strength of the adobe, which developed a slip plane along which the outer section of the wall collapsed.*

Exterior longitudinal walls

Out-of-plane flexural crack patterns were observed in the longitudinal (east and west) load-bearing walls of the main two-story portion of the building. Along the east wall, the flat-plate yield-line crack pattern is particularly clear (Figure 5.7). Relatively rigid lateral support for the longitudinal walls was provided by the two gable-end walls, the two intermediate transverse walls, and the foundation. Less rigid lateral support was provided by the second floor and roof framing.

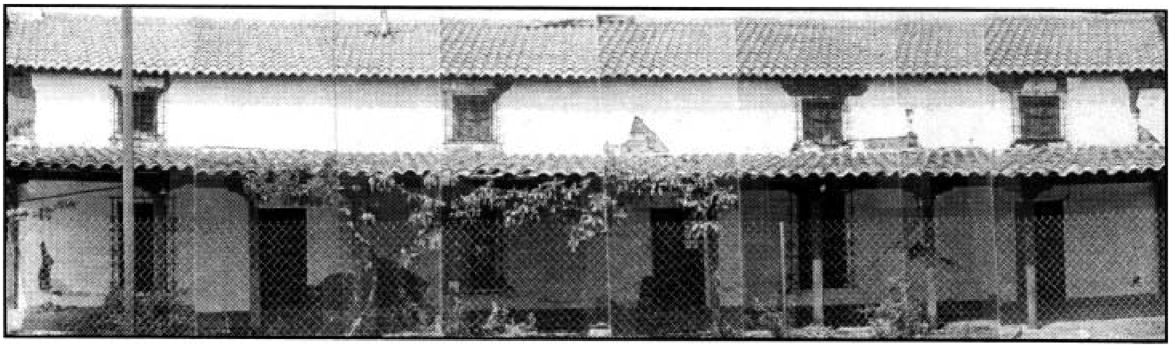


Figure ***5.7. East elevation. The damage to the east wall was largely defined by out-of-plane flexure of the walls. Cracks developed vertically at the end walls at the two interior cross walls (cracks highlighted in Figure 3.8).***

The out-of-plane crack pattern between transverse walls is U-shaped. The crack pattern of the east wall starts at each end at the top of the two-story wall, extends vertically downward to the base of the wall, turns horizontally, extends to the next transverse wall, turns vertically upward, and extends to the top of the wall. This pattern is repeated in each of three panels along the east longitudinal wall. The cracks are nearly vertical at the interior cross walls and end gable walls and extend nearly horizontally at the base. At the second-floor level a horizontal crack runs the length of the east wall at or just below the window sills and turns upward at the intermediate cross walls and gable-end walls.

A similar condition was observed in the west longitudinal wall except that the crack patterns are complicated by the single-story roofs and walls that abut the two-story portion of the building at the north and south ends, and the chimney near mid-span of the west wall. At the north end of the east wall the crack pattern starts at the top of the wall and extends vertically downward to the roof line of the single-story bedroom section or north wing. The crack turns horizontally and continues to the end of this roof, which is also the location of the intermediate transverse wall. The crack turns downward and extends vertically and diagonally to the base of the west wall, where it again turns horizontally. Where the west wall intersects the single-story kitchen wall, the south wing, the crack turns vertically, extending upward above the kitchen roof line into and above the small window opening at the second-floor level. At the south end of the second-floor west wall a diagonal crack turns vertically upward ending at the roof level.

Moisture intrusion at the base of the west wall in the patio area increased the level of crack and spall damage in this area.

Near mid-span of the west wall at the first-floor level, the crack pattern is complicated by the presence of the brick fireplace and chimney, which battered the wall as it attempted to move back and forth out of plane in the east-west direction. There are also some diagonal cracks in the west wall at the first-floor level that suggest in-plane racking in the north-south direction.

The east and west longitudinal walls are leaning toward the west from the ground to the second-floor level. Measurements made along the length of the east wall just below the second-floor ledger indicate a maximum out-of-plumb displacement of more than 4 inches at mid-span between the two intermediate transverse walls.

Gable-end walls

South gable-end wall

The south gable-end wall suffered severe crack damage as well as partial collapse during the Northridge earthquake. Approximately one third of the wall extending from the second floor to the roof rafters collapsed outward (Figures 5.8 through 5.11). In 1991 the **GSAP** survey team identified significant preexisting crack damage to this wall. The east edge of the collapsed section is nearly vertical and is defined by a chimney flue that had been cut into the adobe wall. The west edge of the collapsed section is along a diagonal crack that existed at the time of the 1991 site inspection. The remaining section to the west of the collapsed section sustained severe crack damage and slipped outward from underneath the rafters by as much as 4 inches. The remaining section to the east of the fallen section above the second floor also sustained diagonal shear cracks and is leaning outward at the rafter level approximately 3 inches. Below the second-floor level the crack damage is less severe; however, there is a large amount of plaster spalling that was exacerbated by moisture intrusion to a level just above the 3-foot-high concrete contrapared.

North gable-end wall

The north gable-end wall also suffered severe crack damage; however, except for a small portion at the apex that fell out, it is still intact (Figures 5.8, 5.9, and 5.12). There is a large diagonal crack that starts at the apex of the gable and extends to the west wall, ending at the height of the abutting single-story roof. A smaller diagonal crack runs in the other direction above the balcony door lintel. A vertical crack that runs up the west side of the first-floor window extends to the balcony doorway and to the lintel level. This was a preexisting crack observed by the GSAP survey team in 1991. However, a new horizontal extension of this crack begins from the lower west corner of the doorway and extends to the roof line of the single-story addition to the west.

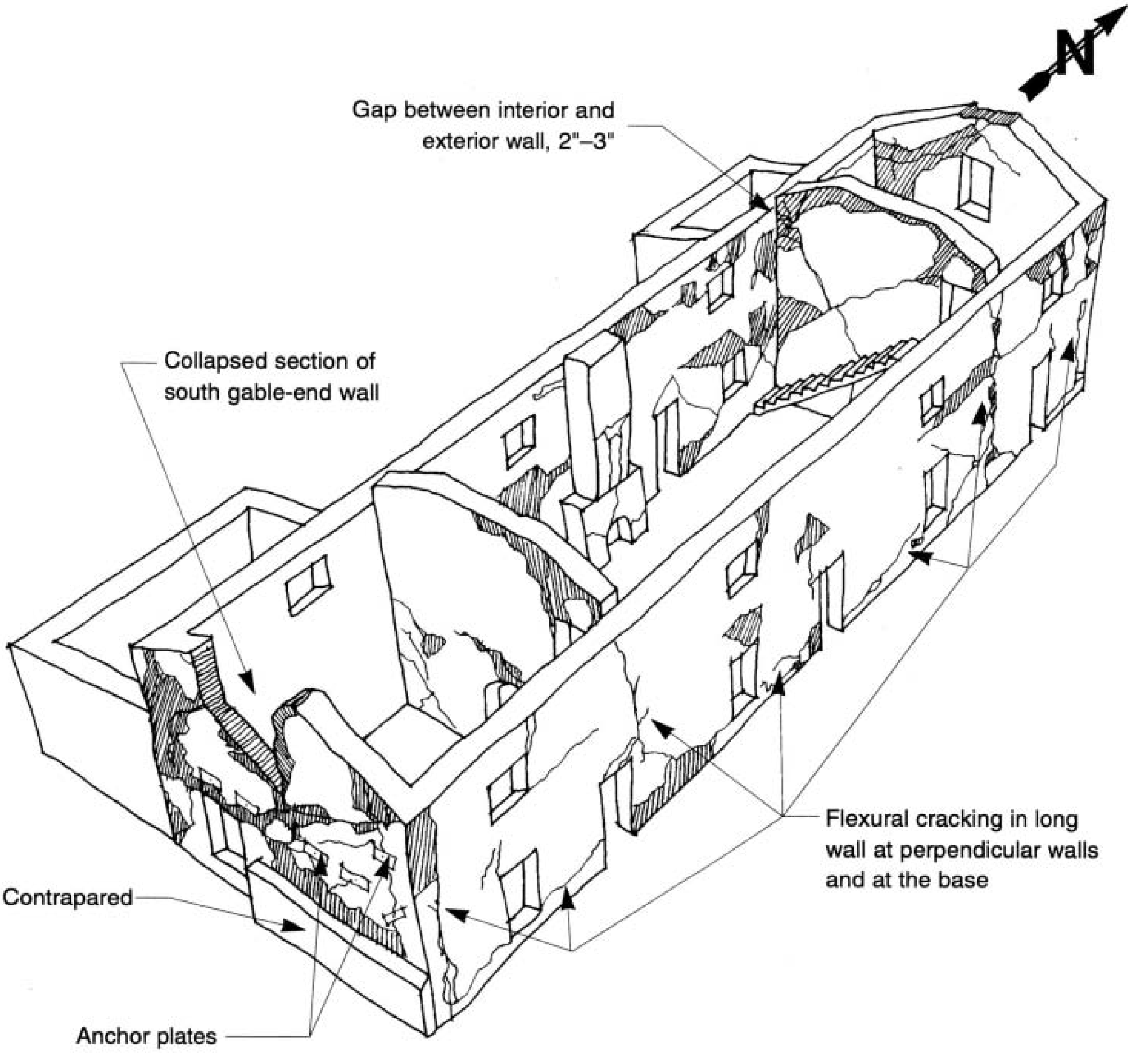


Figure ***5.8. Drawing of damage to the Andres Pico Adobe from the southwest comer after the 1994 Northridge earthquake.***

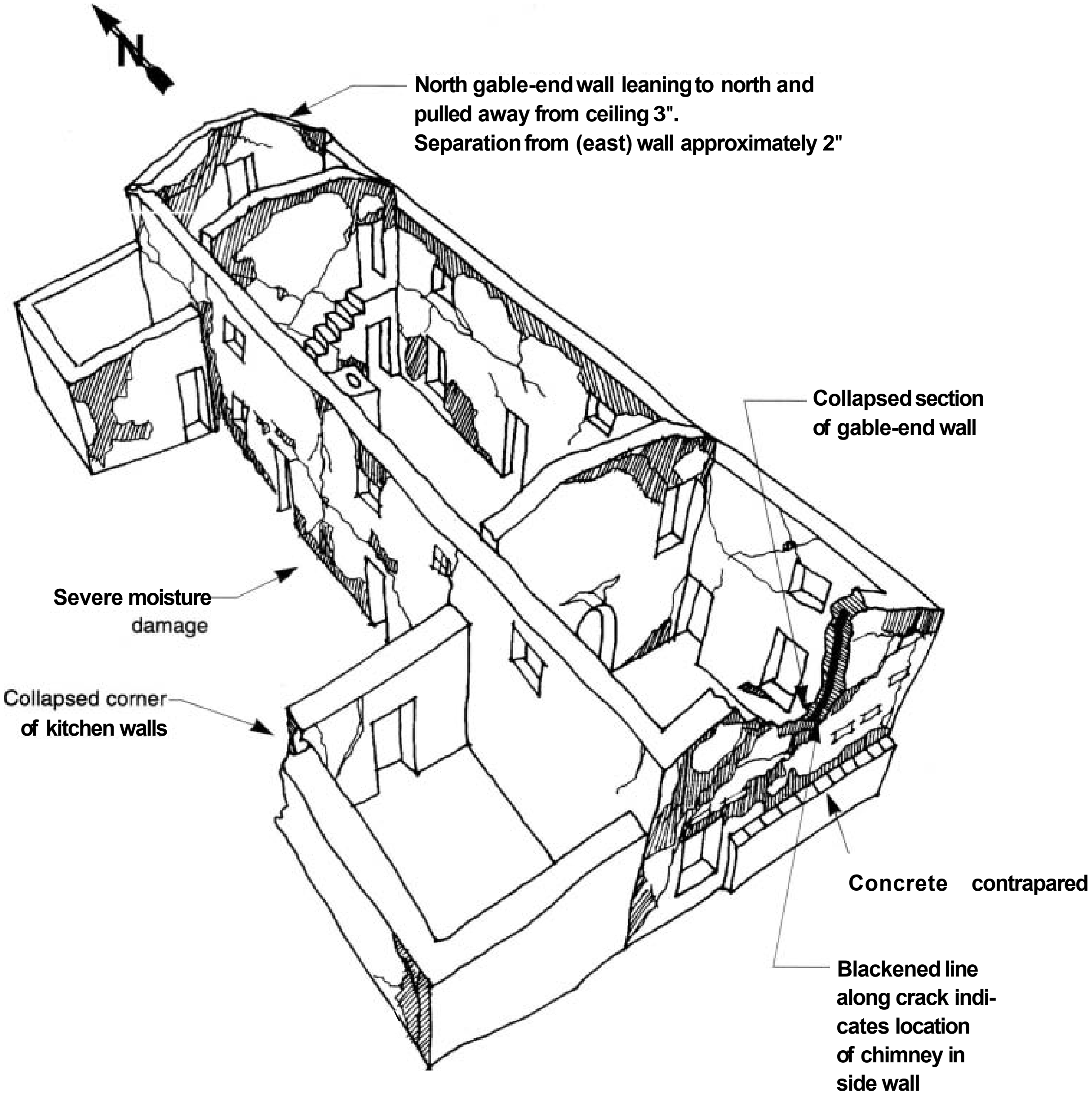


Figure 5.9. *Drawing of damage to the Andres Pico Adobe from the southeast corner after the 1994 Northridge earthquake.*

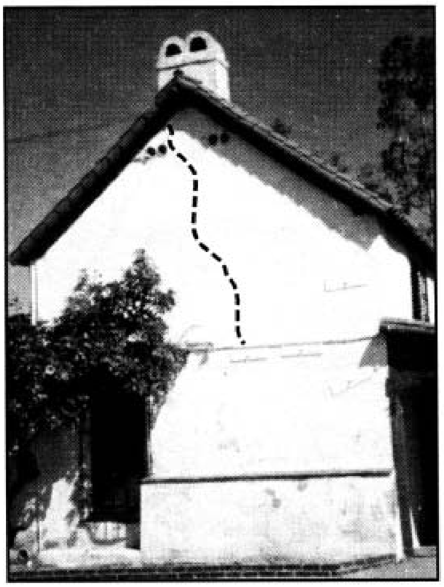


Figure 5.10. *Andres Pico Adobe. Gable-end wall in* **7997** *before the Northridge earthquake (dotted lines along preexisting crack lines).*

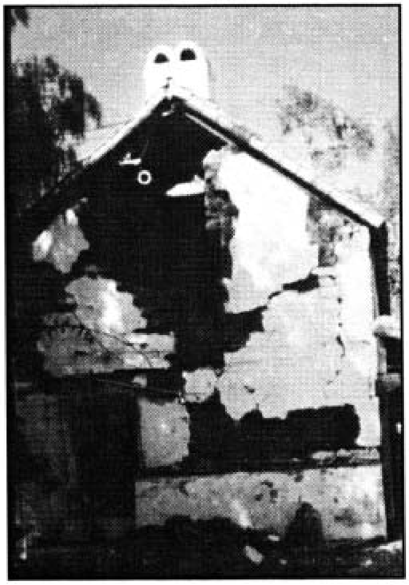


Figure 5.11. *Andres Pico Adobe. Gable-end wall after the Northridge earthquake.*

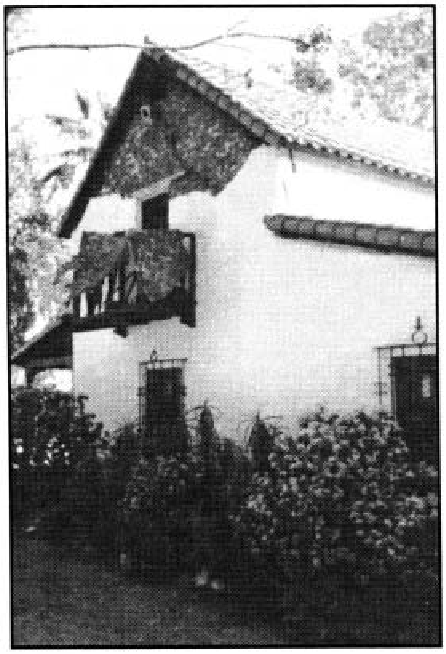


Figure 5.12. *North gable-end wall. The north gable wall suffered some damage but not as severe as the south end. A large diagonal crack extends from the peak of the gable down to the intersection with the lower roof on the right in the photograph. A large section of the plaster fell and damaged the balcony*

A large portion of plaster on the exterior surface above the balcony doorway separated and fell, causing structural damage to the balcony. The wall at the bottom of the balcony is leaning outward approximately 3 inches relative to the base. The wall is nearly vertical from the bottom of the balcony to the top of the gable, although the whole wall has slipped outward from underneath the roof rafters 1 to 2 inches.

Other exterior walls

Kitchen

The west wall of the kitchen suffered severe crack and spall damage, exacerbated by earlier moisture problems at the base, as noted in 1991 by the GSAP team. The northwest comer of the kitchen collapsed as a result of the weakened adobe at the base (Figures 5.5 and 5.6). It is also evident that the double wythe walls are not bonded together by any header courses, allowing the wythes to peel apart at the northwest corner. It appears that the adobe blocks of the north and west walls were simply abutted and not bonded at this intersection. The outer wythes of the north and west walls appear to have failed along a through-wall diagonal slip plane at the base caused by moisture-weakened material (see Figure 5.6). Rather than overturning, the wall section simply slipped downward and slightly outward collapsing in a heap.

A similar condition exists at the southwest corner of the kitchen. Although this corner did not collapse, vertical cracks indicate the separation of the wythes of the wall as well as the separation of the intersecting walls. The north wall of the kitchen also sustained severe crack damage, particularly toward the west end, and the top of the wall has moved out from underneath the ledger approximately 2 inches.

Figure 5.13. ***Collapsed section of garage in the southwest corner of the courtyard.***

Garage and other areas

The northeast corner of the garage collapsed during the earthquake (Figure 5.13). The failure plane of this section developed vertically in the east wall at the corner. The other failure plane runs diagonally from the northeast corner at the base, through the window frame in the north wall and up to the rafters. The failed section slipped out from underneath the ledger rafters (rafters along the surface of the end wall), that were pinned only by a short steel rod at the corner.

A section of the garden wall on the north side of the patio collapsed (Figure 5.14). It appears that this wall simply overturned.

Substantial amounts of plaster spalled in many areas of the building (Figures 5.8 and 5.9). Plaster typically spalls in areas where cracks have developed in the adobe, although the cracking is sometimes difficult to determine in the mortar joints. Spalling

Figure 5.14. ***Collapsed garden wall on the north side of the courtyard, plaster damage along the north wall, and damage to the north gable-end wall.***

occurred at the second-floor level due to horizontal cracking in the upper part of the wall (Figure 5.15).

Pounding damage occurred at the reentrant corners of the building where the lower roofs abut the two-story west wall (Figure 5.4).

A large section of the west exterior wall suffered damage that was exacerbated by preexisting moisture damage. Although this damage did not seriously affect the overall performance of the wall, it did lead to a large amount of spalling in this area (Figure 5.16).

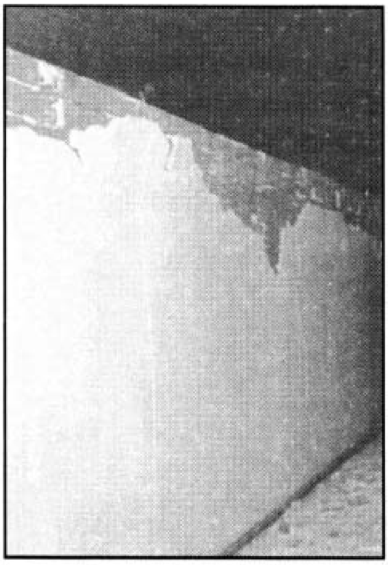


Figure 5.15. ***Interior of the east wall at the second-floor level. Damage to the plaster on the upper section of the wall, but there was no evidence of slippage between the wall and the roof framing.***

Figure 5.16. Base of west wall. Wall has suffered strength loss due to repeated wet-dry cycles. Plaster and adobe have spalled, but the wall has not slumped, nor has the stability of the wall been threatened.

Interior cross walls

There are two interior transverse walls in the two-story section of the structure. The north transverse wall shows evidence of in-plane racking, having sustained three major diagonal cracks, two extending from the west wall above the second floor down and toward the east, the third extending from the top of the doorway down toward the west. The two starting at the west wall pass down through the second-floor level and above an infilled arched doorway in the center of the wall at the first-floor level. The upper most crack ends at the upper west corner of the present first-floor doorway, while the lower crack ends at the lower west corner of the present doorway. Vertical cracks in the plaster behind the staircase outline the edges of the infilled arched doorway. The third diagonal crack runs from the upper west comer of the second-floor doorway down toward the west, stopping where it crosses the other diagonal cracks. The longitudinal west wall has pulled away from this transverse wall approximately 2 inches at the rafter level.

The west wall has also pulled away from the south transverse wall approximately 2 inches at the rafter level. There is a diagonal crack emanating from the upper west comer of the doorway at the east side of this wall. At the first-floor level one major and two minor diagonal cracks extend across the wall panel to the west of the arched doorway. The major shear crack starts at the lower west comer of the doorway and progresses up and over toward the west wall. Above the arched doorway the two minor cracks span from the top of the doorway to the second-floorjoists.

At the first-floor level the east and west longitudinal walls remain tight against the interior transverse walls.

Structural Performance

The classic instability problem of gable-end walls was demonstrated by the partial collapse of the south wall and the severe crack damage and dislodged adobe blocks of the north wall. The out-of-plane partial collapse of the south gable-end wall and the leaning of the north gable-end wall can be attributed to physical conditions prior to the earthquake and the fact that free-standing gable-end walls are inherently unstable and vulnerable to out-of-plane collapse. Neither of these gable-end walls was anchored to the roof framing. However, bearing plates and anchor bolts on the exterior of the south gable-end wall at the second-floor level were an earlier attempt to provide out-of-plane restraint. This did very little for the wall above the second floor.

The longitudinal walls clearly rocked out of plane. The east wall at the second floor is leaning approximately 4 inches to the west at mid-span, but this leaning is not particularly severe for a wall that is 22 inches thick and 40 feet long. Long walls are very susceptible to out-of-plane rocking and the associated crack patterns, but the roof and floor systems provide resistance to large out-of-plane motions and greatly reduce the risk of instability. The out-of-plane performance of longitudinal load-bearing walls, although significant, is not the principal problem in the performance of this type of adobe construction. In fact, when coupled, as they are in this building, it is extremely difficult to overturn them.

The ledger-plate anchorage of the second-floor joists contributed substantially to the stability of the longitudinal walls. It held up well during the earthquake, showing no signs of slippage or failure of the lag-bolt connections. These connections coupled the out-of-plane motions of the east and west walls by way of the floor joists and diaphragm action and contributed to the regularity of the crack patterns. The coupling kept the east and west walls from separating from the interior transverse walls up to the second-floor level, although gaps at the wall intersections did develop above the second floor.

Of greater consequence to the structural performance than the out-of-plane behavior of the longitudinal walls was the in-plane shear behavior of the transverse walls. The most significant damage to the transverse walls was in-plane shear cracking and separation at the intersections with the longitudinal walls. The out-of-plane motion of the longitudinal walls increased the level of in-plane loading on the transverse walls. The first-floor interior walls suffered only moderate damage because of the coupling provided by the second-floor joists and diaphragm. At the second-floor level, the walls suffered considerably more damage with severe shear cracks and separation gaps at the wall intersections. The roof system did an incomplete job of coupling the longitudinal walls at the roof level, thus allowing large separation gaps to form.

It is not known whether the roof framing is anchored to the east and west walls, but there may be 12-inch anchor rods similar to the anchor observed at the collapsed corner of the garage. The out-of-plane displacement of the long walls was exacerbated by the moisture damage at their base.

The collapsed comer of the kitchen was the result of a combination of factors. First, there was significant moisture damage at the base of this wall. Second, the double-wythe construction without header courses made the corner susceptible to vertical cracks that could lead to collapse. Finally, comers of adobe walls can develop vertical cracks on either of the two perpendicular walls as they tear away from and pound against each other, leaving the comer section susceptible to instability.

The vulnerability of the collapsed corner of the garage would have been predictable if a stability-based analysis had been used. Elastic analysis of this structure would have indicated that the open south end of the garage is more susceptible to earthquake damage. The south end, opposite from where the collapse occurred, has no transverse wall. A stability-based analysis would have predicted the cracks that developed and the small size of the cracked section that led to collapse. The initiation of cracks in this area may have been the result of the overall response of the garage, but the collapse was largely due to the proximity of the door and window to the comer. The single 12-inch steel bar that extended down through the wood top plate into the adobe wall was clearly not enough to stabilize this section of wall.

The physical condition of the Andres Pico Adobe prior to the Northridge earthquake dictated much of the structural performance of this building. The lower sections of the walls in many locations had previously suffered significant water damage. Except for the second-floor anchorage of the longitudinal walls and the south gable-end wall, the structural elements were either unconnected or poorly connected. The building also had substantial preexisting crack damage, presumably from prior earthquakes and/or movement caused by moisture problems.

Given these initial conditions and the level of local ground motion, significant damage to the building would be expected. The level of damage to the Andres Pico Adobe is considered to be very extensive, with partial and total collapse of some structural elements.

Chapter 6

De la Osa Adobe

Historical Background

Social history

The De la Osa Adobe was reportedly constructed by Don Vicente De la Osa in 1849 upon Rancho El Encino, which De la Osa purchased from the heirs of original Mission San Fernando Native American grantees (Ramon, Francisco, and Roque) in about 1857 (Turner 1966:1; Robinson 1966:8) De la Osa was married to the daughter of the famed Doiia Eulalia Perez de Guillen of Mission San Gabriel (Giffen 1955:15). The place was a popular stop on the way north for Los Angelenos and eventually guests were charged for hospitality. The adobe remained in the family until 1867 when it was conveyed to Sheriff James Thompson.

Thompson sold it to Eugene Gamier, a French Basque, in 1869. In 1872, Gamier was responsible for construction of a large, two-story stone building on the grounds with a lime-plaster rendering penciled to emulate ashlar and stone quoins; he also constructed other outbuildings. Gamier is also said to have developed the small lake and spring house on site where he maintained large sheep herds. (Hoover et al. 1990:154). He owned the adobe until 1878 when it was purchased by Gaston Oxarart, a Spanish Basque, at auction. It was subsequently inherited by Simon Gless, a French Basque, in 1886. Gless sold the property in 1889 to his father-in-law, Domingo Amestoy, also a French Basque (Los Encinos brochure; Elliott n.d.:67).

Architectural history

The lineal one-story De la Osa Adobe is minimally detailed with chamfered corredor posts and openwork brackets typical of the late nineteenth century in California; the corredors of the Leese-Fitch Adobe in Sonoma, the Miguel Leonis Adobe in Calabasas, and the Lopez Adobe in San Fernando are similarly ornamented. Most of the rooms have access directly from the exterior without internal hallways, although most adjacent rooms are connected by an interior door, a feature typical of early California adobe architecture, here perhaps related to incremental construction (Figure 6.1).

The present configuration is thought to be one wing of an earlier L-shaped building, with the missing east wing extending north from the east end of the present structure. The easternmost room, Room 1, is said to have been built separately as part of the missing wing (Turner 1966;10). What was reported to be an early photograph of the

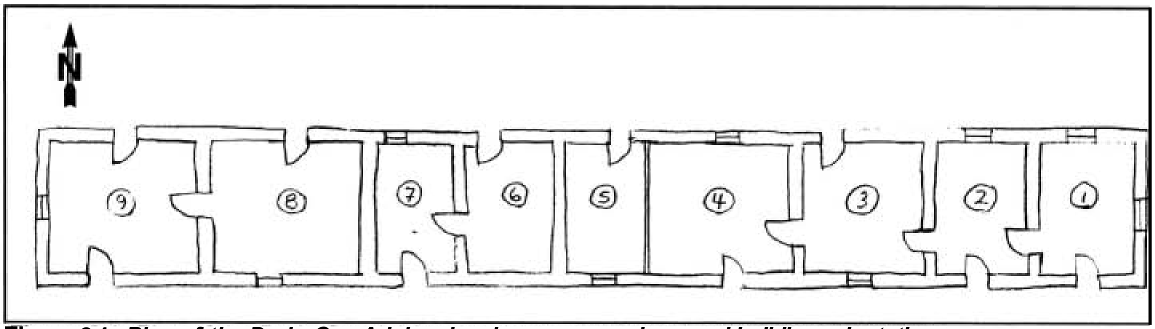


Figure 6.1. *Plan of the De la Osa Adobe showing room numbers and building orientation.*

building shows larger chamfered posts and a high painted dado on the exterior similar to the Rancho Camulos Adobe, is in fact a photograph of the Oel Valle Adobe at Rancho Camulos.

The De la Osa Adobe was lime plastered, perhaps following an earthquake, and a number of large cracks were patched with bits of brick and lime plaster perhaps at the same time. It is generally understood that Gamier was responsible for substantial alterations to the adobe as part of an overall renovation including reroofing (Turner 1966:8). The lime plaster, wainscoting, and millwork appear to be part of one, or at most two, comprehensive remodeling efforts, since there is an overall consistency of door sizes, designs, and casings. This consistency may be the result of restoration efforts to eliminate small changes made over time. An in-depth investigation was not possible during this survey, although it is clear that several doors have been replicated. The brick fireplaces appear to date from a later period than the earlier brick chimneys.

The roof is a relatively recent replacement, the result of rehabilitation efforts in the mid-1960s as is the ceiling of the south corredor. The original roof is thought to have been nearly flat and surfaced with brea, judging from various archaeological and architectural findings (Turner 1966:8). Archaeological investigations also revealed that the De la Osa Adobe has virtually no foundation, a circumstance not uncommon in adobe buildings of Southern California.

The De la Osa Adobe is owned and operated by the California Department of Parks and Recreation as Los Encinos State Historic Park. It is listed in the National Register of Historic Places and is a registered California Historical Landmark.

Building and Site Description

The De la Osa Adobe at Los Encinos State Park is rectangular in plan, approximately 21 feet wide by 142 feet long, and is oriented with the long axis in the east-west direction. The exterior adobe walls are approximately 18 to 20 inches thick, made up of adobe blocks 18x4x8. The adobe material generally was in good condition; it appears to be relatively strong adobe with no significant moisture damage. Several significant cracks predated the Northridge earthquake. The cause of these cracks is unknown, but they had been previously patched with brick and stone rubble and lime plaster.

The running bond pattern consists primarily of headers, occasionally with stretchers. The interior walls are primarily adobe, but there is one wood-frame partition wall between Rooms 4 and 5. Both the east- and the west-end walls were full-height adobe gables before the earthquake. Only the west gable-end wall remains standing. The roof is a simple gable.

The building site is level with a slight drop in grade from the west to the east of approximately 12 to 15 inches. An open space is immediately to the north and also to the south, where a small pond for waterfowl exists. The surrounding soil is alluvium consisting of clay, silt, sand, and gravel, unconsolidated and poorly to well stratified.

The building was constructed without a foundation as the adobes were apparently laid directly on a prepared ground surface. The results of archaeological investigations found some stones at the base of the walls, but these were not used as foundation stones; rather, they were probably used to fill areas of the wall that had deteriorated or were an attempt to prevent basal erosion. The foundation on the east gable was exposed with the collapse of that part of the building. It had previously been repaired with a concrete slurry. There is apparently a partial crawl space, but the extent is not known.

Concrete slab walkways abut the exterior north and south longitudinal walls, with a concrete skirt of 1 to 2 inches thick and 10 inches high at the base of these walls. The base of the west gable-end wall is at grade and the surrounding soil abuts it.

Corredors extend the length of the building on both the north and the south sides. The corredor roofs are extensions of the main gable roof, extending out from the wall lines in a flatter pitch and are supported by wood columns spaced approximately 11 feet apart.

The gable roof appears to be relatively new. The roof structure is 2x4 rafters on 24-inch centers; approximately every third rafter has a 1x6 collar beam. The rafters rest on a wood wall plate on the inside edge of the adobe long walls. The wall plate does not appear to be anchored to the adobe wall. The roof covering is wood shingle over 1x skip sheathing.

Ceiling structures in each room are independent, being interrupted by the transverse walls. Ceilings are 1x straight sheathing supported by 2x4 joists spaced approximately 4 feet on center. Ceiling joists run north-south in some rooms and east-west in others.

Five steel and wood cross-ties interconnect the north and south longitudinal walls at a level between the door lintel and ceiling. Two cross-ties are made of 2x6 wood members, one at the transverse wall between Rooms 2 and 3, and the other at the transverse wall between Rooms 3 and 4. The other three cross-ties are steel rods and are at the transverse walls between Rooms 5 and 6, Rooms 7 and 8, and Rooms 8 and 9.

Estimate of Local Earthquake Intensity

Los Encinos State Park is located approximately 4 miles southeast of the epicenter. There are three CSMIP strong-motion earthquake recording stations located within 2 to 3 miles of the De la Osa Adobe. The north-south, east-west, and vertical peak ground accelerations recorded at the Cedar Hill Nursery in Tarzana, 2 miles west of the De la Osa Adobe, were 1.06g, 1.82g, and 1.18g and are the largest ground motions ever recorded. However, this recording site has shown very high readings during previous earthquakes and is thought to be an anomaly. The north-south, east-west, and vertical PGAS recorded at a site 3 miles northeast of the De la Osa Adobe in Van Nuys were 0.41g, 0.47g, and 0.30g, respectively. The two horizontal and one vertical components of PGAS at a site 3 miles southeast in Sherman Oaks were 0.46g, 0.24g, and 0.18g. The De la Osa Adobe is also located almost directly on the 0.4g isoseismal contour shown in Figure 2.4. It is therefore estimated that the peak horizontal ground acceleration at Los Encinos State Park was 0.4g. The estimated MMI was VIII.

Damage Description

The damage to the De la Osa Adobe was very extensive. The east gable-end wall collapsed completely, pulling away from the longitudinal walls and falling outward toward the east. The collapse of the gable wall subsequently brought down the ceiling structure at this end. The west gable-end wall suffered severe crack damage at the comers, and the upper section of the wall is leaning outward toward the west. The longitudinal load-bearing walls sustained moderate to extensive crack damage, primarily as a result of out-of-plane movement and pounding at the transverse walls. Several of the interior transverse walls have suffered extensive crack damage, having developed shear cracks, separation cracks at wall intersections, and out-of-plane permanent displacement. Five cross-ties were effective to varying degrees. One was completely ineffective, having been previously cut; two of the other ties suffered partial failure when their anchorages partially pulled through the longitudinal walls; and two remained intact and were effective. Much of the plaster throughout the structure was spalled due to the cracking in the adobe walls, and large portions of the remaining plaster have delaminated from the wall surfaces and will have to be removed. Drawings of the overall structural damage are shown in Figures 6.2 through 6.5.

Exterior walls

Gable-end walls

The most serious damage occurred at the gable-end walls, with complete collapse of the east gable end and severe crack damage to the west gable end. The east gable-end wall collapsed by rotating about the base of the wall and pulling away from the north and south longitudinal walls (see Figure 6.6).

The upper half of the west gable-end wall is leaning outward, rotated about a horizontal crack that extends across the wall at the window level and pulled away from the north and south longitudinal walls 3 to 4 inches at the southwest comer. A vertical section of the southwest comer has also collapsed (see Figure 6.7).

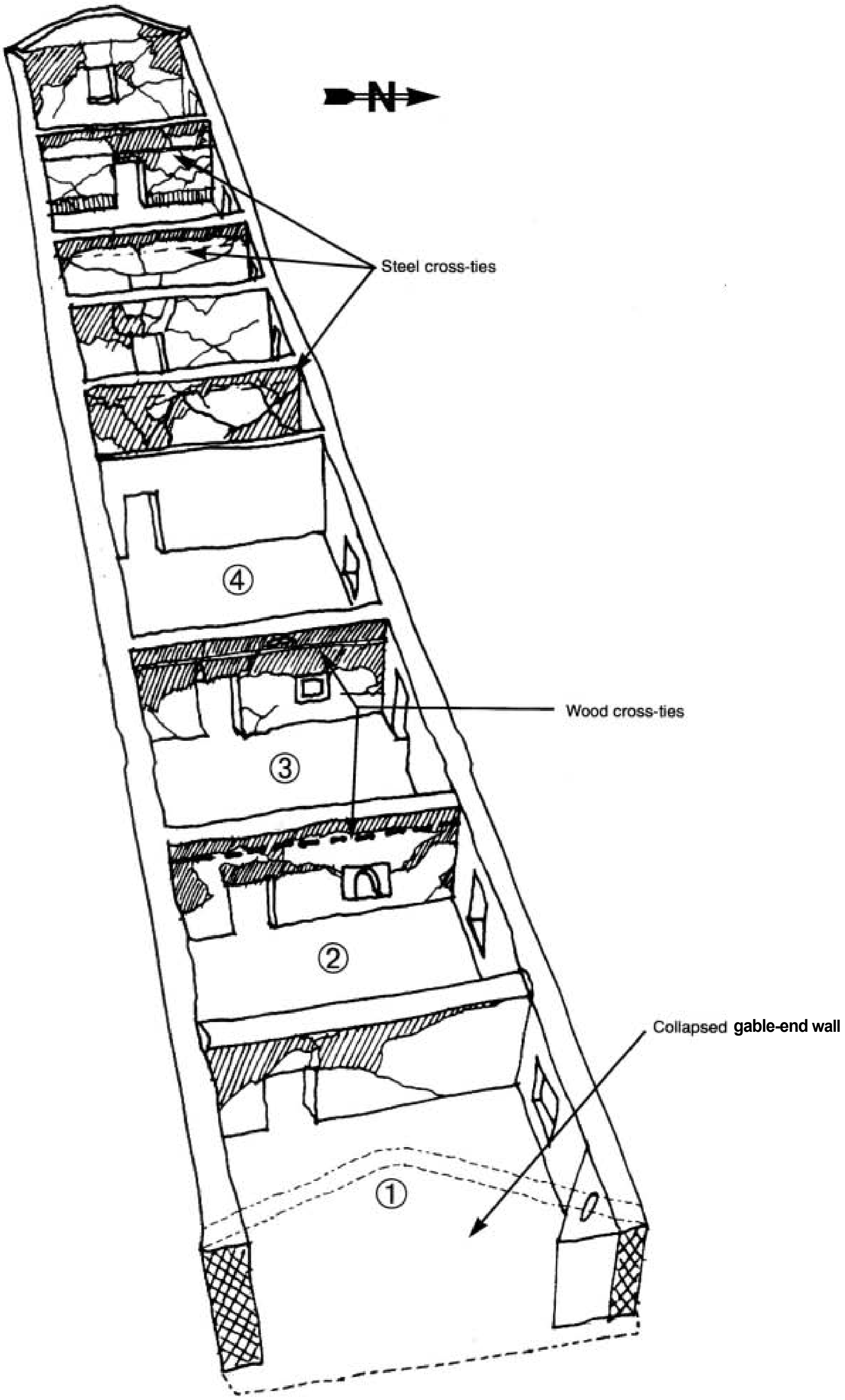


Figure *6.2. De la Osa Adobe. Drawing of earthquake-damagedbuilding from the east end.*

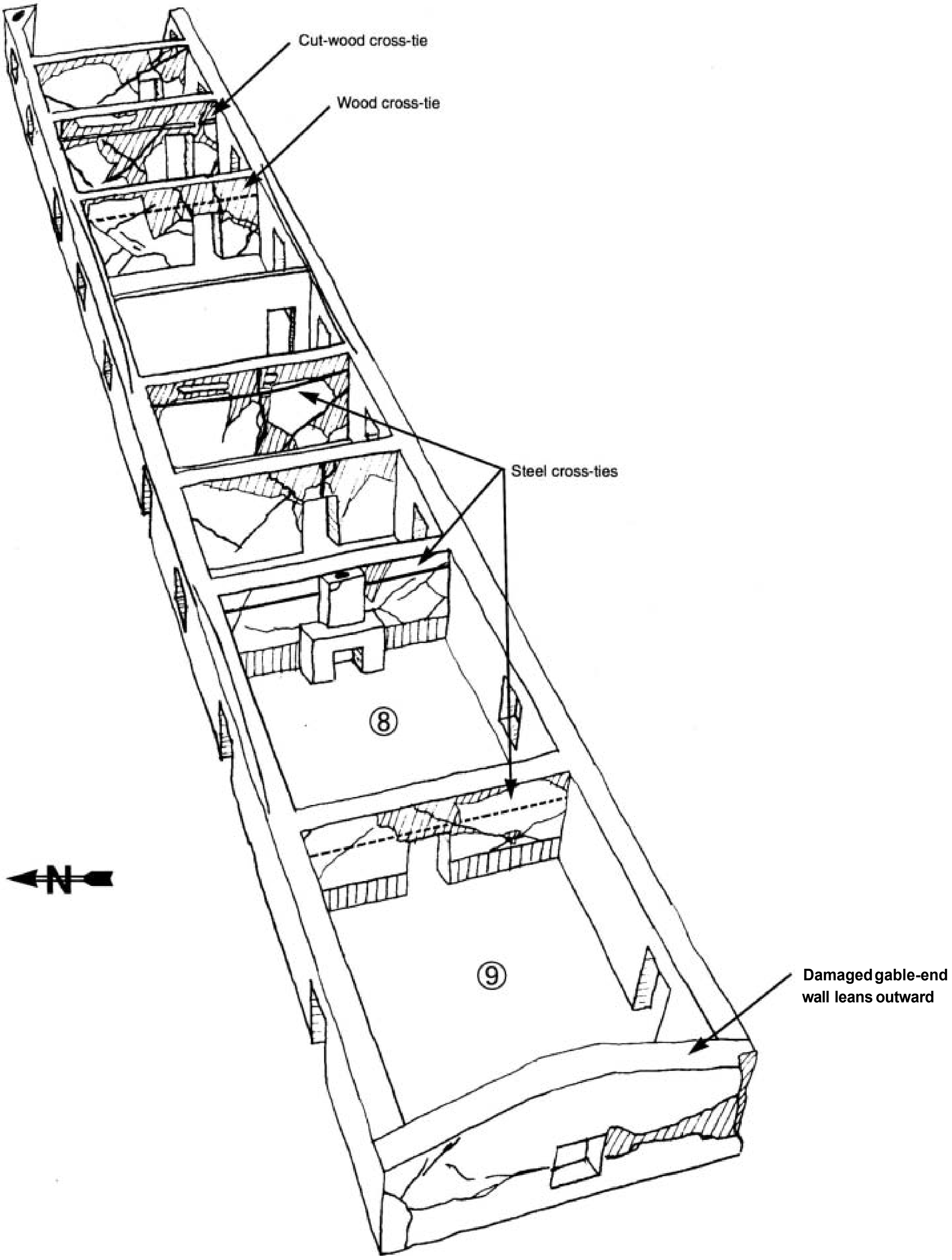


Figure *6.3. De la Osa Adobe. Drawing* of ***earthquake-damanged building from the west end.***

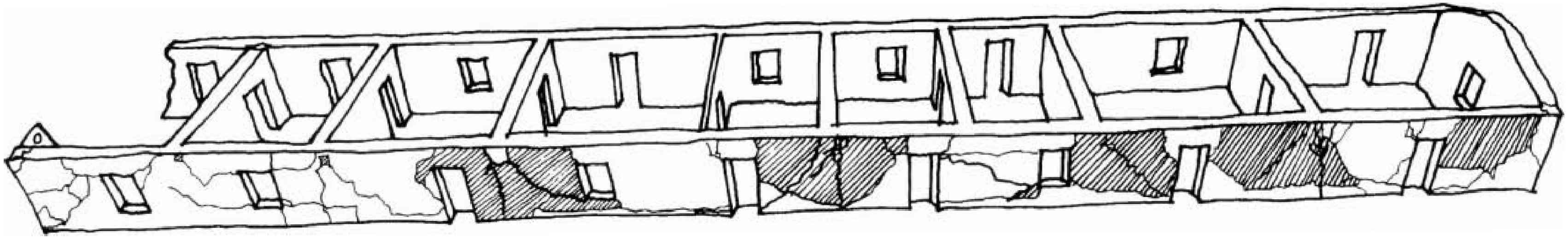


Figure 6.4. *De la Osa Adobe. North elevation showing earthquake crack pattern and plaster damage.*

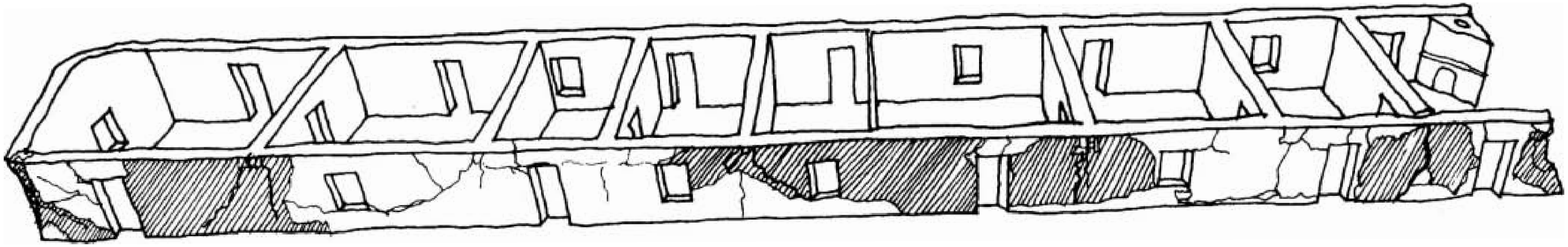


Figure 6.5. *De la Osa Adobe. South elevation showing earthquake crack pattern and plaster damage.*

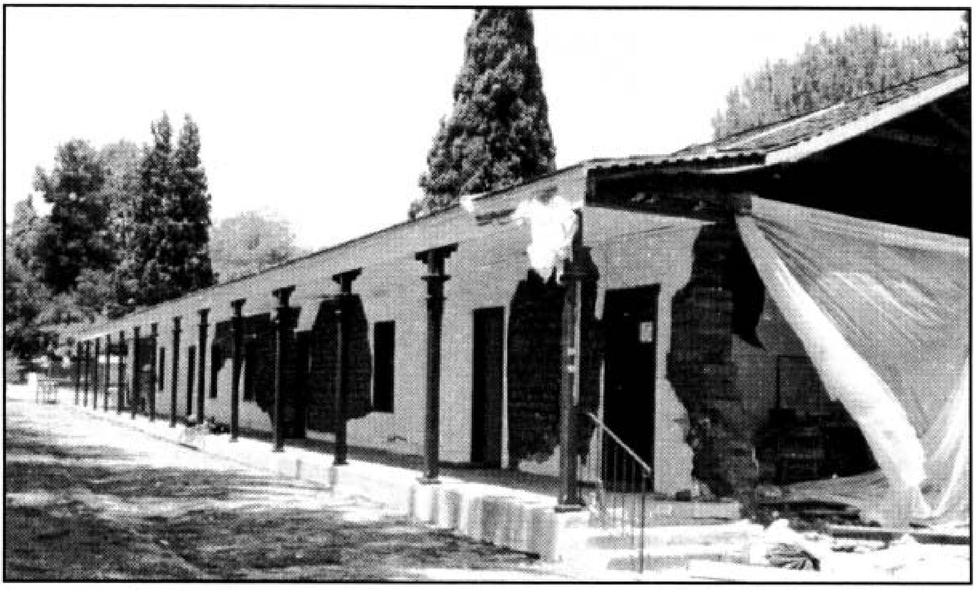


Figure 6.6. ***Southeast corner of the De la Osa Adobe. Collapsed gable-end wall is visible on the right.***

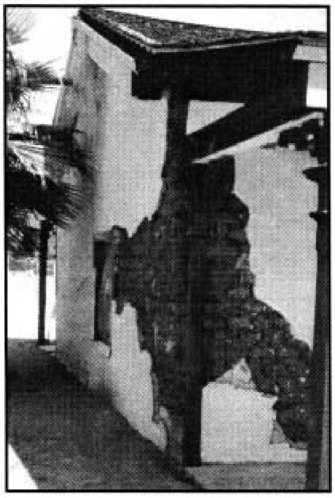


Figure 6.7. ***West gable-end wall. A horizontal crack extends from the south wall to the window and then to the north wall. The lower section is leaning outward. This wall is very susceptible to collapse.***

Longitudinal walls

The longitudinal walls suffered moderate to extensive crack damage (Figures 6.8 and 6.9), but the damage does not significantly affect their structural integrity. Although some of the crack damage included large, previously patched cracks with wide gaps, the damage to the walls caused by the Northridge earthquake was not particularly serious because there was very little permanent offset. The principal crack patterns are related to out-of-plane rocking and flexure in the north-south direction. There is evidence of some permanent out-of-plane displacement of the long wall, particularly in the area of Rooms 4 and 5 where both the north and south walls bow inward 2 to 3 inches, leaving a gap between the wall and the soffit.

Interior transverse walls

The damage to several of the transverse walls was extensive. The earthquake caused large cracks to open and significant permanent offsets in the transverse walls. There are cross-ties on five of the walls but only two worked effectively during the earthquake.

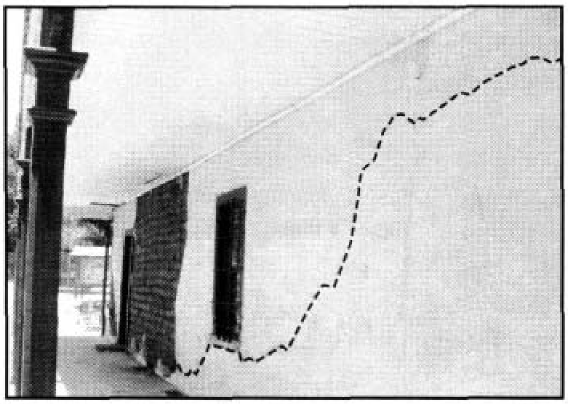


Figure 6.8. *Exterior of south wall outside Rooms 8 and 9. A flexural crack starts at the anchorage at the upper right of the photo (anchorage not visible except for plaster cracking) and extends to the base of the window and then to the lower part of the wall (dotted line along crack).*

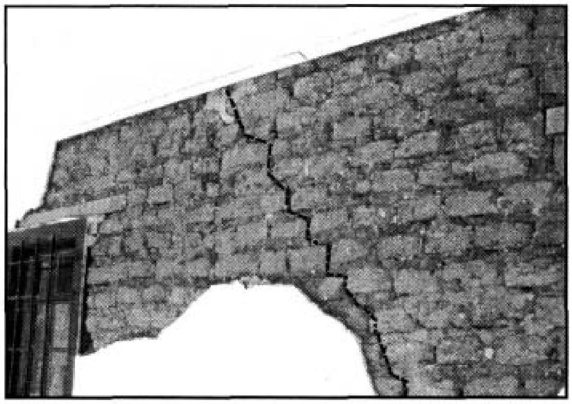
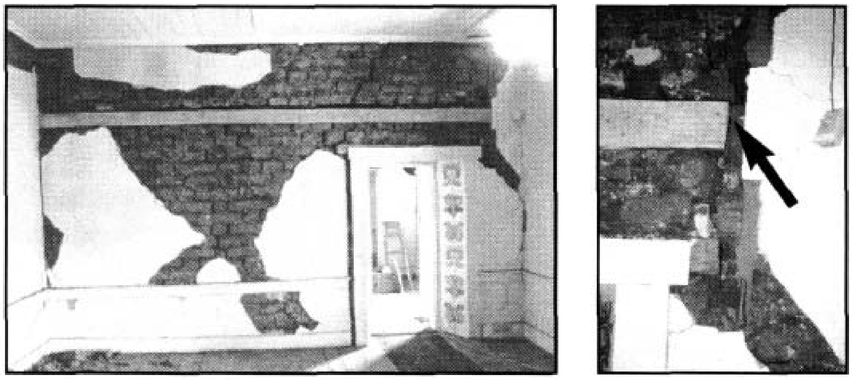


Figure 6.9. *Shear crack in exterior wall starting at the interior wall between Rooms 5 and 6. Wood anchorage with S-shaped steel end plate shown at the soffit line. This anchorage is provided for a steel tie rod that spans the building in the transverse direction (dotted line along crack).*

The transverse wall between Rooms 1 and 2 suffered vertical separation cracks near the north and south walls of 2 to 3 inches and a diagonal crack that starts at the upper south corner and traverses downward across the top of the doorway and to the base of the wall. There is no cross-tie at this wall, and the wall is only 8 inches thick.

The transverse wall between Rooms 2 and 3 suffered a large separation crack near the south wall where the wooden tie beam was cut (Figure 6.10). A large X-shaped shear crack pattern is clearly visible on the west surface of this wall.

The transverse wall between Rooms 3 and 4 suffered substantial damage (Figure 6.11). A large vertical separation crack, 2 inches wide, occurred at the north wall



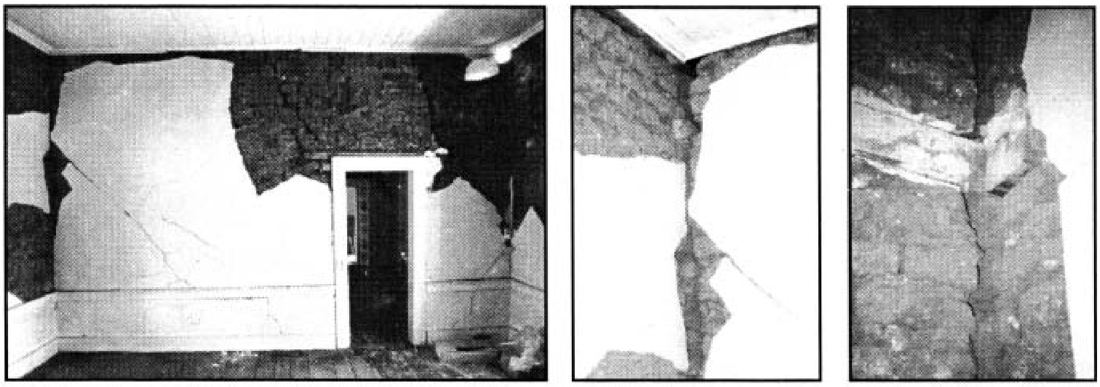
Room 3, east wall.

Room 3, east wall showing pre-existing cut in the wood cross-tie.

Figure 6.10. *Wall between Rooms 2 and 3.*

where anchorage of the wooden tie beam partially pulled through the exterior wall. This anchorage suffered damage at some earlier time and had been previously repaired. The failure at the anchorage permitted the separation between the transverse and exterior walls. Other crack damage includes vertical cracks at the corners of the doorway lintel. Horizontal separation at these cracks is in the range of 1 to 2 inches.

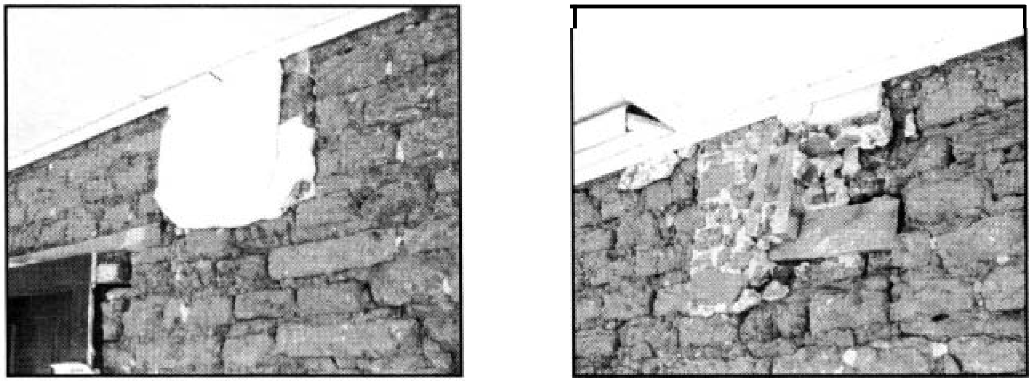
The transverse wall between Rooms 5 and 6 has an old vertical crack near the center of the wall that was previously patched with rubble and plaster. The steel tie rod on the west surface of the wall is sagging about 4 inches at mid-span, resulting from the anchorage at the north wall being partially pulled through the exterior wall. A vertical separation crack has opened up at the north wall, and a wedge has formed at this end



Room 4, east wall

Room 4, east wall at north end.

Room 3, west wall at north end.



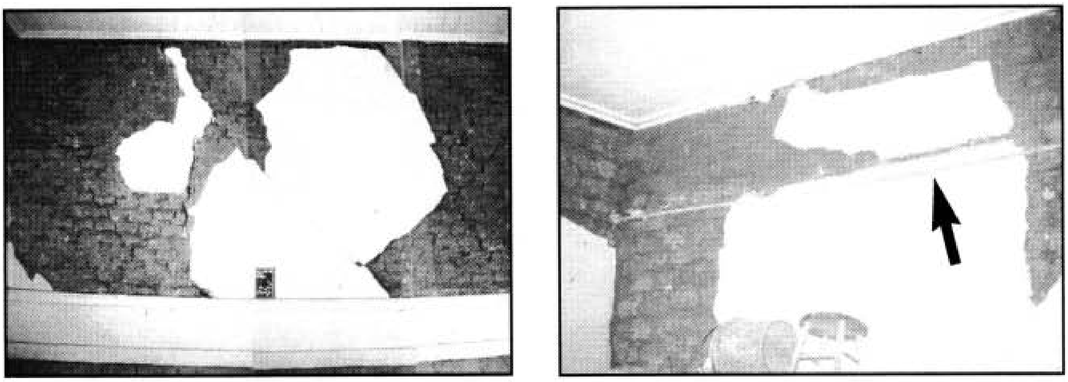
Exterior connection at north end of wood cross-tie between Rooms 3 and 4.

Exterior connection at south end of wood cross-tie between Rooms 3 and 4.

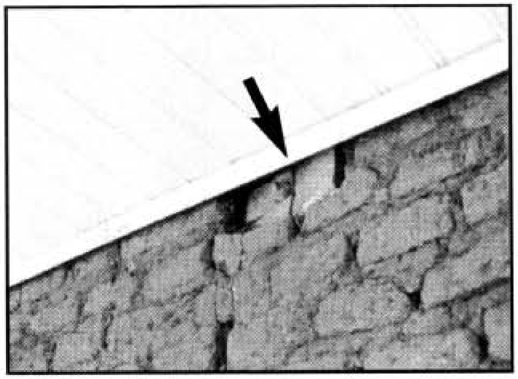
Figure 6.11. *Wall between Rooms 3 and 4.*

with a diagonal crack starting at the ceiling and traversing the wall downward toward the north corner. Photographs of this wall are shown in Figure 6.12.

The transverse wall between Rooms 6 and 7 has no cross-tie and is leaning toward the east 4 to 5 inches at the north wall. It has also pulled the ceiling with it. There is an old vertical crack over the center of the door, a diagonal crack at the doorway lintel, and an X-shaped diagonal shear crack in the north panel of the wall. This wall is only 8 inches thick.



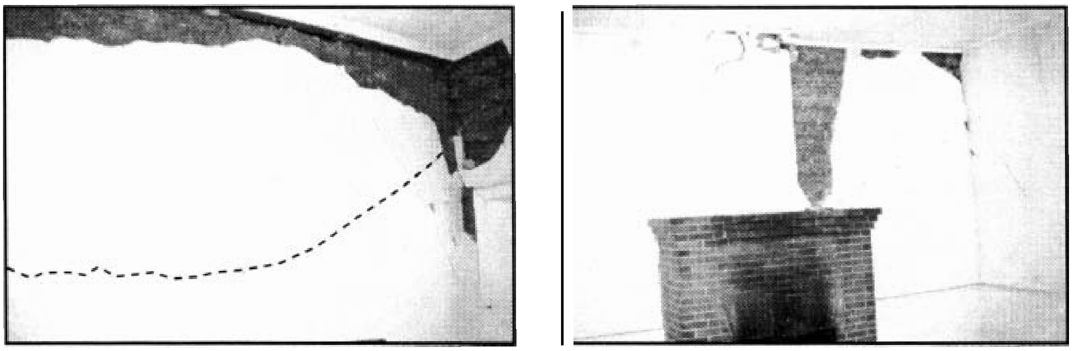
Room 5, west wall. ***Room 6. east wall.***



Damage to the anchor plate on the north wall at the steel tie rod along the wall between Rooms 5 and 6. Damage to the anchorage resulted in sagging of the rod shown above.

Figure 6.12. ***Walls between Rooms 5 and 6.***

The transverse wall between Rooms 7 and 8 has a brick fireplace and chimney on the west side (Figure 6.13). It also has a steel tie rod connecting the north and south walls. This cross-tie did not pull through the exterior walls and therefore kept the long walls tight against the transverse wall. Damage to the wall was dictated by the presence of the chimney and mantel. It appears that the upper half of the wall rocked in a flexural mode about a horizontal crack at the mantel height that turns upward toward the north and south walls. The out-of-plane motion of the wall apparently pushed the ceilings on both sides away 1 to 2 inches. An old vertical crack defined by the chimney also reopened. Separation at the north and south walls is minimal.



Room 7, west wall. Horizontal flexural crack developed just above mantel height, adjacent photograph to the right (dotted line along crack).

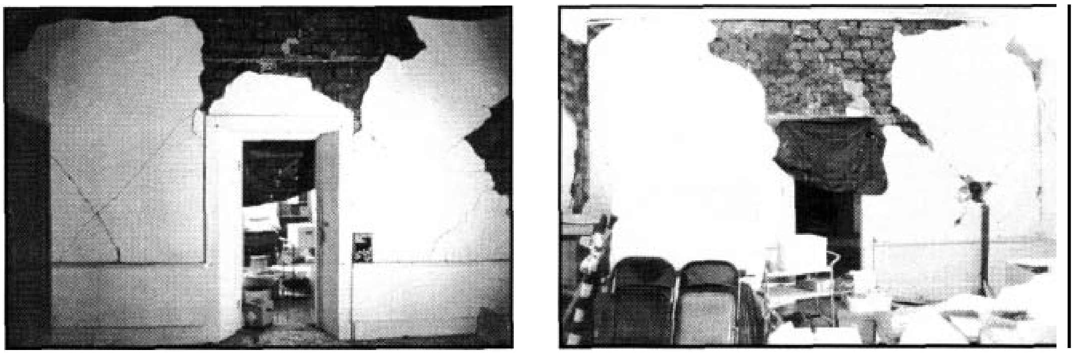
Room 8, east wall. Flexural crack developed just above the brick mantel.

Figure 6.13*. Wall between Rooms 7 and 8.*

The cross-tie on the east side of the transverse wall between Rooms 8 and 9 was also not damaged, and the crack damage to the wall was moderate (Figure 6.14). There are no large offsets or separations between this wall and the exterior walls as the tie rod apparently held the north and south walls relatively tight to the cross wall.

Other damage

The chimney located in Room 8 was seriously damaged, having sheared at the mantel and at the ceiling level. Large sections of plaster spalled during the earthquake and much of the remaining plaster has delaminated from the adobe. The ceiling structures in several rooms have shifted due to the motions of the connecting walls. There is no positive connection between the ceiling framing and the walls.



Room 8, west wall. Note X-shaped shear crack in left panel.

Room 9, east wall. Note diagonal shear crack in the right panel, same as in the photograph to the left.

Figure 6.14. ***Wall between Rooms 8 and 9.***

Overall Structural Performance

The most serious damage to the De la Osa Adobe occurred at the gable-end walls where the east wall collapsed and the west wall ended up leaning precariously outward but did not collapse. As is typical of gable-end walls, there is a great potential for collapse because these walls are generally tall and thin, nonload bearing and not well connected to the roof and ceiling framing.

The next most serious damage occurred to the transverse walls. The longitudinal load-bearing walls were able to rock and the transverse walls provided some lateral support. As a result, the longitudinal walls suffered relatively little damage. By contrast, the transverse walls suffered serious damage with offsets caused by in-plane shear forces and separations at the intersections with the longitudinal walls.

Damage to the De la Osa Adobe shows clearly the contrast between the in-plane and out-of-plane displacement capabilities of adobe walls, as well as the relative merits of well-anchored cross-ties. In the out-of-plane direction, adobe walls can rock to a large extent, several inches in either direction, without suffering significant damage, unless they have a large slenderness ratio.

In contrast, the displacement capabilities of adobe walls in the in-plane direction are limited. A 1-inch relative displacement can easily become a permanent offset between sections of a wall. Shear and separation displacements, particularly in walls that are not well connected to perpendicular walls, are often permanent offsets that may require reconstruction of a portion or all of a wall.

It appears that the in-plane performance of the walls between Rooms 7 and 8 and Rooms 8 and 9 was improved by the effectiveness of the cross-ties at these locations. In-plane continuity and positive anchorage to perpendicular walls may be provided by effectively anchored cross-ties, thereby reducing relative displacements between sections of the walls and ensuring that shear and separation cracks remain small. The level of damage to the De la Osa Adobe was very extensive and was exacerbated by failure of the interconnections between structural elements.

Leonis Adobe

History and Background

Social history

The land surrounding the Leonis Adobe was originally part of Rancho El Escorpion of Mission San Fernando granted to three ex-Mission Native Americans, Urbano, Odon, and Manuel, along with Joaquin Romero. Miguel Leonis, a Basque, acquired it in the 1870s after his arrival in California through marriage to the daughter of Odon, Espiritu Chijulla (Hoover et al. 1990:154; Robinson 1966:6). It is reported that ruins of an earlier house lay behind the present (possibly of 1840s vintage), and that old maps show four houses on the site (Robinson 1966:7).

The setting of the Leonis Adobe contributes much to its charm as it includes typical outbuildings usually missing today (Figure 7.1). The archaeological research potential of the grounds appears to be great, particularly for investigation of cross-cultural contact. This is one of just a few sites occupied by California and Native American couples that have been identified and studied. It is located on public land obtained by homesteading (Robinson 1966:7) and was occupied by Leonis's widow until her death in 1906.

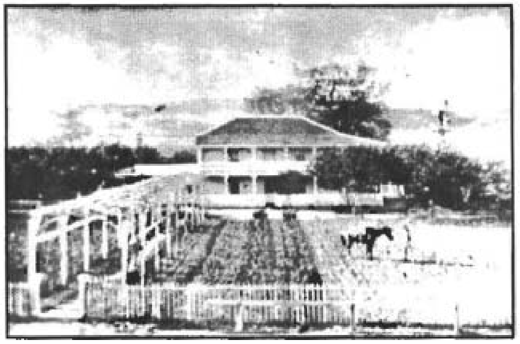


Figure ***7.1. The Miguel Leonis Adobe in about 1905 (source: Leonis Adobe Association).***

Architectural history

The two-story Leonis Adobe, as presently constituted, appears to date from the latter part of the nineteenth century, although some portion of it may have been constructed in about 1844 and completed in 1846. Its charming Victorian gingerbread architectural embellishment undoubtedly dates to a later period, around 1880, during the Leonis tenure.

The dining room on the ground floor features an intact original mezcla floor, one of the few remaining in the state. A partition in the sala was removed in about 1925 and a doorway cut through connecting the sala and the dining room (Leonis Adobe brochure). A bathroom addition was removed at the north side of the building during restoration. Historical photographs indicate that the Leonis Adobe possesses an unusual amount of architectural integrity; inspection reveals a similar quantity of undisturbed historic fabric.

The Leonis Adobe is listed in the National Register of Historic Places and is owned and operated by a private, non-profit corporation.

Building and Site Description

The Leonis Adobe is a two-story structure with a two-story corredor on two sides, a two-story, wood-framed structure on the north, and a one-story plank frame addition on the west. The house is oriented on an east-west axis with the front of the building facing south; in plan the building is approximately 37 feet long and 20 feet wide. The porches, or corredores, extend out approximately 9 feet on the south and east sides as does the frame structure on the north (Figure 7.2). The north structure is an extension of the porches, entirely enclosed, and houses the stair hall, a bathroom on the second floor, and a kitchen and store room on the first floor. Half of the east porch is also enclosed. There is one large room on the first floor and two rooms separated by a hall of plank partitions on the second floor.

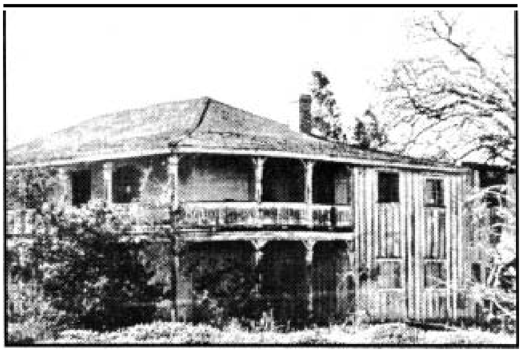


Figure ***7.2. The Miguel Leonis Adobe in the 1930s before reconstruction (source: Leonis Adobe Association).***

The site is flat, and there are no indications of surface or subsurface moisture sources or moisture damage to the adobe walls. The adjacent grounds are maintained as a “swept earth” yard with no vegetation immediately adjacent to the structure. The soil is surficial sediments of gravel, sand, and clay from alluvial fans and slope wash. It is underlaid by claystone and siltstone.

The first-floor adobe walls are covered with board and battens on both interior and exterior surfaces with the exception of the exterior surface of the north wall; the board and battens were added during the nineteenth century over original mud plaster and whitewash finish. The second-story walls have whitewashed or painted plaster on interior and exterior surfaces. The upper portion of the west adobe wall above the plank-frame shed also has board and battens over the adobe.

The adobe walls, which are approximately 20 inches thick, including plaster, all appear to be constructed of adobe headers. The quality of the adobe masonry is good; the mortar joints are relatively thick. Window and door locations on the second floor are located directly above those on the first floor on the south, east, and most of the north walls. A window is located directly above the first-floor doorway to the west shed.

The windows themselves are double hung, 6-over-6 lite sashes. All of the windows and doors are in good working order; all windows were operable after the earthquake. The door through the plank partition from the second-floor hall to the east room sticks slightly.

The hipped shingle roof consists of 2x4 rafters on approximately 2-foot centers. Collar ties exist on every second or third rafter. The rafter ends rest on a 1-inch-thick wall plate on all four sides. The second-floor ceiling joists extend completely through the north and south walls and support the wall plate. On the east and west wall, 2-inch-thick wood blocks support the wall plate. Adobe blocking exists between the joists. It was not possible to determine the relationship of the adobe walls and the first-floor ceiling joists because of the interior board and batten siding. Wooden vertical members are embedded in the adobe walls near the comers of each room, the purpose of which may have been to add support to the roof framing, but it also has the effect of tying the roof system to the walls.

The only chimney that presently exists is the one on the west side of the plank-frame addition; there was at least one other chimney at an earlier time. The west chimney extends approximately 10 feet above the roof of the addition and shows no signs of damage. It was reportedly reinforced in a previous repair.

A steel channel section was embedded into the wall on the west surface of the first-floor west adobe wall just below the floor joists apparently after the San Fernando earthquake of 1971. Steel clip angles are welded to the channel section, and the ceiling joists in the dining room are bolted to these clips. The channel section is anchored to the wall by 5/8-inch lag bolts that are approximately 2 feet long and screwed into an embedded second-floor joist on the east side of the wall.

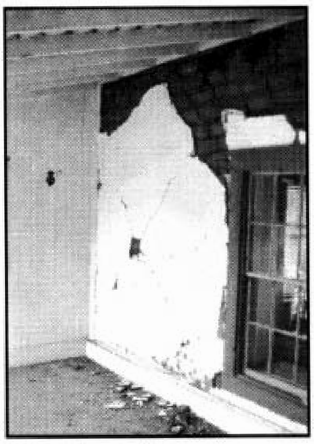


Figure 7.3. ***Crack damage in the south second-floor wall near the southwest corner. X-shaped cracking across this panel indicates shear failure.***

Estimate of Local Earthquake Intensity

The Leonis Adobe is located approximately 7 miles southwest of the epicenter of the Northridge earthquake. There are no CSMIP strong-motion recording stations close to the Leonis Adobe. At the spillway of the Wood Ranch Reservoir, approximately 16 miles west of the epicenter and 12 miles northwest of the Leonis Adobe site, recorded peak ground accelerations reached 0.22g in the north-south direction, 0.21g in the east-west direction, and 0.17g in the vertical direction. The ground motions at the Leonis Adobe were probably greater than those measured at the Wood Ranch Reservoir but less than those at the De la Osa Adobe, which is approximately 8 miles east of Calabasas. It is estimated that the peak horizontal ground acceleration at the Leonis Adobe was 0.3g to 0.4g The estimated MMI was between VII and VIII.

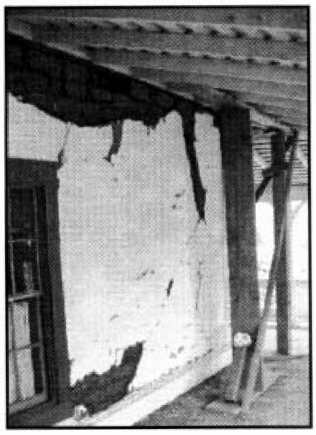


Figure 7.4. ***Crack damage in the south, second-floor wall near the southeast corner. The diagonal crack indicates a probable shear failure.***

Damage Description

Damage to the Leonis Adobe at Calabasas was moderate to extensive. The most significant damage occurred at the second-floor level, with moderate to extensive cracking in the north, south, and east walls. Damage to the north and south walls is primarily from out-of-plane rocking but is not particularly serious (Figures 7.3 through 7.6). The east wall suffered

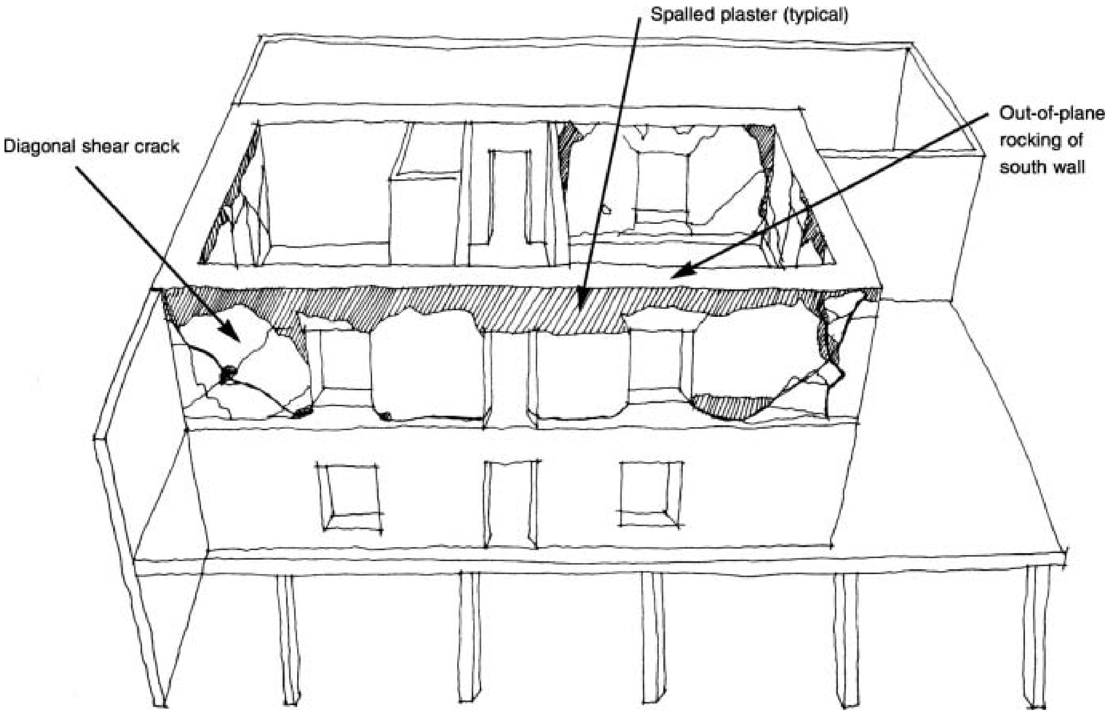


Figure 7.5. *South side of the Leonis Adobe showing crack and spall damage.*

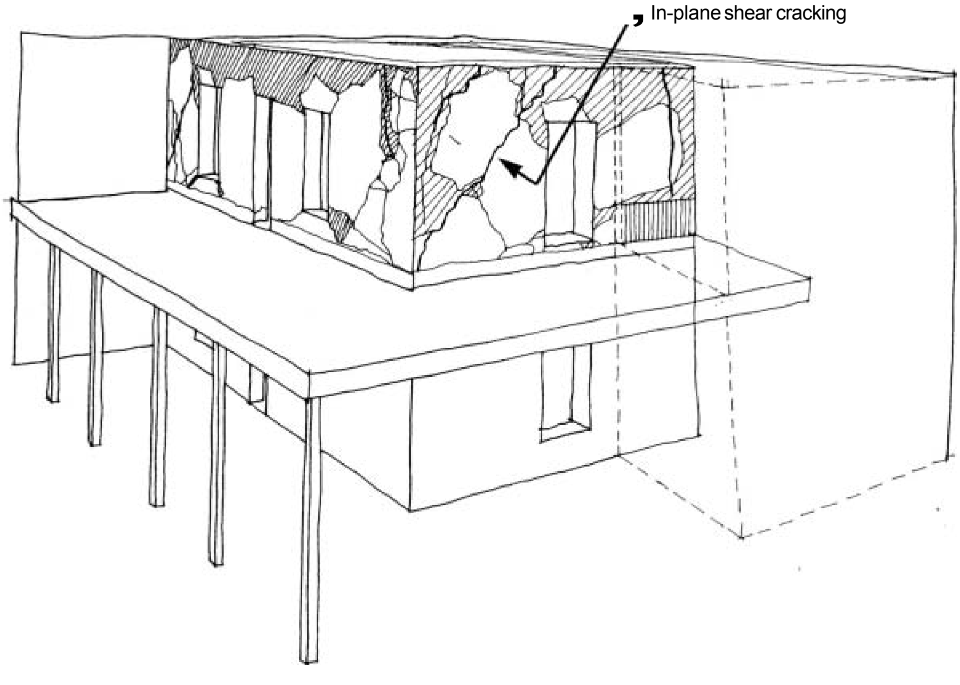


Figure 7.6. *Southeast comer of the Leonis Adobe showing crack and spall damage.*

vertical and diagonal cracks with horizontal offsets of as much as 1 to 2 inches (Figures 7.7 through 7.10).

Wood siding covers most of the interior and exterior first-floor walls so that they could not be observed. Siding removed at the southeast corner revealed only slight crack damage (Figures 7.11 and 7.12). Slight cracking was also observed on the west

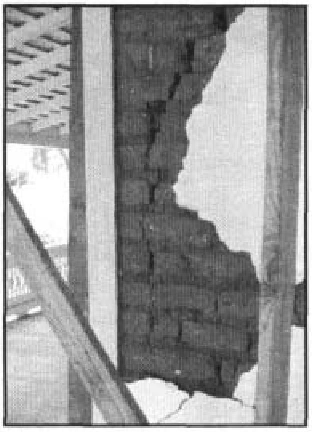


Figure 7.7. *Vertical crack in the east face of the southeast corner of the second floor. The width of the crack is approximately 1 1/2 inches. A crack of this nature develops because of the tensile stresses in the adobe that develop as the south wall pulls away from the east wall.*

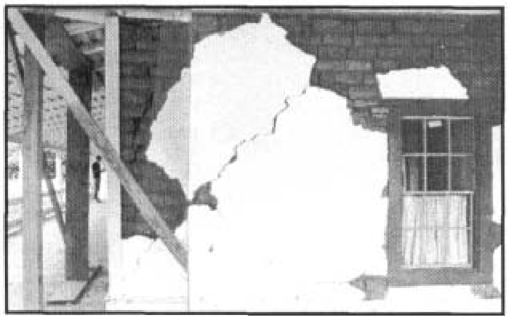


Figure 7.8. *Diagonal crack on the east side of the southeast corner of the second floor. The width of the crack is approximately 1/2 inch. This type of crack can develop at corners, creating a wedge of material that will slide towards the comer*

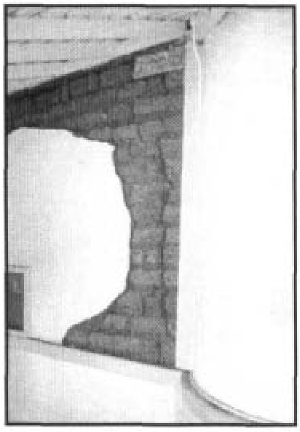


Figure 7.9. *Vertical crack on the east side of the northeast comer of the adobe walls on the second floor, similar to the cracks on the south end of this wall. A crack of this nature develops because of the tension in the adobe that developed when the south wall pulled away from the perpendicular wall.*

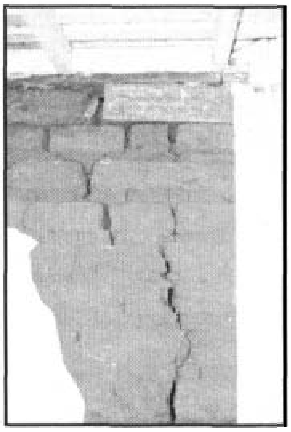


Figure 7.10. *Close-up of crack shown in the previous photograph. The width of this crack is approximately 3/4 inch.*

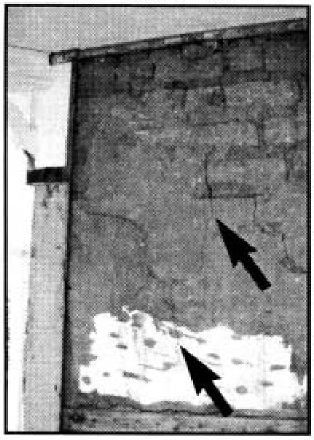


Figure 7.11. *Southeast corner at the first-floor level. The damage is significantly more severe on the second-floor level directly above (Figure 7.7). The photograph shows a vertical crack at the interface of the two perpendicular walls and a diagonal shear crack that extends down to the right.*

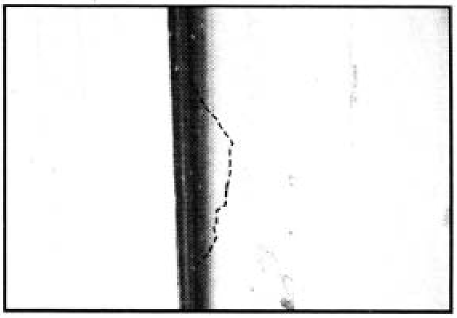


Figure 7.12. *Slight crack at the edge of the wood-paneled south wall at the southeast corner at the first-floor level. The crack appears to extend the height of the wall. The photograph shows a vertical crack at the interface of the two perpendicular walls and a diagonal shear crack that extends down to the right (dotted line along crack).*

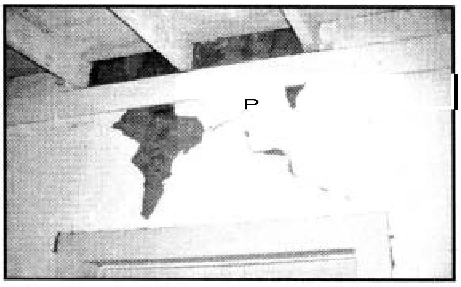


Figure 7.13. *Crack damage over the doorway in the west wall, shed roof area, first-floor level. This area appears to have been previously damaged. A steel channel is hidden behind a horizontal wood element and anchored with lag bolts to a second-floor joist on the opposite side.*

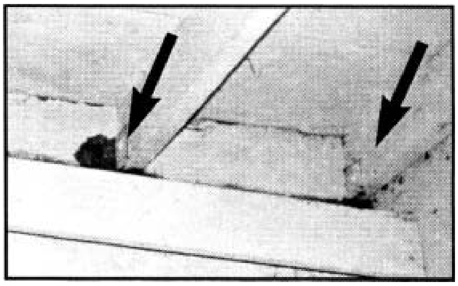


Figure 7.14. *Shed roof rafters, west wall, first-floor level. Steel clips are welded to the channel sections bolted to each of the shed roof rafters.*

surface of the west wall at the first-floor level (Figure 7.13). This damage may have existed prior to the Northridge earthquake.

East and west walls

The east and west adobe walls are nonload bearing. The east wall at the second-floor level suffered moderate to extensive in-plane cracking, including diagonal shear cracks and vertical separation cracks at both the southeast and northeast corners

(Figures 7.7–7.10). Both of the separation cracks of 1 to 2 inches in width were caused by tensile stresses in the adobe at the intersections of perpendicular walls. The diagonal crack extends from the southeast comer up to the wall top plate. This crack, which resulted from in-plane shear forces, has a horizontal offset of approximately 1 inch.

At the first-floor level very little of the wall could be observed due to the board and battens covering both the interior and exterior surfaces. The southeast comer, however, was exposed for inspection. A very narrow vertical crack was observed at about the depth of the thickness of the intersecting south wall and represents the initiation of a separation crack at this corner.

The west wall at the second-floor level suffered only minor crack damage, primarily of an in-plane nature, with diagonal and X-shaped cracks expressed in the plaster surface. Minor vertical cracks also extend from the upper comers of the window to the ceiling.

At the first-floor level the west wall suffered only minor vertical and diagonal cracks above the door lintel (Figure 7.13). It appears that the vertical crack is an old crack that reopened. These cracks are not typical of earthquake damage and may indicate a preexisting condition. It is unknown when the steel channel section was added to the wall, but it may have been in response to previous earthquake damage (Figure 7.14). The addition of this channel adds in-plane continuity and out-of-plane stiffness to the wall and may have helped to prevent additional damage.

North and south walls

The load-bearing north and south walls at the second-floor level suffered moderate to extensive crack damage that appears to have resulted from both in-plane and out-of-plane motions. A classic X-shaped shear crack developed at the west end of the south wall (Figures 7.3 and 7.5). A steeper diagonal crack that turns vertically upward at the west end is also present. At the east end, a vertical separation crack developed at the comer along with a 45-degree diagonal crack extending from mid-height of the southeast comer down toward the baseboard (Figure 7.4). A horizontal crack extends the length of the wall at the base. Both the vertical and diagonal cracks at the east end of the south wall are believed to have been caused by out-of-plane motion of the wall.

Dislodged adobe blocks were also observed at the top of the north and south walls. Although these walls are load bearing, the top plates rest on spaced wooden blocks, some with ceiling joists supported on the second course down. These adobe blocks were used for blocking; thus, they are not compressed by the roof, and many of them were dislodged, sliding out from underneath the top plate.

Damage to the north wall at the second-floor level was slight to moderate, consisting of a diagonal crack at the east end, extending from mid-height at the northeast comer down to the cabinet opening, and a vertical crack at the northwest comer. A horizontal crack extends the length of the wall at the baseboard level. Loose adobe blocks were dislodged at the top of the wall.

Damage observed to the north and south walls at the first-floor level was slight; however, most of the wall surfaces are covered and could not be examined.

Overall Structural Performance

Damage is greater in the south and east walls than in the north and west walls, with the greatest damage at the southeast corner. This perhaps is due to the stiffening of the north and west sides by the adjacent wood structures that abut the adobe walls. The crack pattern of the long south wall clearly indicates a crack pattern caused by out-of-plane rocking. The shorter, transverse east wall primarily suffered in-plane crack damage although it also may have been damaged by out-of-plane motions.

In the out-of-plane direction, adobe walls can rock to a large extent without suffering significant permanent damage unless they are too tall and unsupported. Many adobe walls in historic adobe buildings have slenderness ratios of about 5; thin adobe walls have slenderness ratios that are greater than 10.

Four of the largest cracks are vertical separation cracks at the corners due to separation of the long walls from the transverse end walls during the out-of-plane rocking. Corners of adobe walls are susceptible to collapse because vertical cracks often develop on adjacent wall faces at the corner. This condition occurred at the southeast corner where the corner section of wall is nearly freestanding and could collapse outward during another shake; it was also observed at several of the other adobes in this survey. A similar set of vertical cracks has begun to develop at the same corner on the first floor (Figures 7.10 and 7.15).

The diagonal crack in the east wall near the southeast corner also is serious because of the permanent offset. This crack was probably caused by a combination of in-plane shear in the east wall and the pullout forces generated by the out-of-plane motions of the south wall. After the diagonal cracks formed, gravity forces are constantly working to widen the separation, especially when coupled with in-plane horizontal motion.

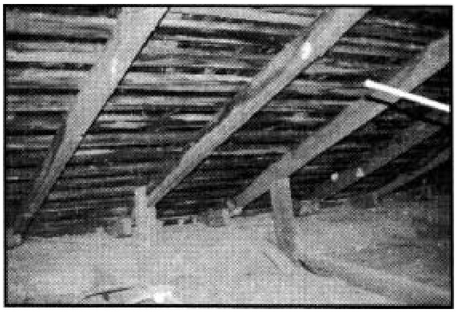


Figure 7.15. ***Roof framing shown in the attic. The roof rafters and the porch rafter sit on top of the top course of adobes. The ceiling rafters are supported by the second course of adobes with adobe blocks between the joists.***

There was only slight damage to the adobe walls at the first-floor level. The physical condition of the Leonis Adobe prior to the Northridge earthquake was excellent even though there was only one apparent structural improvement (the steel channel section added to the west wall). The level of damage to this adobe from the Northridge earthquake was moderate to extensive with no collapse of any structural elements. The lateral support provided by the porch that abuts three sides of the building may have provided some resistance to the out-of-plane motions of the first-floor walls.

Lopez Adobe

History and Background

Social history

The Lopez Adobe was constructed (or enlarged, depending upon sources consulted) in the late 1870s or early 1880s by Valentin Lopez for parents Geronimo and Catalina Lopez, some of the earliest residents of the San Fernando Valley (Parks 1928:46). Catalina Lopez' father, Pedro, was mayor domo of the mission in 1837 (Lopez Adobe brochure). Geronimo Lopez, husband of Catalina, purchased 40 acres of a "1000 Vara Tract" near Mission San Fernando, which had been granted by Micheltorena to a Native American named Samuel (Robinson 1966:9).

Architectural history

The Lopez Adobe residence represents a pleasing marriage of lacy, perforated Victorian architectural detailing and adobe walls (Figure 8.1). Originally, the Lopez Adobe is said to have had seven rooms with bedrooms upstairs opening onto the corredor and an exterior kitchen. Today, the Lopez Adobe has lost a little of its distinctive architectural character due to the clumsiness of the exterior surface rendering, but it retains an exterior kitchen and an outdoor staircase (not in the original location, but nearby). According to HABS data it was remodeled in 1926 by a descendant of the original owner; it was altered again in the 1950s. Remodeling resulted in the creation of three rental units with three kitchens and three bathrooms, a feature that may have contributed substantially to its economic viability and survival but that detracts from the originality of the interior.

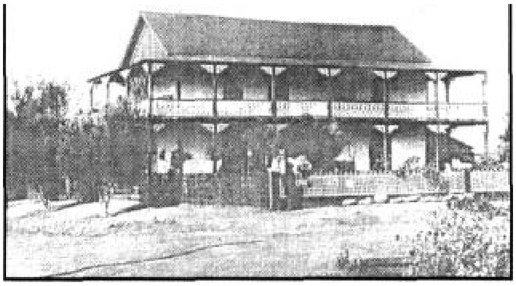


Figure 8.1. *HABS photograph of the Lopez Adobe.*

The interior of the Lopez Adobe primarily reflects the revival tastes of the 1920s with radius comers and arched openings. The tiled roof dates to 1928 and is a Spanish colonial revival feature quite at variance with the Victorian architectural detailing of the two-story corredores but consistent with the interior treatment.

The Lopez Adobe is publicly owned and listed in the National Register of Historic Places.

Building and Site Description

Figure 8.2. ***North elevation of the Lopez Adobe.***

Figure 8.3. ***East elevation of the Lopez Adobe.***

The Lopez Adobe is a two-story structure with one-story additions to the rear. An open two-story porch is on the north, east, and west sides; the south half of the west porch has been enclosed on the second-floor level (see Figure 8.2). There are two rooms on the first floor of the two-story part, and the second floor is currently divided into several small rooms on either side of a central hallway that connects the east interior stair with the west porch. The second floor is supported by exposed wood beams bearing on the north and south walls.

The main structure has a gable roof, and, while the gables are presently plastered, historically, vertical wood siding of the gables was exposed. Gutters and down spouts direct rain water from the main roofs. The primary addition to the two-story main building is attached to the south end of the east wall and extends parallel to the adjacent street and sidewalk (Figure 8.3). This addition has a gable roof covered with clay tiles; clay tiles currently cover all of the roofs, although wood shingle roofs existed previously.

The present stairway located on the west end of the north porch is a later addition. The present interior stairway to the second floor is also a later addition, having been added in the 1920s. Other alterations consist of interior partitions, the rear additions, interior and exterior finishes, and structural modifications. The most significant structural alteration was the addition of a concrete bond beam at the second-floor ceiling line. The bond beam is not continuous, however, stopping at the location of interior partition walls in at least two locations, one on the north wall and one on the south wall. Another significant alteration to the structure was the addition of the modeled cement-like hard exterior stucco. Hard plaster also covers all of the interior wall surfaces. The exterior stucco is very different from any historic period stuccoes, and while it may have prevented some damage to the load-bearing adobe walls from the Northridge event, it also prevents inspecting the walls for damage that they probably received.

The Lopez Adobe is sited on level ground in the city of San Fernando at the corner of Maclay and Pico Streets. The surrounding soil is recent alluvium consisting of clay, silt, sand, and gravel, unconsolidated and poorly to well stratified.

Two preexisting structural elements appear to have significantly influenced the structural behavior of the Lopez Adobe during the Northridge earthquake. These elements include the concrete bond beam at the tops of the second-floor walls and the thick cement stucco and stucco wire lath on the exterior surface of the walls. A newspaper article at the site stated that both sides of the perimeter adobe walls were covered with wire mesh and bolted through the walls at regular intervals. However, there was no evidence of wire mesh on the interior surfaces of the walls nor any visible evidence of through-bolting. These structural enhancements were added after the 1971 San Fernando earthquake.

The building appeared to be in good physical condition and there was no evidence of preexisting moisture damage.

Estimate of Local Earthquake Intensity

The Lopez Adobe is located approximately 7 miles northeast of the Northridge earthquake epicenter. There are three CSMIP strong-motion earthquake recording stations located within 2 to 4 miles of this site. The Nordoff Avenue fire station in Arleta is approximately 3 miles south and the County Hospital parking lot in Sylmar is 3 miles to the north. The third is the Kagel Canyon Station in Pacoima, 4 miles to the northeast. The north-south, east-west, and vertical peak ground accelerations recorded at the Nordoff Avenue fire station were 0.29g, 0.35g, and 0.59g respectively, while those at the Kagel Canyon Station were 0.44g, 0.30g and 0.19g, respectively. The north-south, east-west, and vertical PGAS recorded at the County Hospital parking lot were 0.91g, 0.61g, and 0.60g, respectively. The maximum horizontal acceleration at the Lopez Adobe is estimated to have been between 0.4g and 0.5g. The estimated MMI in the area of the Lopez Adobe is estimated to have been VIII.

Damage Description

The Lopez Adobe suffered only moderate damage although located relatively close to the epicenter. The brick chimney collapsed, but this was the most serious damage to the building. On the exterior, only very slight cracking is visible in a few locations; the exterior has been recently covered with a thick cement stucco over wire lath, obscuring

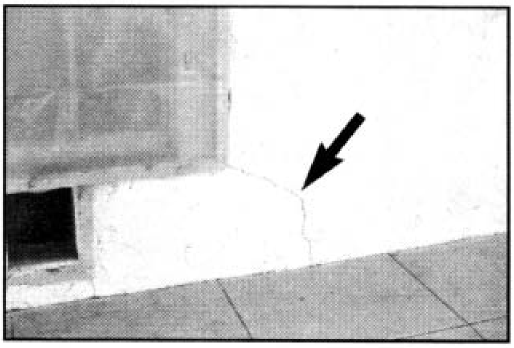


Figure 8.4. ***Minor cracking to exterior stucco. All of the cracking to the exterior stucco is minor. This is one of the larger cracks.***

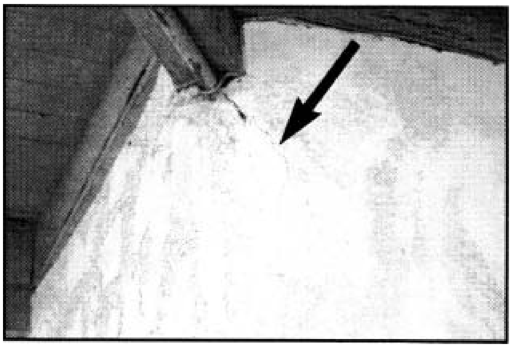


Figure 8.5. ***Minor crack in the exterior stucco at the northeast corner of the building below the balcony. The crack extends to just above the balcony.***

inspection of the adobe (Figures 8.4 and 8.5). The crack damage is more visible on the interior of the building where there is no stucco and wire-lath coating. There is wall cracking at the first-floor level, particularly within the living room. At the second-floor level the crack damage is concentrated at the interface between the concrete bond beam and the adobe wall.

First-Floor walls

Crack damage at the first-floor level was slight to moderate. There are slight hairline cracks in the exterior plaster. However, damage is more visible on the interior. The south wall of the living room has cracks around the fireplace and hairline cracks at the comers of the doorway (Figure 8.6). The north wall of the living room has a horizontal crack that extends from the top of the window to the top of the doorway (Figure 8.7). The east wall of the living room is an interior wall, 12 inches thick, and has suffered some damage at the top of the arched doorway, which is wood-framed and finished with plaster in this area.

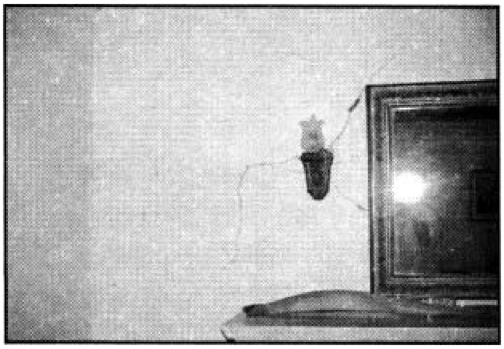


Figure 8.6. ***Cracks in the south wall of the living room. Crack damage was more visible on the inside of the building.***

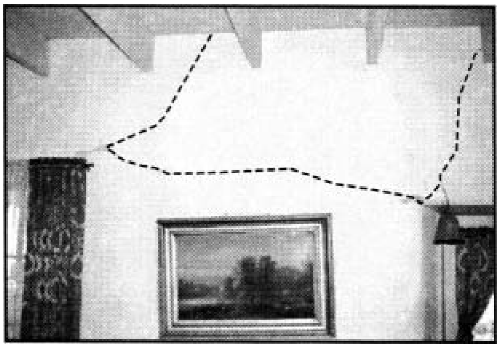


Figure 8.7. ***Minor cracking on the north wall of the living room (dotted line along cracks).***

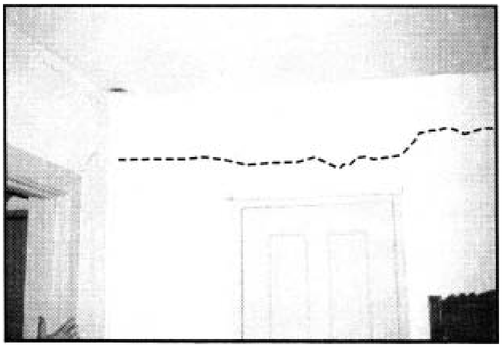


Figure 8.8. ***Horizontal crack in an upstairs bedroom. A horizontal crack was apparent in several locations at the base of the concrete bond beam (dotted line along crack).***

Bond beam

Cracks developed in several locations along the base of the concrete bond beam at the second-floor level (Figure 8.8). However, there is no evidence of permanent offset. Horizontal cracking was observed on both the interior and exterior at the bond beam level, particularly on the south and west faces of the building near the southwest corner (Figure 8.9).

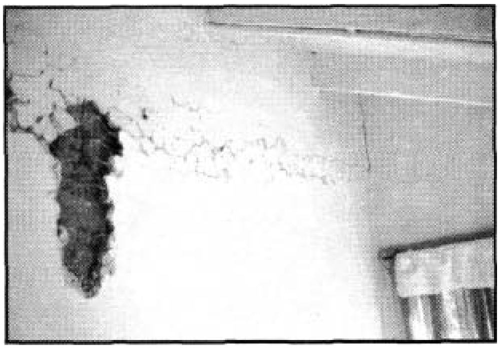


Figure 8.9. ***Damage to the plaster inside the porch on the west side of the building at the bond beam level.***

Overall Structural Performance

The overall damage pattern in the Lopez Adobe is not distinguished. The Lopez Adobe suffered only moderate crack damage. The most significant damage was the collapse of the brick chimney on the south side of the structure.

The bond beam, although not continuous, undoubtedly had a positive effect on the performance of this building, as did the stucco and wire-lath rendering on the exterior wall surfaces. The crack along the base of the bond beam indicates that there were significant stresses at this interface. It is unknown whether a positive connection between the bond beam and the walls exists. The Portland cement plaster stucco with wire lath remained intact with only slight damage on the exterior, but may hide more damage underneath.

Given the proximity of the epicenter and the level of damage to other buildings and structures in the surrounding area, the damage to the Lopez Adobe is surprisingly light. The level of crack damage to the Lopez Adobe is considered to be moderate, with collapse only of the chimney.

Chapter 9

Convento at the San Gabriel Mission

Historical Background

Social history

The convento, or priests' residence, of the San Gabriel Mission of 1812 is a large building with tall, thick exterior walls and numerous rather small rooms. Mission San Gabriel was reestablished on the present site in 1776, five years after initial settlement at the Mission Vieja site (Motz 1990:6). The extant portion of the convento seems to have been but a small part of the mission quadrangle, judging from an 1832 painting, but is highly significant as an original part of the mission (Figure 9.1). The original convento was reportedly 300 feet long (Mission San Gabriel Arcangel brochure). The convento has long been used as a museum and some important architectural artifacts and decorative objects were stored within its enclosed interior corredor until recently.

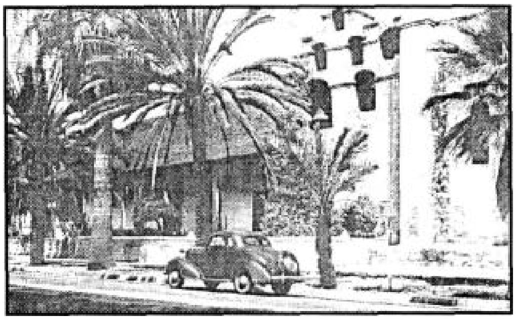


Figure 9.1. Historic photograph of the San Gabriel Mission (source: HABS drawings).

Architectural history

The precise use of the rooms of the convento is difficult to project from the current layout. None of them appear large enough to have been either a sala (reception or drawing room) or comedor (dining room); they may have been bedrooms for the two resident priests and guest rooms. The Whittier and Northridge earthquakes have enabled the survey team to see evidence of a number of changes that have been made to the convento over time. Arched door openings to the southwest corredor observable in the 1832 painting of the building were infilled apparently after that date, and windows have been substantially altered. Interconnecting doors between rooms have been converted to windows and subsequently infilled. The interior corredor posts facing the quadrangle are missing but evidence exists for their former location at lap joints of the extant lintels.

The convento exhibits signs of moisture damage to some of the exterior walls and interventions, including concrete contraparedes (aprons or curbs) that, although apparently intended to deal with the moisture problems, appear to have exacerbated them.

Mission San Gabriel is listed in the National Register of Historic Places and is a registered California Historical Landmark.

Building and Site Description

The convento at Mission San Gabriel is attached to the northwest side of the sacristy of the mission sanctuary; it shares a common wall at that point. It is 26 feet wide, approximately 70 feet long, and the adobe walls are approximately 14 feet high. The building is oriented on a southeast-northwest axis and is skewed approximately 10 degrees north of the axis of the church. For directional simplicity, reference north has been added to the HABS drawings.

The basically rectangular space is presently divided into eight rooms, ranging in size from several that are approximately 10 feet by 12 feet to the largest room at approximately 15 feet by 21 feet. A comdor extends along the west wall and an enclosed porch extends along the northeast side. The openings on the west and east walls are located symmetrically. A full attic exists above the first-floor rooms with the roof extending over the comdor and the porch. The gable end is wood framed.

The 14-feet-high west exterior adobe wall is approximately 3 feet thick and the north and east walls are approximately 2 feet thick. The interior walls are all approximately 1 foot thick, consisting of adobe stretchers. The walls do not appear to be connected at all to the existing roof system.

The adobe walls were severely damaged and had not been repaired or structurally braced prior to the Northridge earthquake. Subsequent to this most recent seismic event, the walls were braced on the interior. There is also considerable evidence of moisture damage, particularly in the west part of the building in Room 12, the northem-most room. Some temporary lower-wall repairs have been undertaken and the degree of moisture damage appears to be much less now than in the recent past. The repair itself consists of mud having been packed into a lower-wall basal erosion void and it exhibits no additional damage. Three years ago, this same area of wall was extremely friable and appeared to be damp at that time; the surface did not appear to be damp during this current inspection. There has also been lower-wall moisture damage to portions of the south wall in the past that has resulted in some wall slumping or settling. It is interesting that the west wall is presently protected from rainwater splash and surface water by the comdor.

The San Gabriel site is on level ground of Pleistocene nonmarine sedimentary deposits of gravel, sand, clay, and silt.

Estimate of Local Earthquake Intensity

San Gabriel Mission is located approximately 26 miles southeast of the epicenter. There are two CSMIP strong-motion earthquake recording stations located within 2 to 4 miles of this site: The Southwestem Academy in San Marino is 2 miles north and the Fremont School in Alhambra is 4 miles southwest. The north-south, east-west, and vertical peak ground accelerations at the Southwestern Academy were 0.16g, 0.12g, and 0.09g, respectively. Those recorded at the Fremont School were 0.09g, 0.12g, and 0.07g. The convento is located almost directly on a 0.2g contour line shown in Figure 2.4. Therefore the maximum horizontal ground motion at the convento is estimated to have been 0.2g, with an estimated MMI between VI and VII.

Damage Description

The extent of preexisting earthquake damage, primarily from the Whittier earthquake of 1987 and the 1992 Landers earthquake, made the convento quite susceptible to additional damage as a result of the Northridge earthquake. The vulnerability was particularly acute since the walls were unbraced until after the January 17, 1994 event.

The condition of the convento was observed in 1991 by an inspection team as part of the Getty Seismic Adobe Project. Most of the cracks observed after the Northridge earthquake already existed following the Whittier earthquake; they only enlarged and caused greater instability. As an example of the increased damage, Figure 9.2 shows the condition of a portion of the building in 1991 and Figure 9.3 shows the same wall in 1994, following the Northridge earthquake.

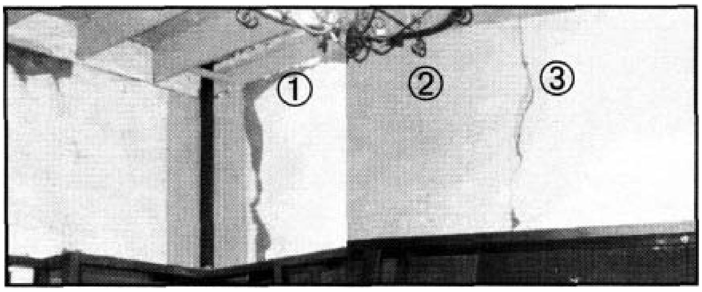


Figure 9.2. ***Crack damage to interior cross walls of Room 10 after the Whittier earthquake. The crack damage worsened after the Northridge earthquake (see Figure 9.3; numbers identify cracks for matching to those in Figure 9.3).***

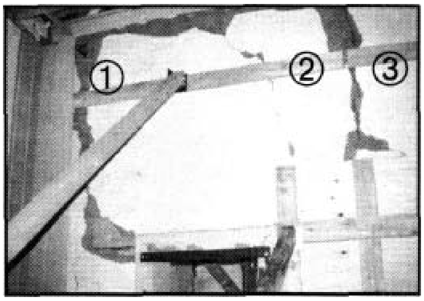


Figure 9.3. ***Recent condition of the wall at the northwest corner of Room 10. Cracks have wor-sened since 1991 (see Figure 9.2 for condition prior to Northridge earthquake).***

Exterior walls

The convento abuts the church to the south, sharing a common masonry wall at this location. The only exterior walls, therefore, are on the north, east, and west sides. The north end exterior wall has suffered the most damage of the exterior walls. It is leaning outward (toward the north) as much as 4 inches at the top and has separated from the east and west exterior walls, as well as from the thin interior intermediate wall that separates Rooms 11 and 12. The base of the north wall has suffered severe moisture intrusion up to 30 inches above the interior floor level. This condition is likely to have been a principal factor in allowing the wall to lean outward. In addition, there is no apparent connection between the roof and ceiling structures to the walls, thus allowing this wall to simply pull away from the perpendicular interior and exterior walls.

The west exterior wall suffered earthquake-related damage, particularly toward the north end where there is significant moisture intrusion at the base. In Room 12, the west exterior wall appears to be leaning outward (toward the west) between 1 and 2 inches at the top. Again, the moisture problem at the base of the wall is believed to be a major reason for the west wall having suffered this type of earthquake damage. Moisture has been an ongoing problem along the entire west wall as evidenced by the concrete contrapared constructed against the exterior surface to the level of the window sills.

In Room 12 the west wall has an infilled brick arch and minor cracks extending from the ends of the window lintel upward. The brick arch was outlined by crack damage. There is only slight damage to the west wall in Rooms 9 and 10. There is some damage at the ceiling level where the joists have moved relative to the wall and caused damage to the plaster. This may also be an indication that the wall has moved outward from underneath the ceiling structure. There was very little damage observed to the west exterior wall in Rooms 6 and 7.

The east exterior wall is enclosed by a porch that is part of a more recently constructed museum structure. The museum structure appears to have effectively braced the east exterior wall and only slight to moderate damage was observed. There is only slight crack damage at the ceiling joists along the entire east wall. Moisture at the base of the wall has caused spalling of the plaster in some areas along the interior surface, although the problem appears to be of a lesser extent than for the north and west walls. Slight crack damage around the window opening in Room 11 was also observed.

Interior walls

The interior walls of the convento sustained the majority of the damage. The interior walls are approximately 12 inches thick and 13 to 14 feet high. These walls are nonload bearing and unrestrained at their tops, thus making them quite susceptible to out-of-plane damage. In addition, because they are not interconnected via a bond beam or tie rods, damage in the form of separation and battering at the wall intersections is also common.

The intermediate wall between Rooms 11 and 12, which runs north and south, is seriously compromised by moisture and crack damage. The jambs of an infilled window define the location of vertical cracks from the floor up to the ceiling joists. There are gaps in the upper portion of the wall at either end that are due to the outward leaning of the perpendicular walls. There is a horizontal crack at the base of the wall defined by the upper extent of the moisture damage.

Transverse interior walls sustained crack damage that is more clearly a function of out-of-plane bending and displacements. The crack pattern that most clearly demonstrates the effect of out-of-plane bending is shown on the south wall of Room 10, between Rooms 9 and 10 (Figures 9.4 and 9.5). Here the crack pattern is dominated by flat-plate yield lines, the plate (adobe wall) being supported along three edges (top edge not supported). Yield lines, or flexural cracks, develop along lines of maximum flexural

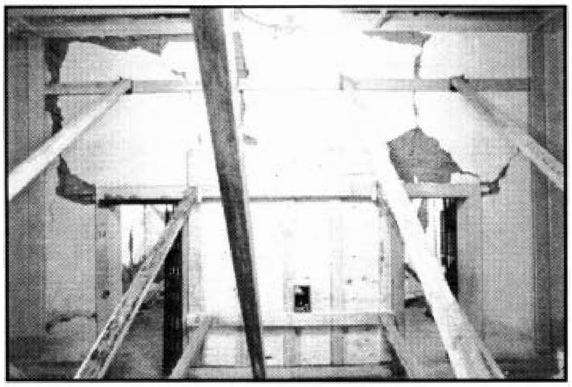


Figure 9.4. ***North side of the transverse wall between Rooms 9 and 10. Figure 9.5 shows the opposite side of the wall.***

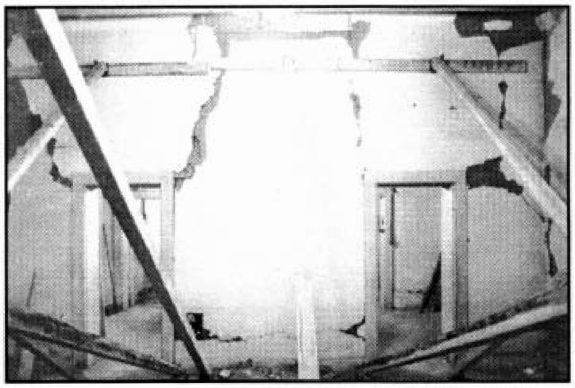


Figure 9.5. ***South side of the transverse wall between Rooms 9 and 10. Out-of-plane motion is the principal reason for damage to this wall.***

or bending stresses. The major plate element is defined by a crack that starts in the upper left (east) corner, extends downward to the top left corner of the left-hand doorway, continues across the wall at the base to the right-hand doorway, and extends from the top right of this doorway to the upper right (west) corner of the wall forming a U-shaped crack pattern. Secondary yield lines, or flexural cracks, extend from the inside corners of both doorways to the top of the wall. This wall is the only transverse interior wall that has no central support from a perpendicular intermediate wall and most clearly demonstrates the out-of-plane behavior of slender adobe walls.

The north wall of Room 10 has a more complex pattern of cracks, complicated by the central support provided by the intermediate wall between Rooms 11 and 12. This wall is also partially covered by plywood and temporary bracing, which obscured observation. It appears that the crack pattern is governed by the flat-plate yield lines from the door lintels up to the ceiling, with some of the secondary cracks being influenced by the intermediate interior wall. It also appears that in the lower half of the wall the piers between the two doorways and the pier at the west end of the wall have suffered in-plane diagonal shear cracking.

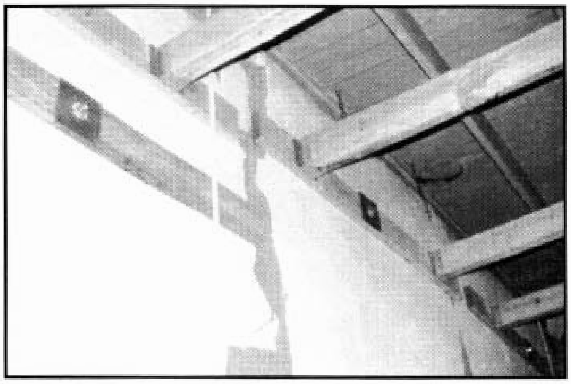


Figure 9.6. ***Out-of-plane offset of approx-imately 4 inches at a crack in the south wall of Room 9. Although this wall is buttressed by a perpendicular wall behind, the central section has pulled away from the buttressing wall. Figure 9.7 shows the gap between this wall and the buttressing wall behind.***

The south wall of Room 9 is also badly damaged. Again, there is an intermediate perpendicular wall that had an effect on the crack pattern, as it did with the north wall of Room 10. The east section adjacent to the intermediate wall is leaning toward the north approximately 4 inches at the top (Figure 9.6). The exposed surface at the intersection of these two abutting walls indicates that the adobe blocks were not bonded together when constructed, but abutted

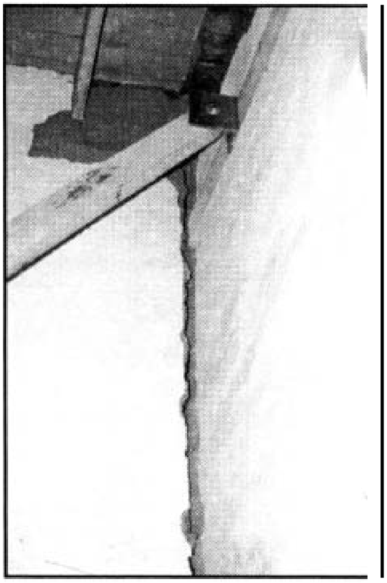


Figure 9.7. ***Separation at the interface between perpendicular walls. The wall to the right is the south wall of Room 9. The clean break between these two walls indicates they were not interconnected at the joint.***

forming a cold joint. The intermediate wall may have been added at a later date. The gap that has opened between these two walls is shown in Figure 9.7.

While the south wall of Room 7 also shows the out-of-plane flexural behavior above the door lintel level, the remainder of the interior walls show significantly less crack damage. What damage was observed, however, is dominated by out-of-plane behavior and influenced by moisture intrusion at the base of the wall.

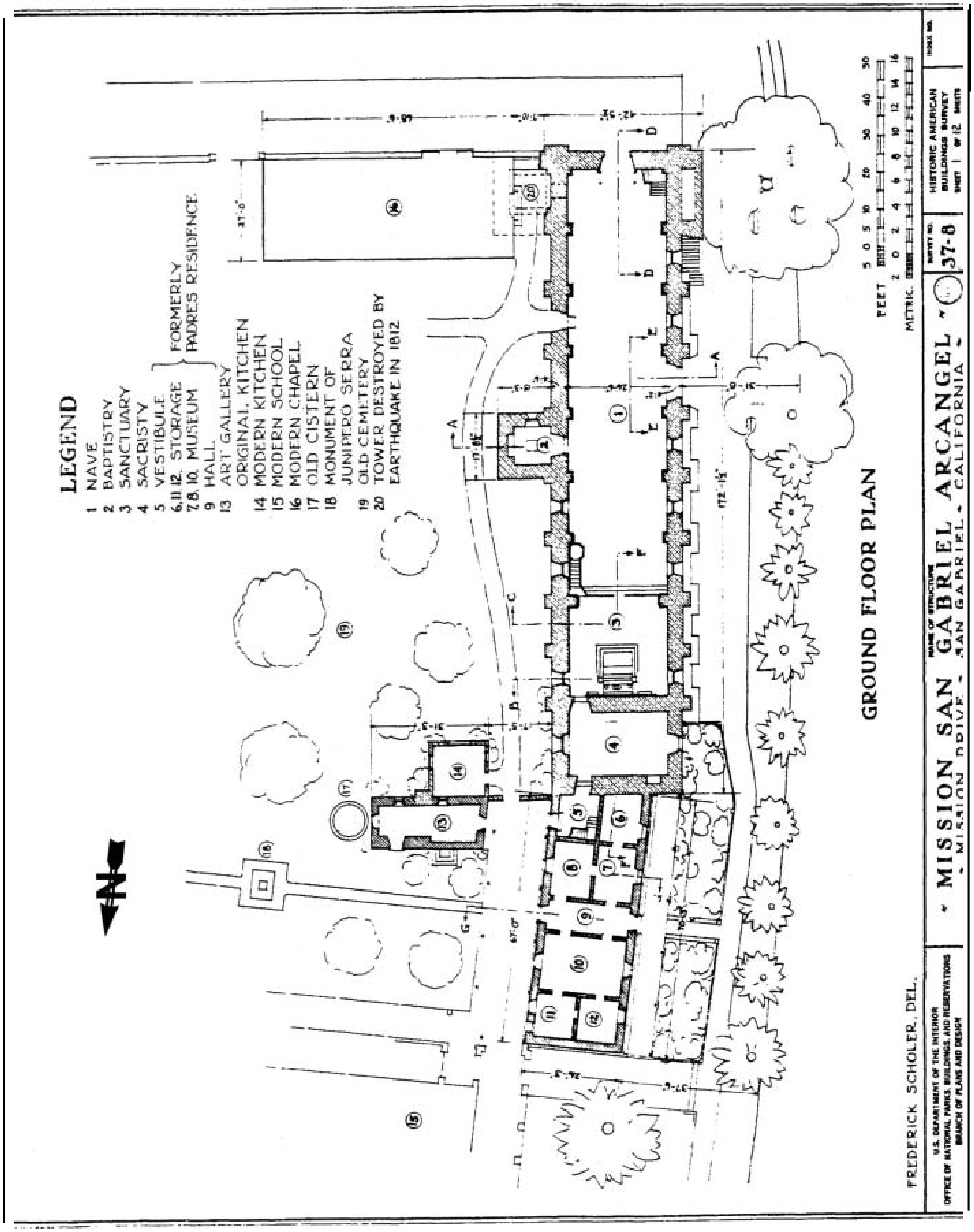
Structural Performance

The convento at Mission San Gabriel has thick exterior and thin interior walls approximately 13 feet high with no bond beam or tie rods connecting the walls of the structure. Because of their greater thickness, the exterior walls should be relatively more stable out of plane when compared to the interior walls that have a much greater slenderness ratio, and, indeed, major damage occurred to the tall, thin interior walls. However, as a result of moisture intrusion at the base of the walls, the north and, to a lesser extent, the west exterior walls have leaned outward, rotating about the area of moisture damage.

The overall damage appears to decrease from west to east and from north to south. This is due to the fact that the building is supported on the east side by the newer mu-seum structure and it abuts the massive end wall of the church sacristy at the south end.

The out-of-plane crack patterns observed in many of the interior walls were similar to those predicted by yield-line theory. These crack patterns have been influenced by the existence of door openings, intermediate intersecting walls, and moisture damage.

The amount of damage to the San Gabriel Mission convento, which is moderate to extensive, is high for an adobe building so far from the epicenter, with maximum ground acceleration of only 20 percent of gravity. The unrepaired and unbraced pre-existing damage caused by previous earthquakes made the building very susceptible to additional damage and increased instability.


LEGEND
1 NAVE
2 BAPTISTRY
3 SANCTUARY
4 SACRISTY
5 VESTIBULE
6,11,12. STORAGE
7,8,10. MUSEUM
9 HALL
FORMERLY PADRES RESIDENCE
13 ART GALLERY ORIGINAL KITCHEN
14 MODERN KITCHEN
15 MODERN SCHOOL
16 MODERN CHAPEL
17 OLD CISTERN
18 MONUMENT OF JUNIPERO SERRA
19 OLD CEMETERY
20 TOWER DESTROYED BY EARTHQUAKE IN 1812
N
GROUND FLOOR PLAN
FEET
METRIC
FREDERICK SCHOLER, DEL.
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BRANCH OF PLANS AND DESIGN
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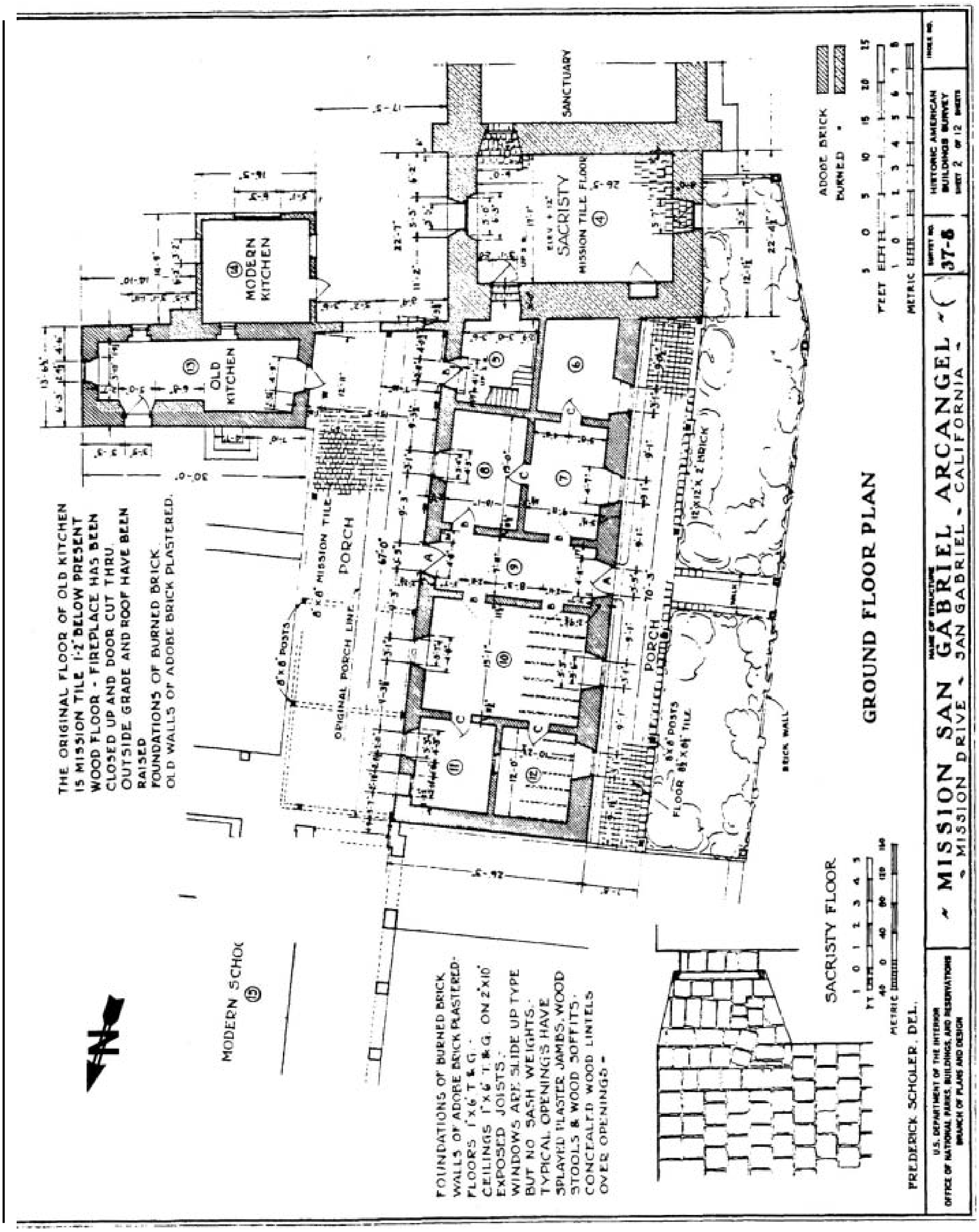
THE ORIGINAL FLOOR OF OLD KITCHEN IS MISSION TILE 1'-2" BELOW PRESENT WOOD FLOOR - FIREPLACE HAS BEEN CLOSED UP AND DOOR CUT THRU. OUTSIDE GRADE AND ROOF HAVE BEEN RAISED
FOUNDATIONS OF BURNED BRICK.
OLD WALLS OF ADOBE BRICK PLASTERED.
OLD KITCHEN ⑬
MODERN KITCHEN ⑭
SANCTUARY
SACRISTY MISSION TILE FLOOR ④
PORCH
8"x8" MISSION TILE
ORIGINAL PORCH LINE
8"x8" POSTS
12"x12"x 2" BRICK
FLOOR 8½"x8½" TILE
BRICK WALL
MODERN SCHOOL ⑮
FOUNDATIONS OF BURNED BRICK. WALLS OF ADOBE BRICK PLASTERED. FLOORS 1"x6" T&G. CEILINGS 1"x6" T&G. ON 2"x10" EXPOSED JOISTS. WINDOWS ARE SLIDE UP TYPE BUT NO SASH WEIGHTS. TYPICAL OPENINGS HAVE SPLAYED PLASTER JAMBS, WOOD STOOLS & WOOD SOFFITS. CONCEALED WOOD LINTELS OVER OPENINGS.
SACRISTY FLOOR
ADOBE BRICK
BURNED
FEET
METRIC
GROUND FLOOR PLAN
MISSION SAN GABRIEL ARCANGEL
MISSION DRIVE - SAN GABRIEL - CALIFORNIA
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Chapter 10

Lopez-Lowther Adobe

History and Background

Social history

On the San Gabriel Mission property is another former mission building known as the Lopez-Lowther Adobe, which was also damaged in the 1987 Whittier earthquake and not repaired. It has recently been braced and shored. Judging from the 1832 painting of the mission and the location of the Lopez-Lowther Adobe, it may have been part of the northernmost wing of the quadrangle. The adobe was formerly owned by the Lopez family and reacquired in recent years by the mission.

Architectural history

The Lopez-Lowther Adobe was rehabilitated by Doña Maria Lopez de Lowther in the mid-1920s in an exceedingly picturesque manner, evocative of that era, utilizing liberal quantities of colored hand-painted Mexican tiles never imported into California in historical times. It has been altered very little since the HABS drawings were done in the 1930s, and retains remarkable architectural integrity to the era of its transformation (Figure 10.1). The dining room now blends into the 1920s era kitchen, a wood-framed wall having been removed at an unknown date. The old kitchen is a tour de force featuring an *azulejo* (colored decorative tile) Mexican *brasero* (range) with cast iron gas

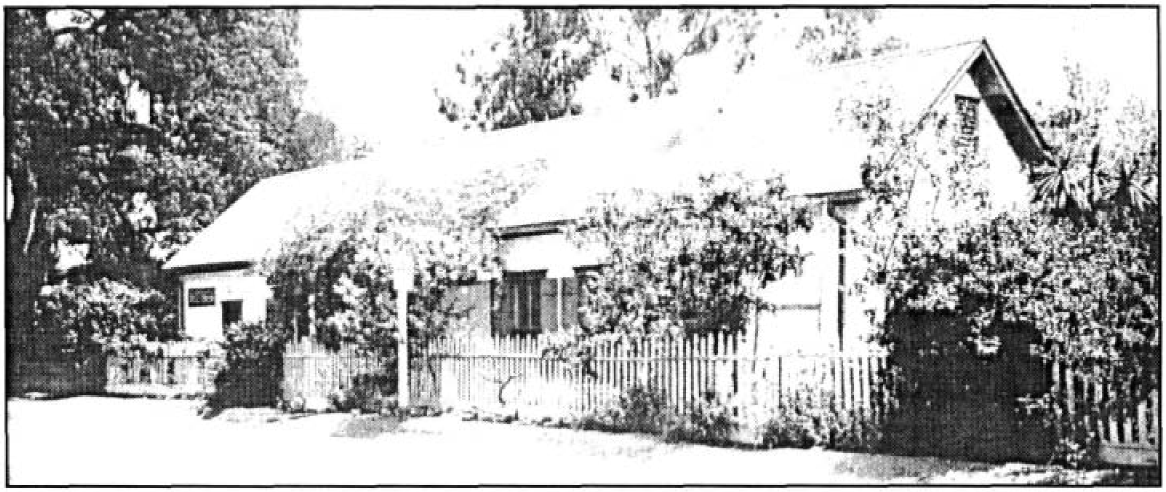


Figure 10.1. ***Historic photograph of Lopez-Lowther Adobe (source: HABS drawings).***

stove, as well as a copper lavebo surrounded by tile. A more recent wood-framed kitchen has been constructed at the rear, also accented by azulejos. The few alterations made since the HABS documentation have been consistent with the look and feel of the major rehabilitation. Here is a perfect example of changes that have gained significance over time, ones that, if removed, would be considered an adverse effect.

Building and Site Description

The Lopez-Lowther Adobe is a one-story adobe building 15% feet by 67% feet with later wood-framed additions on the rear. It is oriented along a north-south axis with the front of the building facing west. The interior of the adobe consists of a large living room and two small bedrooms. The two bedrooms are separated by an adobe wall approximately 12 inches thick; a stud wall partition divides the living room and a bedroom. The frame additions on the rear extend another 10 to 11 feet making the overall size of the building approximately 67 feet by 26 feet.

The building is located on Santa Anita Avenue. A concrete sidewalk along the west street side slopes toward the building creating a negative surface runoff condition. Water collects against portions of the wall base, particularly near the center of the structure near the front doorway. The site in general is relatively flat.

Three doors and four windows are located symmetrically along the west exterior wall with one central, or main door, and two other doors located near the two ends of the wall. There is one window in each of the gable-end walls and two doors in the east wall that presently provide access to the rear additions. There is a large fireplace built partially into the rear wall in the living room and a fireplace in each of the two bedrooms.

The gables are of adobe construction with a vent in each one. The gable roof spans the adobe portion of the building and the roof continues at a flatter slope to a shed roof in the rear. The ceiling is supported by 2-inch-thick wood joists; larger false joists in the living room, are attached to the underside of the ceiling. Rain gutters previously extended along the eaves, but they do not exist presently.

There is some variation in the adobe wall thickness, but it is assumed that all the adobe walls are constructed of adobe headers based on observations of the north gable-end wall. The north gable-end wall is 18 inches thick and the south gable end is approximately 24 inches thick. Each of the long walls appears to be approximately 20 inches thick, excluding the surface renderings.

At present a hard cement stucco covers all the exterior wall surfaces. A concrete apron has been constructed along the entire length of the west wall, representing a previous attempt to solve an even earlier lower-wall basal erosion problem. All of the adobe walls have suffered damage from water intrusion and walls have slumped or settled to some extent. The central portions of the east and west walls have the most extensive damage. At one location on the east wall the effective load-bearing portion is probably only half of the original wall thickness. The amount of moisture that caused the wall slumping in the past was greater than the moisture content of the present wall.

The physical condition of this building prior to the Northridge earthquake is not well known. The survey team was informed, however, that the major damage resulted from the Northridge earthquake, with only some damage occurring as a result of previous recent earthquakes. There is no evidence of seismic retrofits or structural elements that would have affected the seismic performance.

Estimate of Local Earthquake Intensity

The Lopez-Lowther Adobe is located close to the San Gabriel Mission on Santa Anita Street, approximately 26 miles southeast of the epicenter. There are two CSMIP strong-motion earthquake recording stations located within 2 to 4 miles of this site: The Southwestern Academy in San Marino is 2 miles north and the Fremont School in Alhambra is 4 miles southwest. The north-south, east-west, and vertical peak ground accelerations at the Southwestern Academy were 0.16g, 0.12g, and 0.09g, respectively. Those recorded at the Fremont School were 0.09g, 0.12g, and 0.07g. The Lopez-Lowther Adobe is located almost directly on a 0.2g contour line shown in Figure 2.4. Therefore the maximum horizontal ground motion at the site is estimated to have been 0.2g, with an estimated MMI between VI and VII.

Damage Description

A major portion of the damage the Lopez-Lowther Adobe sustained was influenced by preexisting moisture damage at the base of the walls. The longitudinal, load-bearing walls were cracked and damaged along their length. In several areas, crumbling of the weakened adobe at the base of the walls caused the plaster to bulge outward.

Another area of major damage was the north gable-end wall that appears to have deteriorated over the last few years, but was seriously affected by the earthquake. The south gable-end wall has some cracking but is in much better condition than the north.

Figure 10.2. ***North gable-end wall. Plaster spalled from the exterior surface. A crack extends along the horizontal wood plate embedded in the adobe at the ceiling level. The roof rafter at the top of the wall provides some restraint against overturning of the upper section of the gable end.***

Gable-end walls

The north gable-end wall was in poor condition at the time of this inspection (Figure 10.2). Much of the plaster has spalled and water damage has occurred to the upper portion of the wall. There is a horizontal crack along the wood plate located at ceiling height. Roof rafters on the exterior are snug against the adobe of the gable and appear to have provided some restraint to outward movement. Two cracks extend from the top of the window lintel upward to the horizontal plate. The gable portion of the wall appears to have rocked during one of the recent past earthquakes because the vent framing is displaced outward about 1% inches.

The south gable-end wall is in better condition (Figure 10.3). The plaster is still intact. Cracks extend from the upper comers of the first-floor window. These cracks turn horizontally as they extend from the window. There is also a crack that extends from the west end of this wall, just above the ceiling line, 4 to 5 feet toward mid-span. All of these cracks appear to be influenced by what is probably a wood plate embedded at the ceiling level, as there is in the north gable-end wall. Again, the roof rafters on the exterior of the gable are snug against the adobe and appear to have provided some restraint to outward movement.

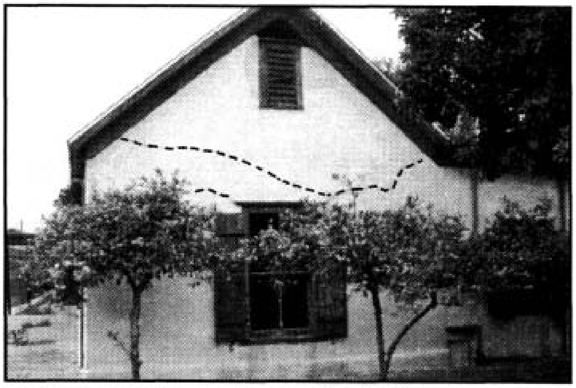


Figure 10.3. *South gable-end wall. Horizontal cracks above window lintel and above ceiling height may define the location of a wood Plate, similar to that seen on the north end.*

Longitudinal, load-bearing walls

Both the east and west walls have moderate to extensive damage along their lengths. Some of the damage to the east wall looks to be typical earthquake damage, with vertical and diagonal cracks occurring at the upper comers of the doorways and windows, and horizontal cracks at the base. But most of the earthquake damage was exacerbated by preexisting moisture damage. Moisture damage and subsequent slumping of the wall (Figures 10.4

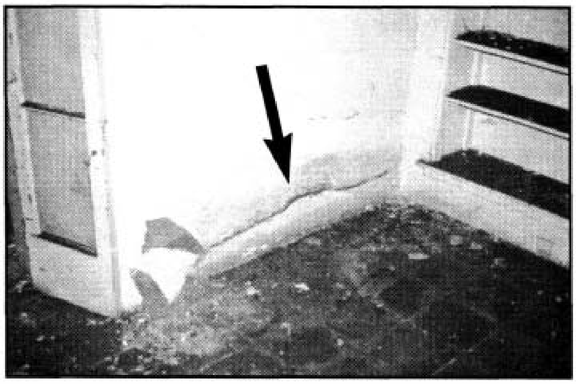


Figure 10.4. *Spalling of adobe and plaster at the base of the east wall. The adobe has been severely weakened by previous wet/dry cycles.*

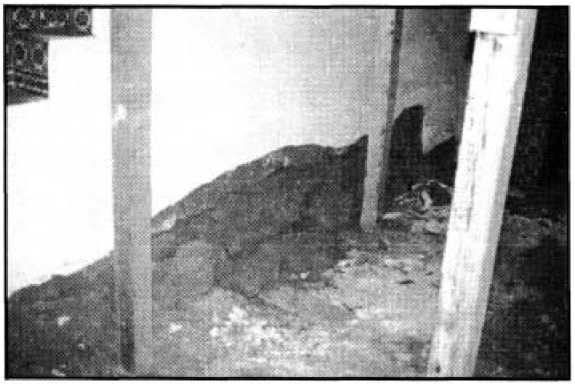


Figure 10.5. *Slumping at the base of the east wall. The east wall also suffered considerable water damage that resulted in slumping and bulging of the wall at the base.*

and 10.5) are most severe along the central portion and north end of the east wall. There is a large vertical crack just to the north of the fireplace and a diagonal crack that extends across a tile inset above the stove in the kitchen. There is only limited crack damage in the east wall at the south end.

Along the west wall, there is a horizontal crack at the base that extends from the window on the south side of the central doorway over to the doorway. This crack continues north of the doorway along the rest of the west wall (Figures 10.8 and 10.9). At the windows the cracks turn upward to the sills. At the base of the wall and at some of the cracks, the plaster is compressed, again a sign of slumping of the adobe. Cracks at the upper corners of doorways and windows appear to be related more to slumping than to earthquake damage (Figures 10.6 and 10.7).

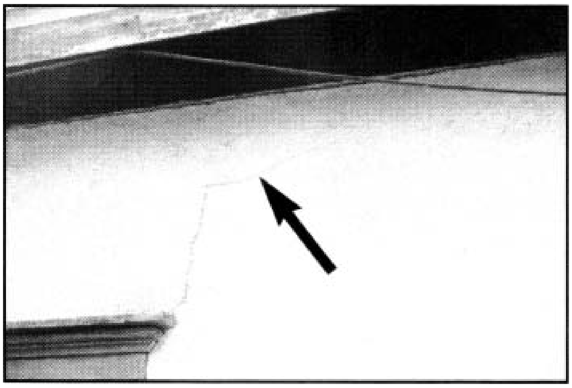


Figure 10.6. *Crack at a window opening, west wall above the area shown in Figure 10.8. The window is just south of the central doorway The crack tapers in width indicating that the wall has slumped in this area.*

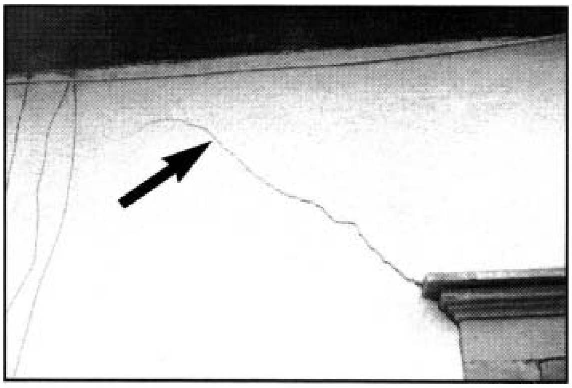


Figure 10.7. *Crack at a window opening on the west wall above the area shown in Figure **10.9.** The window is just north of the central doorway The crack tapers in width indicating slumping of the wall below*

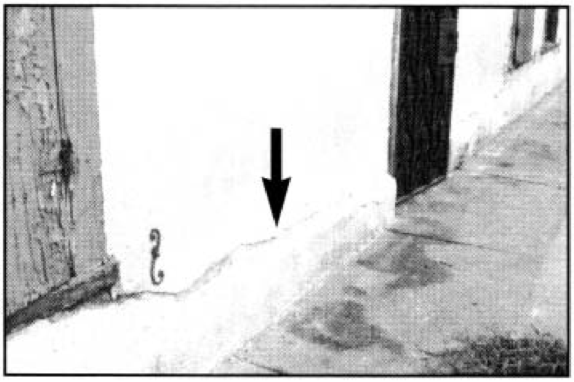


Figure 10.8. *Crack at the base of the west wall caused by combined out-of-plane rocking and slumping.*

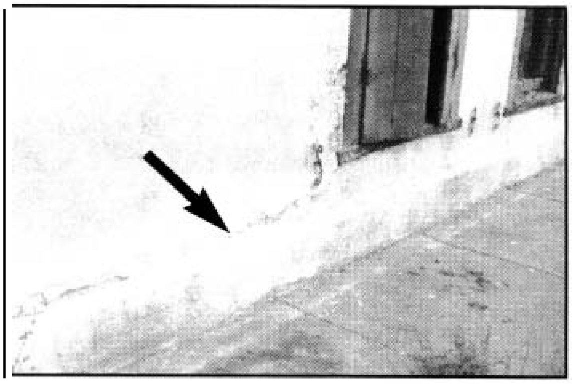


Figure 10.9. *Continuation of crack shown in Figure 10.8 on the opposite side of the doorway Slumping and out-of-plane rocking caused this crack.*

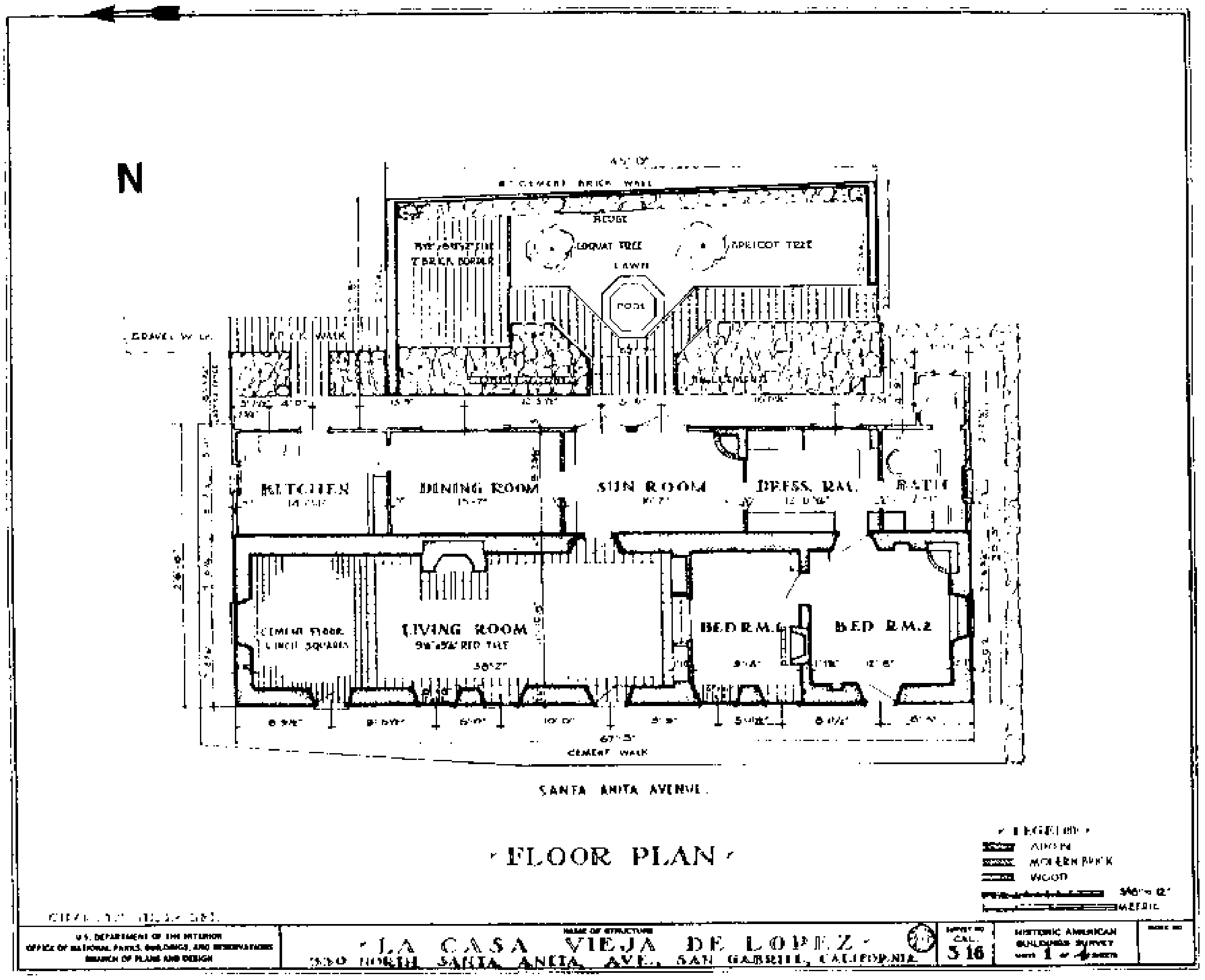
Transverse walls

There are two transverse walls in the adobe portion of the building. The northern one is wood framed and has bookshelves built into it. The southern one is adobe with a brick chimney on the north face. There is a vertical crack extending from the ceiling to the floor near the west side of the fireplace and there are two cracks over the doorway. This wall is presently shored to stabilize the central section, which is now independent. There is also evidence of plaster patching at the base of the wall, presumably the result of previous moisture damage.

Overall Structural Performance

Earthquake damage to the Lopez-Lowther Adobe was principally caused by the extensive preexisting moisture damage. The earthquake damage is considered moderate to extensive but it is certain to have been much less had it not been exacerbated by moisture damage. The gable-end walls behaved reasonably well, even considering the substantial moisture damage to the north gable wall. There are no vertical separation cracks at the comers of the structure, indicating that relatively low levels of horizontal forces have been exerted on this building in recent earthquakes.

The east and west longitudinal load-bearing walls suffered moderate crack damage along their lengths. The damage level was largely influenced by the poor physical condition at the base of the walls. The damage to the Lopez-Lowther Adobe is more than would be expected given the relatively long distance (26 miles) to the epicenter and the moderate ground shaking (0.2g maximum).


N
CEMENT BRICK WALL
HEDGE
LOQUAT TREE
APRICOT TREE
LAWN
POOL
BRICK BORDER
GRAVEL WALK
BRICK WALK
KITCHEN
DINING ROOM
SUN ROOM
DRESS. RM.
BATH
CEMENT FLOOR
LIVING ROOM
9⅞"x9⅞" RED TILE
BED RM.1
BED RM.2
67'-5"
CEMENT WALK
SANTA ANITA AVENUE
· FLOOR PLAN ·
· LEGEND ·
ADOBE
MODERN BRICK
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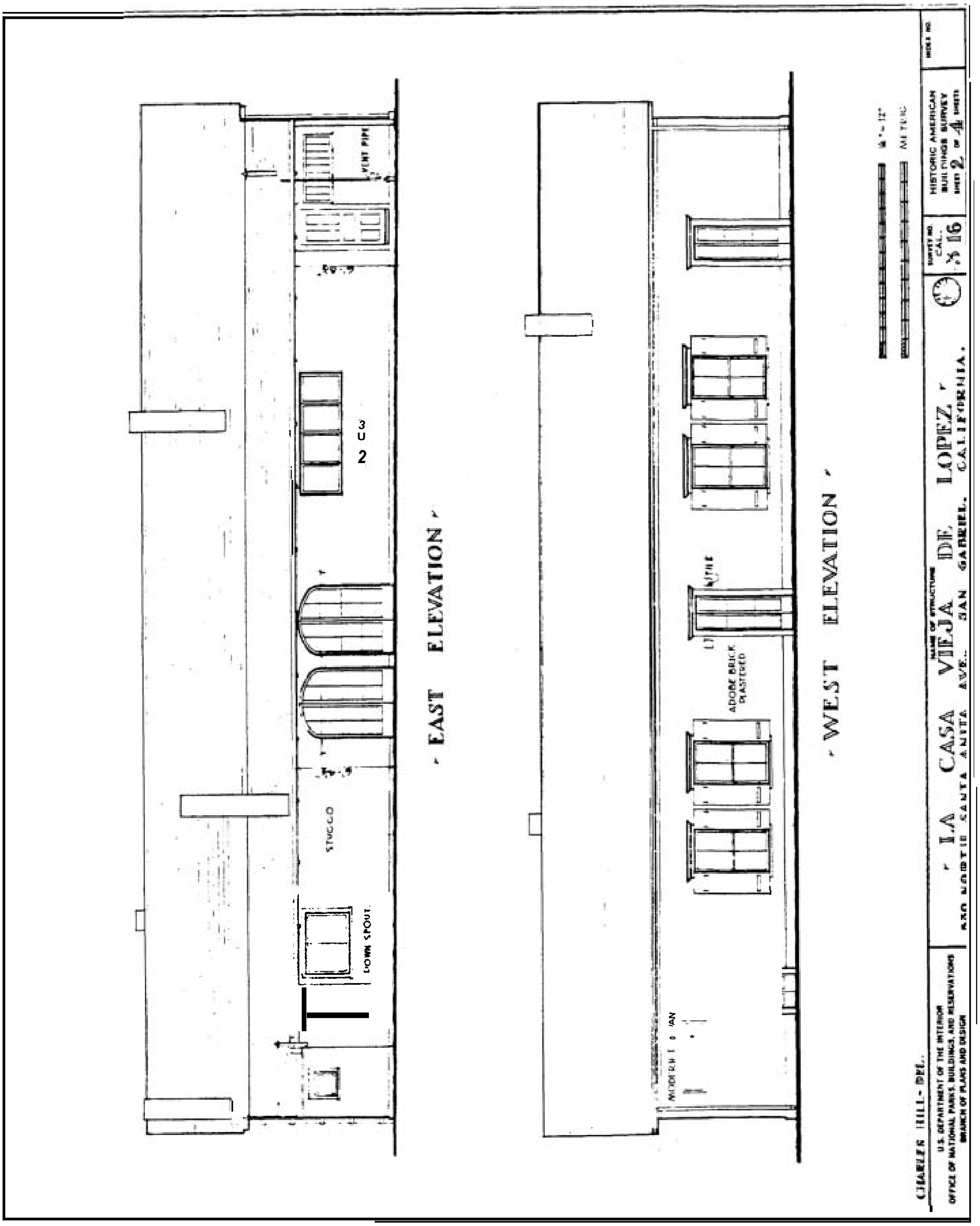
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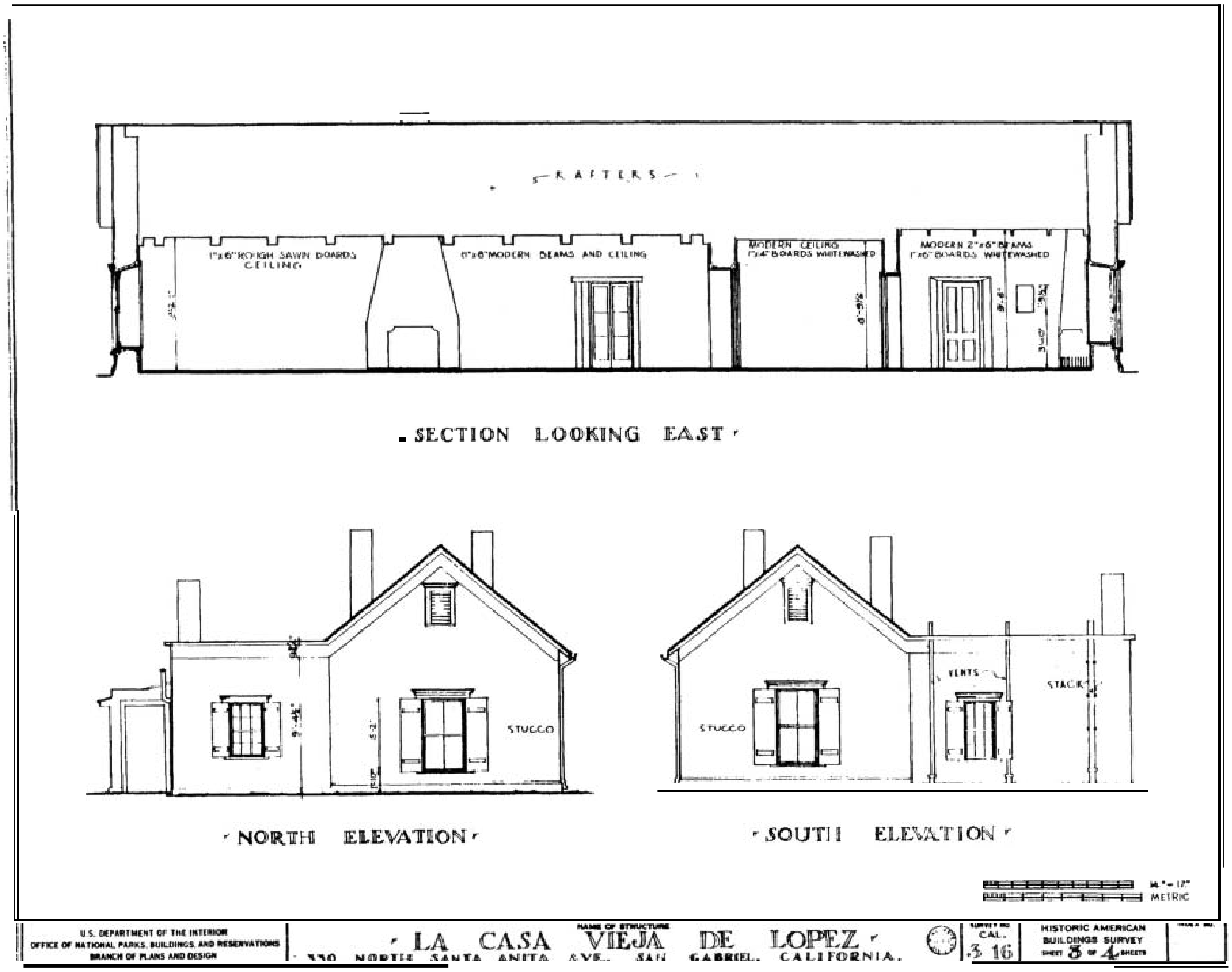
RAFTERS
1"x6" ROUGH SAWN BOARDS CEILING
8"x8" MODERN BEAMS AND CEILING
MODERN CEILING 1"x4" BOARDS WHITEWASHED
MODERN 2"x6" BEAMS 1"x6" BOARDS WHITEWASHED
SECTION LOOKING EAST
STUCCO
9'-4½"
8'-2"
NORTH ELEVATION
STUCCO
VENTS
STACK
SOUTH ELEVATION
¼" = 1'-0"
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HISTORIC AMERICAN BUILDINGS SURVEY
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Chapter 11

Pio Pico Adobe

History and Background

Social history

The Pio Pico Adobe is significant in California history as the final residence owned and occupied by the last Mexican-era governor of California, Don Pio Pico. His mother came to California with the Anza expedition. Portions of the adobe were originally constructed in the 1830s on Rancho Paso de Bartolo Viejo called Ranchito by Pio Pico, who purchased the ranch from the heirs of Juan Crispin Perez in the early 1850s. The rancho had been part of the irrigated agricultural lands of Mission San Gabriel to which the construction of the earliest adobe archaeological ruins may be attributable. It was but one of several large land holdings Pio Pico acquired in the era. Pio Pico enlarged the adobe over the years, living there until 1892 when he was evicted from his home following financial reverses (Holter 1986:10).

Architectural history

The oldest wing of the building, facing the San Gabriel River, possibly dates to the 1830s or 1840s, with other portions being added to and subtracted from the building over the years as a result of floods and various restorations. It is not known with any certainty if the earliest portion of the building was erected by Pio Pico or the previous owner. One researcher argues for an initial construction date of 1852, alterations in 1867, and rebuilding following a flood in 1884 (Motz 1990:14). The early roof is said to have been flat and brea covered (Holter 1986:13). In 1907 the Pio Pico Adobe was saved from destruction by Harriet Russell Strong who had occupied the building as a child. It was subsequently "restored" by the Governor Pico Mansion Society and Museum Association in the mission revival style then popular (Holter 1986:18). The site and structure were donated to the state in 1914. In 1944 the building was again restored by the California Division of Beaches and Parks (Motz 1990:36). Several rooms were removed at this time despite the fact that they had been added during the Pio Pico tenancy. As part of this restoration, six walls were retrofitted with horizontal steel tie rods placed in chases cut into the adobe walls and anchored by steel plates. Additional alterations to floors and roof lines were made in 1968 (Holter 1986:18). The building exists today more or less as it was restored in the 1940s and 1960s, although the shed porch roof at the northwest end has been removed recently (Figure 11.1).

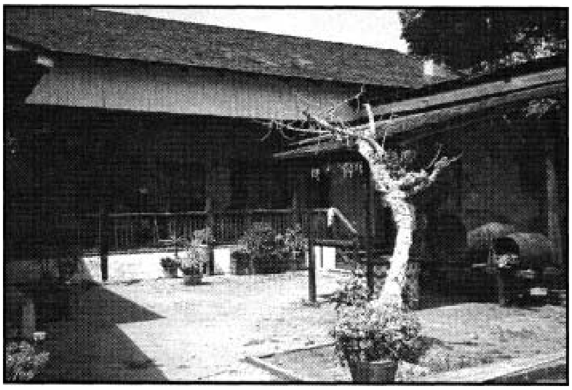


Figure 11.1. *Pio Pico Adobe.*

Excavations were made in portions of the interior in an effort to understand the habitation and use sequences of the nineteenth century, with an eye to possible reinterpretation. The building was seismically stabilized following extensive damage in the 1987 Whittier earthquake.

The Pio Pico Adobe is publicly owned and operated as a State Historic Park, and is listed in the National Register of Historic Places. It is a registered California Historical Landmark.

Building and Site Description

The Pio Pico Adobe is U-shaped in plan with the open part of the complex facing east. Overall dimensions are approximately 98 feet long in the north-south direction and 72 feet wide in the east-west. It consists of a total of thirteen first-floor rooms and one large room in the tapanco over the main portion of the building; the two wings are each single story. The wood shingle roofs over the various building segments are a combination of gable and hip roofs. The main building has a gable roof that spans over and forms the ceiling of a corridor along the east wall making the tapanco approximately 35 feet wide, twice the width of the first-floor rooms.

Most of the walls of the present structure are 24 inches thick, including the finished surface; but one partition wall at the north end of the sala (Room 8) is only 12 inches thick. The adobe used vary somewhat in size, but the majority are 22 inches long. The 24-inch-thick walls are made up mainly of adobe headers and the 12-inch wall was constructed of adobe stretchers, adobes laid end to end. The gables are also constructed of adobe. Some of the exterior wall surfaces are covered with hard cement stucco and the interior wall surfaces have softer plasters, primarily mud with finish washes and paints.

The Pio Pico Adobe is sited on nearly flat terrain sloping slightly downward to the west toward the San Gabriel River. The soil is recent alluvium consisting of clay, silt, sand, and gravel, unconsolidated and poorly to well stratified. A patio extends along the north, east, and south sides of the north, single-story wing and under the porch between the two wings. The south wing and the west side have natural ground cover. Ornamental plants exist along the length of the south and west walls of the building.

The Pio Pico Adobe has undergone many changes and alterations over the years with the addition of some rooms and the demolition of others. Door and window openings have also changed as have corridors, stairs, porches, and interior partitions. The most recent alteration was the seismic stabilization in 1991.

While most of the exterior surfaces of the adobe walls could not be observed because of the exterior stucco, moisture-related problems are obvious along the east portion of the north wall of the north wing, where a corredor roof was removed. The problem is not a new one and appears to be more significant as time goes by. There is a significant number of cracks throughout the interior and exterior wall renderings, as well as structural cracks in the adobe walls.

The damage from the 1987 Whittier earthquake and the subsequent repairs and stabilization performed on this building in 1991 are the most significant preexisting conditions for this structure. Also influencing the structural performance were the steel tie rods and anchor plates embedded in some of the walls in the 1944 restoration.

In 1991 the existing cracks were repaired by injection of an adobe-flyash grout. Several of the wall intersections were additionally reinforced with fiberglass rods cored and grouted into the walls. Vertical anchors, approximately 4 feet long, were also cored and grouted into the tops of three gable-end walls. Similar anchors were placed in the top of one interior nonload-bearing adobe wall by drilling through the tapanco floor. The north and south gable-end walls were anchored to the tapanco floor with flat steel straps that were grouted into holes drilled at 22%degrees from the horizontal. All anchors and straps were embedded in the same adobe-flyash grout used to repair the cracks.

Estimate on Local Earthquake Intensity

The Pio Pico Adobe is located approximately 31 miles southeast of the epicenter. The closest CSMIP strong-motion earthquake recording stations are located in Whittier and Downey, within 3 to 5 miles of the site. The north-south, east-west, and vertical PGAS recorded at a hotel in Whittier, 3 miles to the southeast, were 0.18g, 0.11g and 0.10g, respectively. The north-south, east-west, and vertical PGAS recorded at the county maintenance building in Downey, 4.5 miles to the southwest, were 0.23g, 0.17g, and 0.14g, respectively. Peak horizontal ground motion at the Pio Pico Adobe is estimated to have been in the range of 0.1g to 0.2g, The estimated MMI at the site is VI to VII.

Damage Description

Damage to the Pio Pico Adobe was slight to moderate and the ground motion was weak to moderate. The performance of the Pio Pico Adobe contrasts with that of the convento at the San Gabriel Mission where the ground motion was comparable but the building suffered extensive damage. The convento had not been repaired since it was damaged by the 1987 Whittier earthquake, whereas the Pio Pico Adobe had been substantially repaired and stabilized following that event. The types of stabilization measures implemented at Pio Pico would be expected to limit the damage during weak to moderate ground motions, as experienced at this site during the Northridge earthquake.

Repaired cracks

The repaired cracks held up well during the Northridge earthquake. Some slight reopening occurred at some of the previous cracks, but it was difficult to discern what damage may have been caused by the Northridge earthquake and what damage preexisted. The type of repair implemented would be expected to prevent previous cracks from becoming excessive as a result of the weak to moderate ground motions during the Northridge earthquake.

Gable-end walls

The south gable-end wall suffered no damage. There was no apparent movement at the top of the wall relative to the roof and no apparent damage to the flat steel straps anchored to the attic floor. This wall abuts a single-story room to the south with a slanted shed roof. Some restraint of the gable wall may have been provided by the shed roof diaphragm.

The north gable-end wall suffered slight to moderate damage. On the exterior, slight cracks developed adjacent to the window, Figures 11.2 and 11.3. On the inside of the tapanco, it is apparent that the wall slightly pulled away from the roof. There was slight pullout of the steel straps at the tapanco floor level, approximately 1/8 inch to 1/4 inch (Figure 11.4), and some permanent outward displacement at the roof level (Figure 11.5). There was also spalled adobe just below where the straps enter the wall. This is likely the result of the vertical component of the anchor reaction force caused by the 22% degree entry angle of the straps.

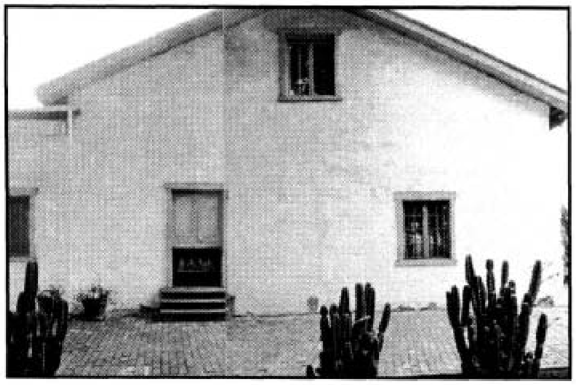


Figure 11.2. *Minor cracks in the north gable wall.*

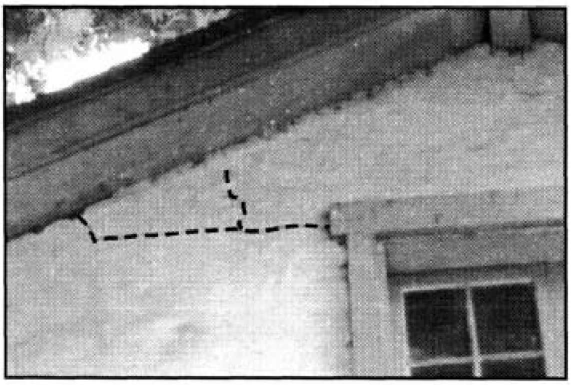


Figure 11.3. *Detail of a crack in the north gable-end wall (dotted line along crack).*

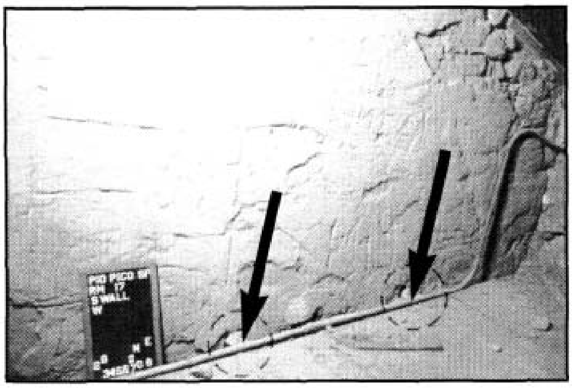


Figure 11.4. *The north gable-end wall pulled away from the tapanco floor.*

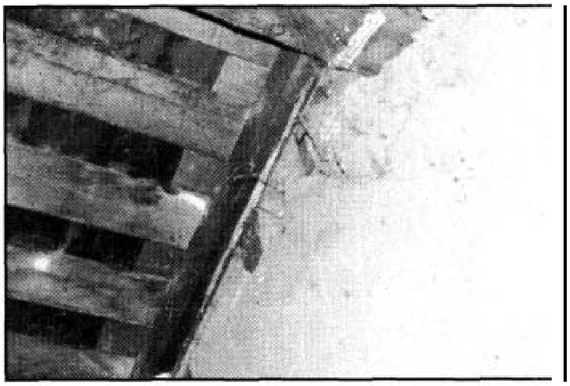


Figure 11.5. *North gable-end displaced outward slightly from the roof framing.*

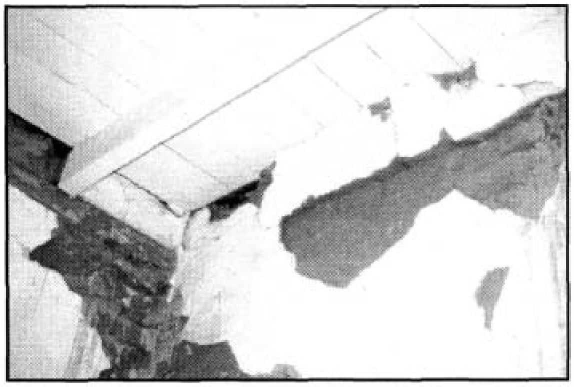


Figure 11.6. *Damage to the interior wall on the south of Room 6. The wall suffered a slight offset at the top due* **to** *out-of-plane rocking of the wall.*

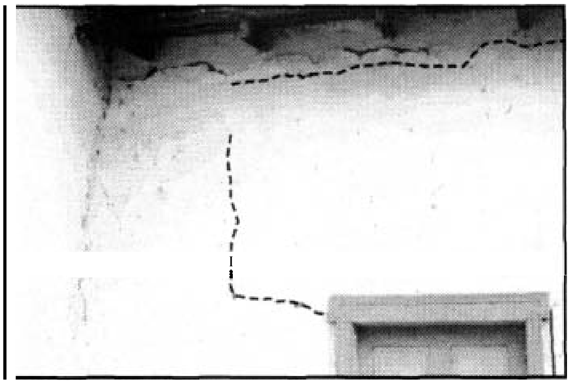


Figure 11.7. *Additional minor damage at a window opening and the roof line in a wall near the southwest side of the building (doffed line along crack).*

Interior walk

There is a slight offset at the top of the interior wall on the south side of Room 6 (Figure **11.6).** The wall apparently rocked during the earthquake and spalled some of the plaster at the ceiling joist level. There was little other significant damage to the interior walls.

Other damage

Some crack damage in other parts of the building were apparently caused by the Northridge earthquake. One of those areas is near the southwest corner of the structure. A horizontal crack at the top of the north wall developed underneath the eaves, and the plaster along this line spalled (Figure 11.7). On the interior of this room, loose adobe blocks slid at the top of the wall. There is also a crack at the top of the west wall that follows the eave line. However, there were no other signs of rocking or flexural wall damage such as separation cracks at comers. It appears that the roof over this single room wing attempted to shift relative to the walls.

The wall on the east side of Room 8, the sala, is leaning significantly inward away from the staircase (Figure 11.8). At mid-span the inward displacement is approximately 6 inches and at the

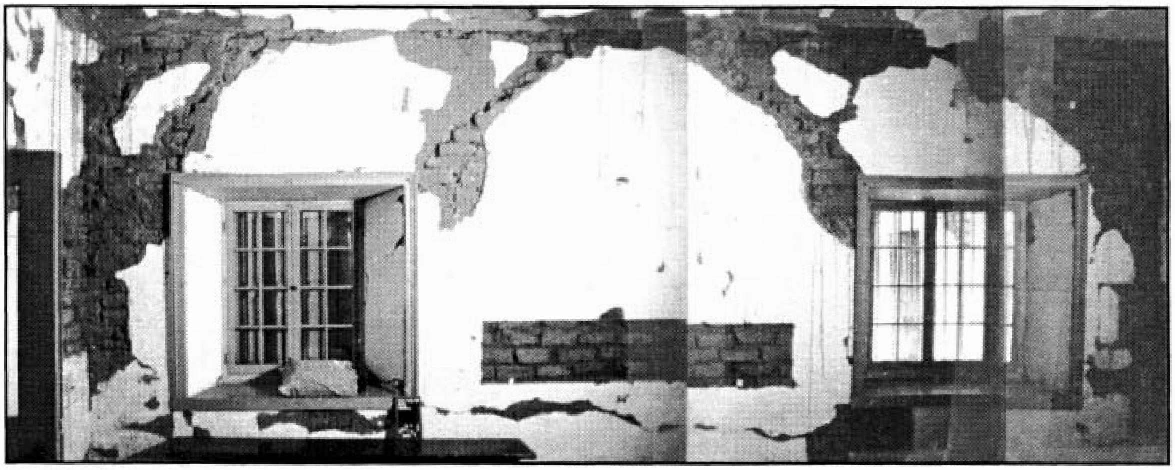


Figure 11.8. *Interior elevation of the east wall of Room 8. This wall was repaired in 1991 with an adobe-flyash grout and appears to have suffered little additional damage in the Northridge earthquake.*

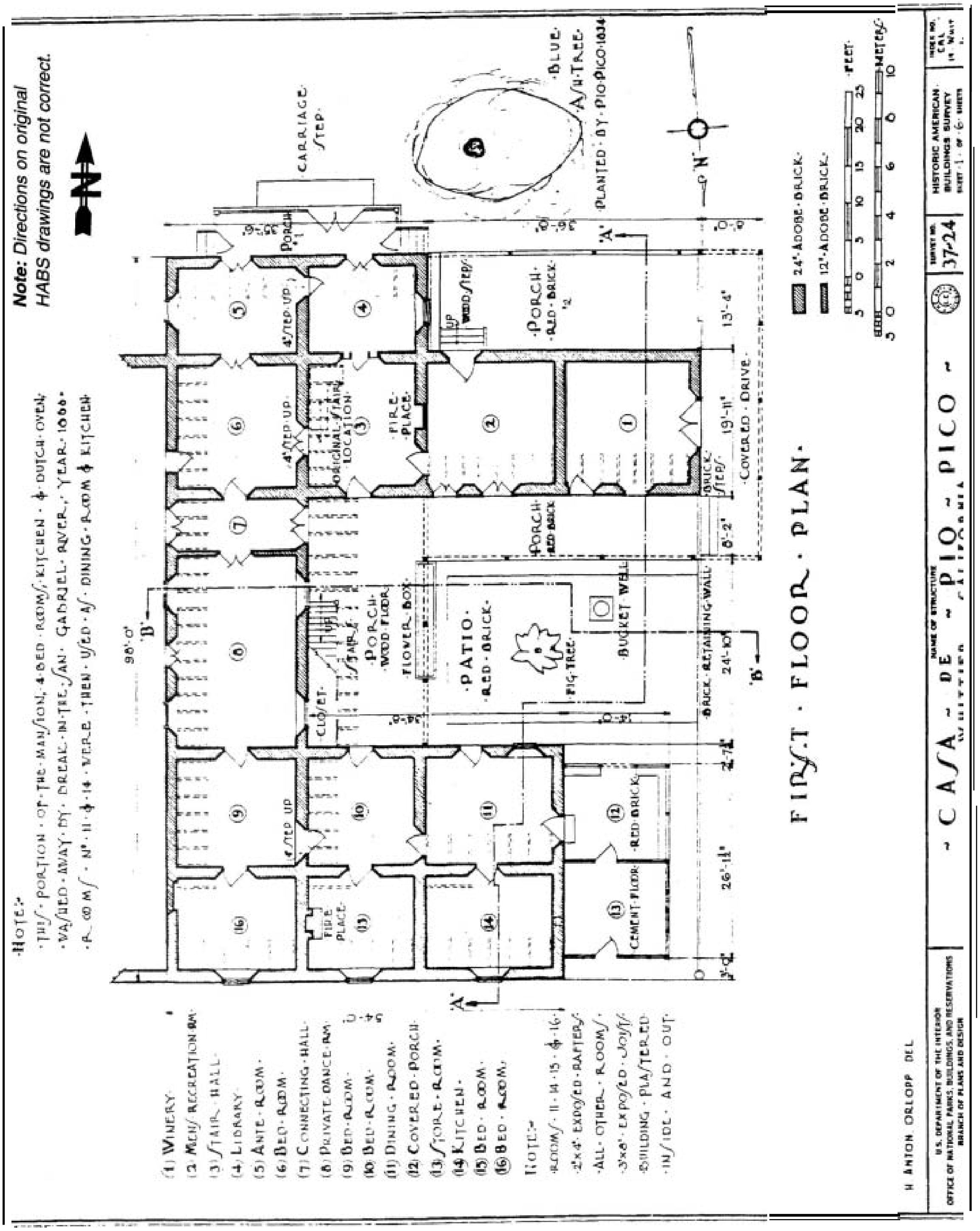
north and south ends it is approximately 5 inches. However, it is believed that most of this tilting preexisted the Northridge earthquake.

Overall Structural Performance

The overall performance of the Pio Pico Adobe shows the benefits of the repair and stabilization measures implemented in 1991 following the 1987 Whittier earthquake. The horizontal ground motions at this site during the Northridge earthquake are estimated to have been as high as 20 percent of gravity, but the repairs and stabilization measures were sufficient to prevent serious additional damage. This performance contrasts sharply with the performance of the unrepaired convento at Mission San Gabriel, where additional damage to the already seriously damaged structure was significant.

However, the slight to moderate damage that occurred to the north gable-end wall indicates that the stabilization measures implemented in this area may not have sufficient capacity to resist larger earthquake forces. At the top of the north gable wall, the vertical pins that anchored the top portion to the wall below, provided insufficient restraint to prevent offsets between the roof framing and the wall.

The level of damage to the Pio Pico Adobe was significantly influenced by the repairs and stabilization of walls that were implemented following the Whittier earthquake. The level of crack damage is considered to be slight to moderate, with no collapse of any structural elements.


Note: Directions on original HABS drawings are not correct.
N
NOTE:-
THIS PORTION OF THE MANSION, 4 BED ROOMS, KITCHEN & DUTCH OVEN, WASHED AWAY BY BREAK IN THE SAN GABRIEL RIVER, YEAR 1866.
ROOMS No. 11 & 14 WERE THEN USED AS DINING ROOM & KITCHEN
(1) WINERY
(2) MEN'S RECREATION RM.
(3) STAIR HALL
(4) LIBRARY
(5) ANTE ROOM
(6) BED ROOM
(7) CONNECTING HALL
(8) PRIVATE DANCE RM.
(9) BED ROOM
(10) BED ROOM
(11) DINING ROOM
(12) COVERED PORCH
(13) STORE ROOM
(14) KITCHEN
(15) BED ROOM
(16) BED ROOM
NOTES:-
ROOMS 11 14 15 & 16
2x4 EXPOSED RAFTERS
ALL OTHER ROOMS
3x8 EXPOSED JOISTS
BUILDING PLASTERED INSIDE AND OUT
CARRIAGE STEP
PORCH #1
4' STEP UP
WOOD STEPS
UP
PORCH RED BRICK #2
FIRE PLACE
ORIGINAL STAIR LOCATION
BRICK STEPS
COVERED DRIVE
PORCH RED BRICK
STAIR
PORCH WOOD FLOOR
FLOWER BOX
CLOSET
PATIO RED BRICK
FIG TREE
BUCKET WELL
BRICK RETAINING WALL
RED BRICK
CEMENT FLOOR
BLUE ASH TREE PLANTED BY PIO PICO 1834
'A'
'B'
98'-0"
35'-6"
36'-0"
54'-0"
34'-0"
13'-4"
19'-11"
8'-2"
24'-10"
2'-7½"
26'-11"
3'-0"
24" ADOBE BRICK
12" ADOBE BRICK
FEET
METERS
FIRST FLOOR PLAN
CASA DE PIO PICO
WHITTIER CALIFORNIA
H. ANTON ORLOPP DEL.
U.S. DEPARTMENT OF THE INTERIOR
OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
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HISTORIC AMERICAN BUILDINGS SURVEY
SHEET 1 OF 6 SHEETS
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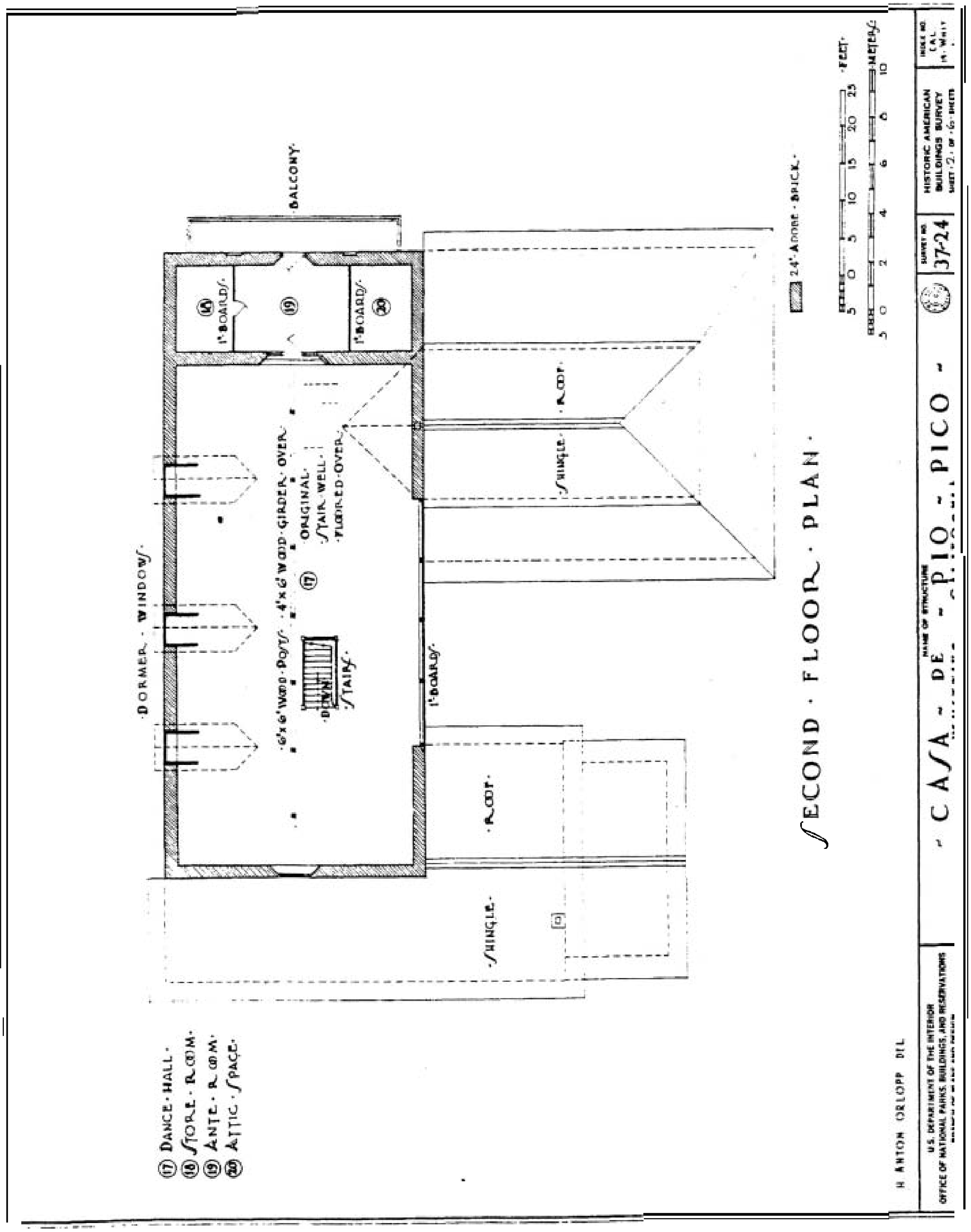
BALCONY
DORMER · WINDOWS
1" BOARDS
1" BOARDS
1" BOARDS
⑱
⑲
⑳
⑰
6"x6" WOOD · POSTS
4"x6" WOOD · GIRDER · OVER
ORIGINAL · STAIR · WELL · FLOORED · OVER
DOWN
STAIRS
SHINGLE · ROOF
SHINGLE · ROOF
SHINGLE
24" ADOBE · BRICK
FEET
0 5 10 15 20 25
METERS
0 2 4 6 8 10
SECOND · FLOOR · PLAN
⑰ DANCE · HALL
⑱ STORE · ROOM
⑲ ANTE · ROOM
⑳ ATTIC · SPACE
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OFFICE OF NATIONAL PARKS, BUILDINGS, AND RESERVATIONS
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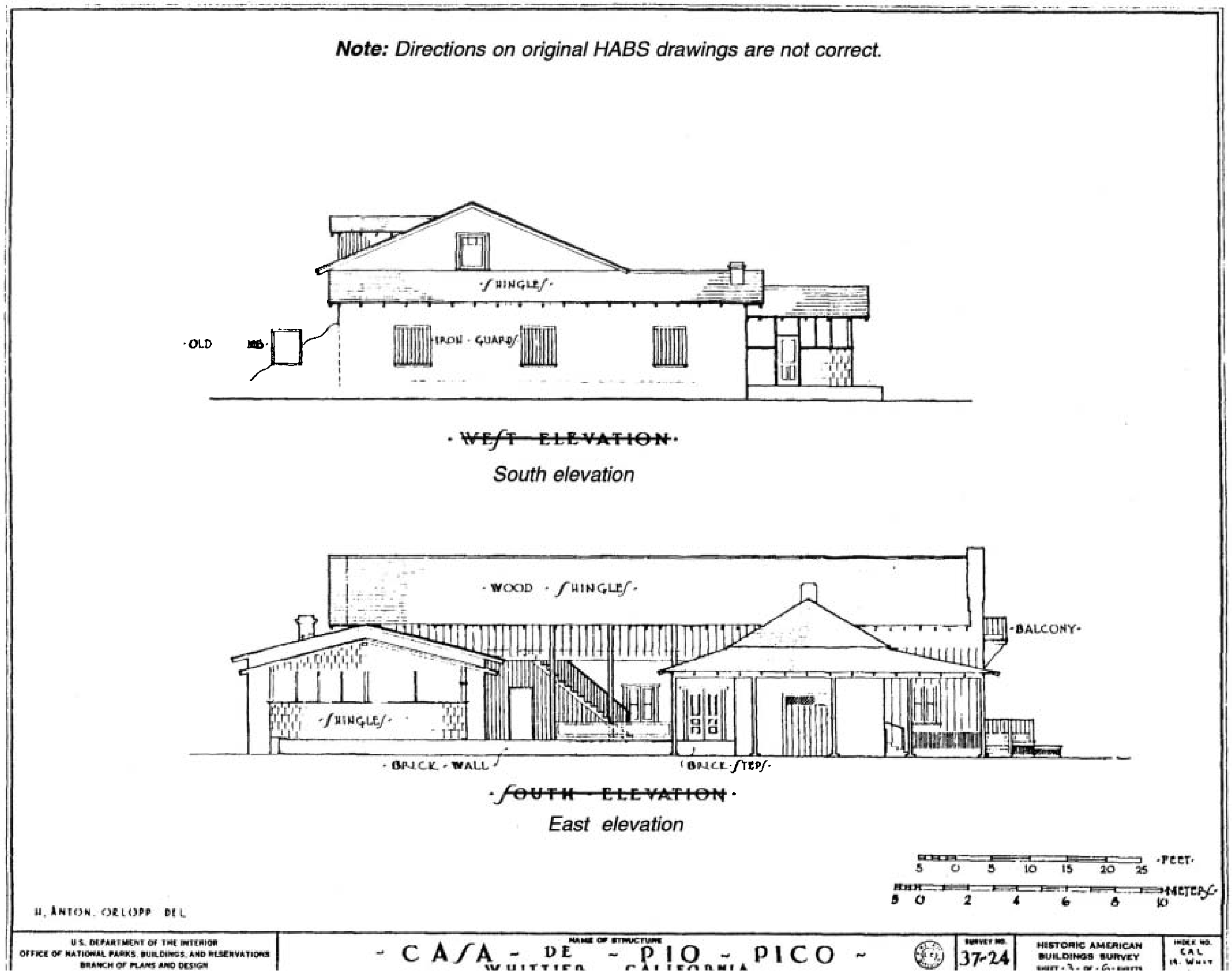

South elevation

East elevation

Chapter 12

Other Adobe Buildings

Introduction

This chapter briefly reviews the other adobe buildings that were not selected for an in-depth study but were included in the survey. These buildings are:

1. Convento at the San Fernando Mission
2. Purcell House (Las Tunas Adobe)
3. Vicente Sanchez Adobe
4. Rocha Adobe (Gilmore or La Brea Adobe)
5. Centinela Adobe
6. Sepulveda Adobe
7. Simi Adobe
8. Reyes Adobe
9. San Rafael Adobe (Casa Adobe de San Rafael)
10. Catalina Verdugo Adobe
11. Miguel Blanco Adobe

Some of these were visited by the entire survey team (Purcell House, San Fernando Mission convento, Sepulveda Adobe, Reyes Adobe, Simi Adobe) while others were inspected by individual members of the team (Vicente Sanchez, Rocha, Centinela, San Rafael, Verdugo, and Miguel Blanco Adobes). A brief overview and comments on damage at each site are presented in this chapter.

Convento at the San Fernando Mission, Mission Hills

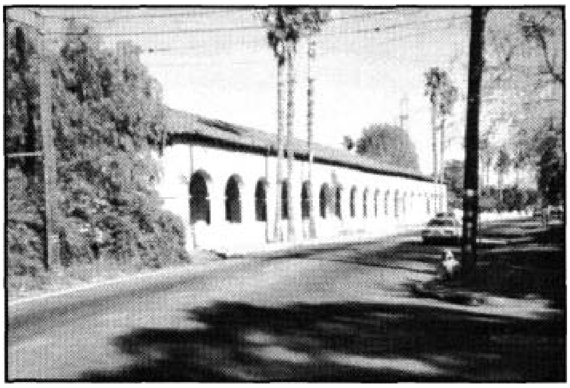

Figure 12.1. *Elevation of the convento at the San Fernando Mission.*

The convento of Mission San Fernando is considered one of the finest priests' residences of the California missions (Figure 12.1). It possesses considerable integrity, despite having been damaged by previous earthquakes and subsequent interventions that resulted in obliteration of its magnificent original wall decorations. A very large two-story structure, it was partially retrofitted following the 1971 San Fernando earthquake with the addition of a least one concrete block wall, perhaps more, and some anchorage between the exterior walls and the second floor. Its graceful bell enclosure on the tile roof was not restored, presumably as it represented a falling hazard, but it is replicated on the shops wing at Mission San Antonio de Padua. The building retains a great amount of historic fabric on the second floor where much of the original roof framing utilizing zapatas and rawhide lashing is intact. Also, much of the original surface decoration lies beneath the present wall surfacing. It is crucial that great sensitivity be used in designing repairs or further retrofit measures for this building and that any and all historic fabric to be affected be documented completely. Mission San Fernando is a registered California Historical Landmark, but does not appear to be listed in the National Register of Historic Places at this time.

Survey team observations were limited to the exterior of the convento due to a lack of access to the interior of the structure. A more complete investigation into the damage of this important adobe was intended, but permission was denied.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was 0.5g. The estimated MMI was VIII. The damage state is estimated to be between moderate and extensive.

The buildings suffered moderate to extensive damage from examination of the exterior. The long walls of the building suffered horizontal cracks (Figures 12.2 and 12.3) and separation from the west end wall. The east-end wall was replaced after the 1971 San Fernando earthquake. The west-end wall suffered vertical and diagonal cracks as the wall tried to pull away from the building. The brick columns along the colonnade

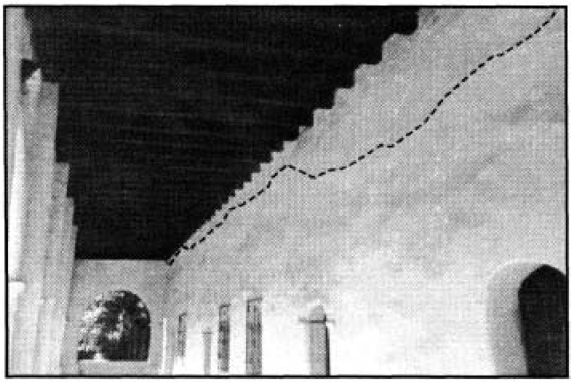

Figure 12.2. *Horizontal cracking in the upper section of the adobe wall along the colonnade of the convento at the San Fernando Mission. This crack extends approximately two-thirds of the length of the building (dotted line follows crack). Out-of-plane rocking is indicated by this crack, the horizontal crack in the wall on the opposite side of the building (Figure* ***12.3),*** *and a crack along the base of this wall.*

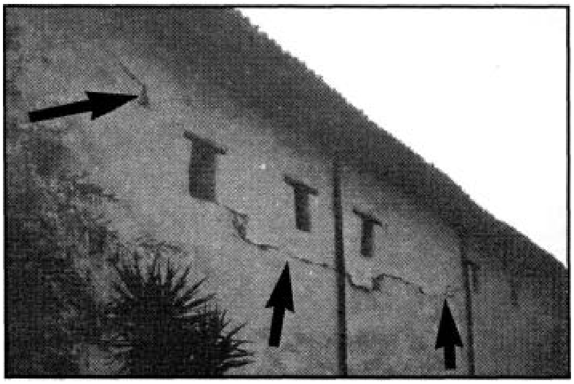

Figure 12.3. *Horizontal cracking in the upper section of the adobe wall. This crack extends approximately two-thirds of the length of the building. Out-of-plane rocking is indicated by this crack and the crack on the opposite side of the building (Figure 12.2).*

suffered some damage as cracking occurred at the tops of several arches (Figure 12.4) and at the base of the columns.

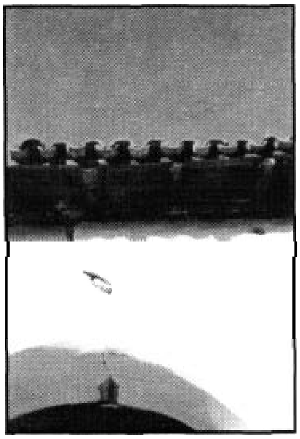

Figure 12.14. ***Cracking in one of the brick ar-ches of the colonnade of the convento at the San Fernando Mission.***

Purcell House (Las Tunas Adobe)

The Purcell House, also known as the Las Tunas Adobe, is a mission-associated structure, the precise use of which during the mission era is not totally clear. It is said to have been used for residential purposes by the padres (Giffen 1955:29).

The Purcell House is located on a relatively flat site with residential landscaping of trees, ornamental plants, and grass. The maximum overall dimensions of the present structure is approximately 76 feet by 100 feet. The main block of the building is approximately 36 feet wide along the north front (Figure 12.5) and 46 feet deep. There is a partial second floor over the main building block that is approximately 38 feet by 24 feet. There are three main additions to the main building block one extending west from the west side at the north end, another extending east from the southeast corner, and the third extending south off of the southwest corner. The main block has a hip roof and the additions have combinations of gable and shed roofs.

Figure 12.5. ***North elevation of the Purcell House.***

The first story is primarily adobe construction. The second floor is frame as are several of the additions; there is also some brick masonry. Some of the floors are on grade and some are wood supported by wood joists.

The structure has been altered extensively from the time of the original construction in about 1776 until the present. The original 1776 portion was approximately 36 feet long and 12 feet wide, and probably divided into three rooms, or cells. In about 1810 the size of the original was more than doubled, and by the 1870s, the main building block was complete. The majority of the load-bearing adobe walls are 18 to 20 inches thick, but there is some variation. A portion of the wall foundation between two 1810 portions of the building were observed from a crawl space and in that case the foundations, while altered, appeared to be cobbles. It is not known how extensive cobble foundations are; it is possible that some of the later adobe walls have concrete foundations, although none were observed.

All exterior wall surfaces are covered with hard cement-like stucco as are the majority of the interior wall surfaces. Softer lime plaster was evident at several locations on the exterior where portions of the hard stucco were missing.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was 0.2g. The estimated MMI was between VI and VII. The damage state is estimated to be slight.

The building suffered minor crack damage during the Northridge earthquake. Minor cracks developed at some door and window openings and at the intersection of walls (Figure 12.6).

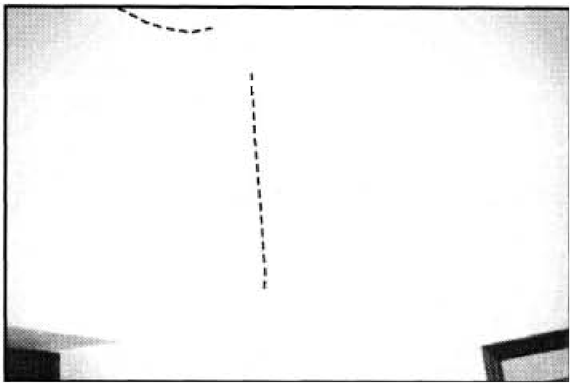

Figure 12.6. ***Purcell House. Minor vertical cracking at the interface of two butting walls (dotted line along crack).***

Moisture problems are evident along the lower portions of several walls (Figures 12.7 and 12.8). The south and east wall of the bedroom at the southeast corner has some deterioration on both interior and exterior wall surfaces. The same area of damage continues along the south wall of one of the easternmost original rooms. The moisture deterioration also extends along both east and west walls of the north entrance hall. Some of the moisture damage appears to affect only the surface but elsewhere has affected the integrity of the adobe. Additional lower-wall deterioration occurs along the west exterior wall of the kitchen.

The Las Tunas Adobe was in good condition before the earthquake despite the described moisture damage. The slight damage corresponds to the expected level of damage for a building subjected to the moderate ground motions this building experienced during the Northridge earthquake.

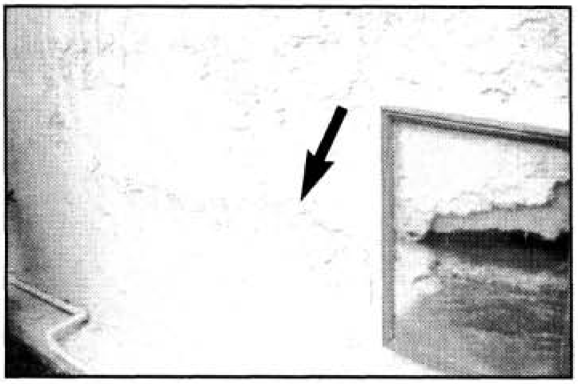

Figure 12.7. ***Purcell House. Moisture damage on the south wall is shown by the bulge in the wall and the eroded adobe shown inside the display window.***

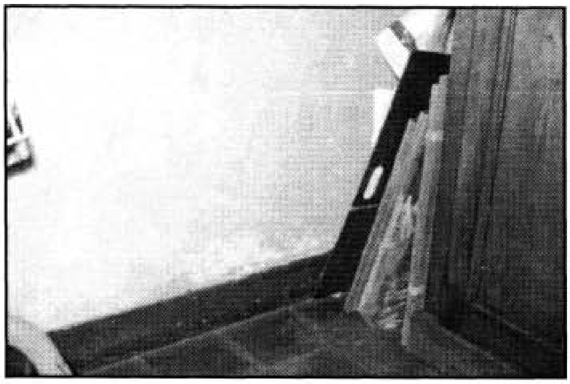

Figure 12.8. ***Purcell House. Moisture damage is also shown by peeling paint on the same wall as shown in Figure 12.7.***

Vicente Sanchez Adobe

Rancho Cienega O Paso de La Tijera was granted to Vicente Sanchez, alcalde of Los Angeles, by Governor Micheltorena in 1843. After Sanchez's death in about 1850, his grandson, Tomas Sanchez (sheriff of Los Angeles starting in 1860), inherited the rancho. It was subsequently purchased by Lucky Baldwin (Parks 1929:176). Baldwin's heirs leased the part with the Vicente Sanchez Adobe to the Sunset Golf Corporation which remodeled the adobe for a clubhouse. Apparently, the rear wing of the original building closest to the hills had deteriorated and collapsed in the early years of this century (Parks 1929:178). The golf clubhouse was laid out following the lines of the old plan when the building was rehabilitated before 1929 (Parks 1929:178). Historian Helen Giffen noted in 1955 that "Wisely, the architect did not change the original lines of the adobe, retaining the quaint second story, the hand hewn timbers and the old wooden floors" (Giffen 1955:12). Later the Vicente Sanchez Adobe became a women's clubhouse (Kyle 1990:160).

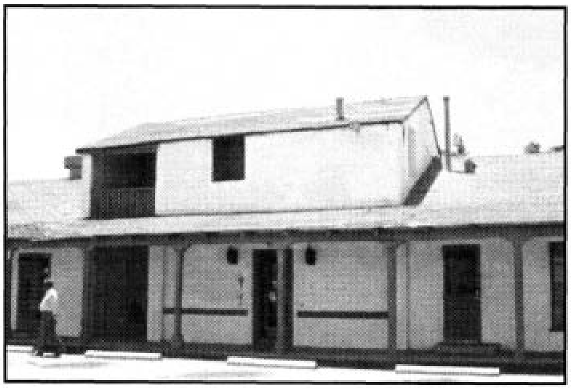

Figure 12.9. ***Front elevation of the Vicente Sanchez Adobe.***

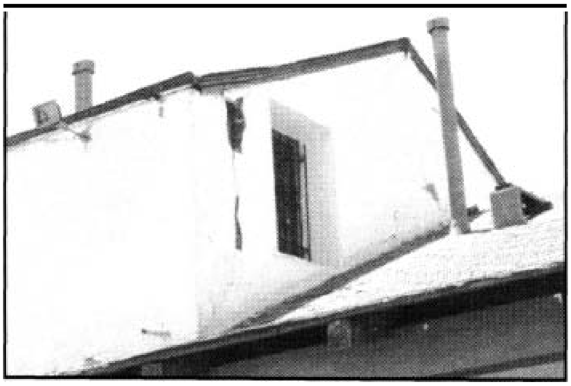

Figure 12.10. ***Vicente Sanchez Adobe. Cracking at the comer of the upstairs gabled wall.***

The adobe sections of the present building consist of a rectangular building approximately 20 feet wide and 50 feet long with a small two-story section (Figure 12.9). On either side of this adobe section are wood-framed sections. To the south and attached to a large wood-framed meeting room is a second adobe section. This section is approximately 20 feet wide and 50 feet long. Much of the building has wood framing on one or both sides of the walls covered with a cement stucco or plaster.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was between 0.2g and 0.3g. The estimated MMI was between VI and VII. The damage state is estimated to be moderate.

The building suffered crack damage in the second-story walls (Figure 12.10). Separation developed between perpendicular walls in this area. The reinforced brick chimney collapsed over the adobe section (Figure 12.11). Some moisture damage was observed on the exposed exterior wall shown in Figure 12.12 although this damage was only superficial. Nevertheless, the main adobe section of the building appears to have additional moisture damage that has resulted in bulging of the wood paneling at the base of the walls.

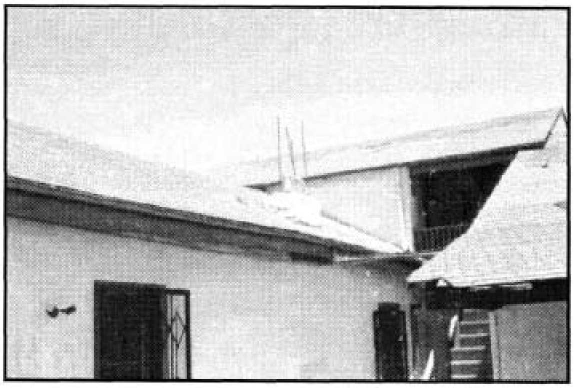

Figure 12.11. ***Vicente Sanchez Adobe. A collapsed chimney in the north section of the adobe. The chimney collapsed even though it had reinforcing rods which are now exposed.***

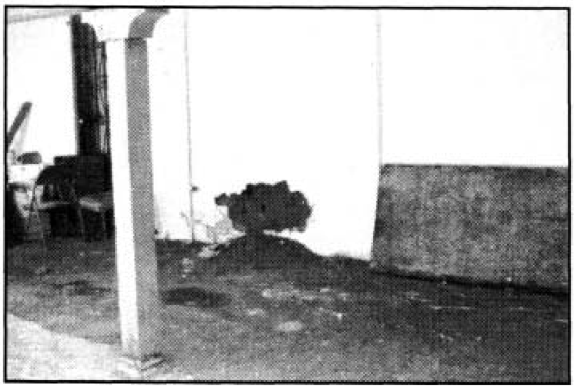

Figure 12.12. ***Vicente Sanchez Adobe. Moisture damage to an exterior wall in the south section of the building.***

The Vicente Sanchez Adobe suffered moderate damage as expected for a building subjected to ground motions between 0.2g and 0.3g. The extent of preexisting moisture damage did not seem to have greatly affected the performance of this buildings as it did in the case of the Lopez-Lowther Adobe.

Rocha Adobe (Gilmore or La Brea Adobe)

The Rocha Adobe was purportedly constructed in 1828–30 on the Rancho La Brea granted in 1828 to Antonio Jose Rocha (a Portuguese who came to California in 1815 and naturalized in 1831) and Nemicio Dominguez. The grant was made by the alcalde of Los Angeles and later confirmed by Governor Echeandia. The adobe is thought to be one of the original rancho adobes of which there were several. Sheriff James Thompson owned it and later sold it to Arthur F. Gilmore in the 1870s (Parks 1929:184). One of a cluster of adobes on the site, the Rocha Adobe was rehabilitated by his son Earl C. Gilmore, an oil magnate (parks 1929:183). He was born in the house in the 1880s and died there in 1964 (Kyle 1990:154-5). Much of the woodwork, while appearing old, dates to the rehabilitation designed by Mr. Gilmore's architect (Parks 1929:185).

The Rocha Adobe has a rectangular plan with the long axis oriented in the north-south direction (Figure 12.13). The building is a tapanco-style adobe with gable-end walls on the north and south ends. The floor of the tapanco has been removed in the north half of the building leaving a large northern room that is open to the ceiling.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground

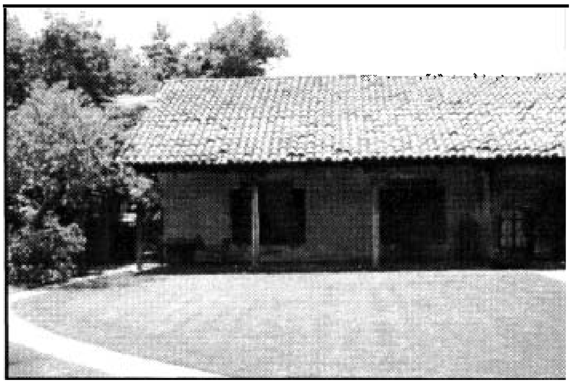

Figure 12.13. ***West Elevation of the Rocha Adobe.***

motion at the site was 0.3g. The estimated MMI was VII. The damage state is estimated to be slight to moderate.

There is crack damage to the building in several locations although none of the damage is particularly severe. The south gable-end wall suffered minor cracking in the south gable end wall (Figure 12.14). Minor interior cracking occurred in some of the interior walls (Figure 12.15). The tall, north gable-end wall shown in Figure 12.16 suffered some crack separation at the connection to the east and west walls.

Although the ground motion was fairly strong at this site, the Rocha Adobe suffered relatively minor damage indicating the building was in good condition at the time of the Northridge earthquake. Nevertheless, the gable-end walls of this building, especially with the removal of the second-floor framing in much of the building, may be susceptible to serious damage in future earthquakes.

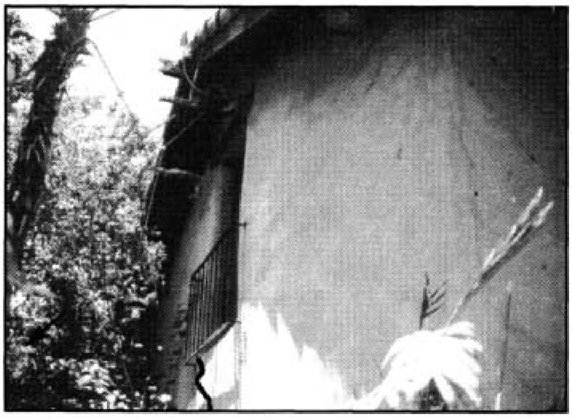

Figure 12.14. ***Rocha Adobe. Minor cracking in the south gable-end wall visible below the balcony railing.***

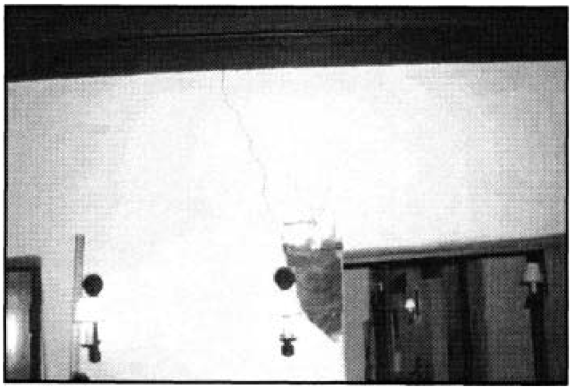

Figure 12.15. ***Rocha Adobe. Minor cracking in one of the interior walls.***

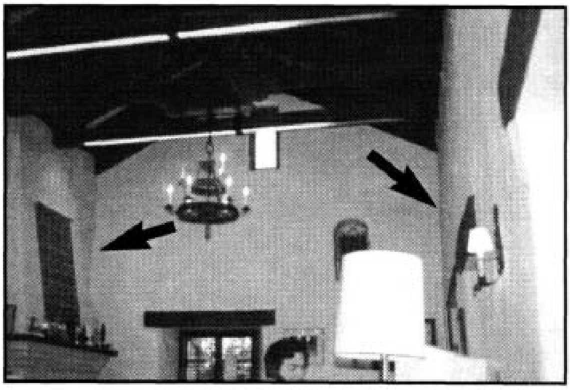

Figure 12.16. ***Rocha Adobe. Interior elevation of the north gable-end wall. The floor framing in this area has been removed. There are cracks that show beginning separation between the gable-end wall and the perpendicular walls.***

Centinela Adobe

Rancho Aguaje de Centinela was granted to Ygnacio Antonio Machado in 1844 by Governor Micheltorena; however, he reportedly occupied the rancho beginning in the mid 1830s. In 1845 he traded it to Bruno Avila for a town house in the pueblo of Los Angeles. In 1859, the adobe was purchased by Joseph Lancaster Brent, owner of nearby

Figure 12.17. *Front elevation of the Centinela Adobe.*

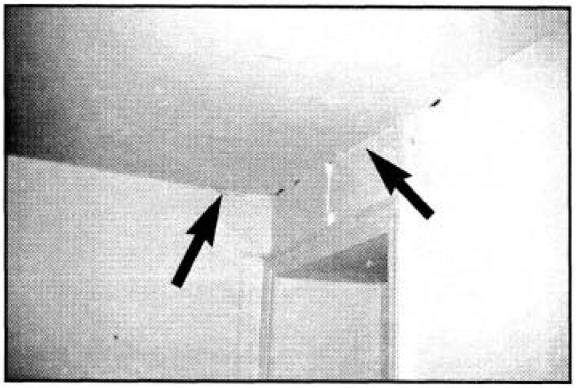

Figure 12.18. *Centinela Adobe. Minor cracking developed in many locations at the ceiling line. Most adobe buildings have poor attachment between the roof and ceiling framing and the walls.*

Rancho Sausal Redondo (Parks 1929:190). In about 1864 he sold it and the Rancho Sausal Redondo to Sir Robert Bumett who refurbished it for his bride. Bumett sold the ranch and adobe in 1885 to Daniel Freeman, a Canadian. Today, the Centinela Adobe, furnished to reflect the period of occupancy of the latter two owners, is operated by the Historical Society of Centinela Valley (Kyle 1990:160). Only two rooms of the original adobe, the living room and dining room, remained in 1955, together with the old smoke house outside (Giffen 1955:12).

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was 0.2g. The estimated MMI was between VII and VIII. The damage state is estimated to be slight to moderate.

The Centinela Adobe is a long, one-story building with a series of connecting rooms (Figure 12.17). There was slight to moderate damage that primarily expressed itself near the ceiling level as the roof and ceiling framing shifted on top of the walls (Figures 12.18 and 12.19). Other minor damage was observed in a few locations such as the interior wall that suffered diagonal cracking (Figure 12.20).

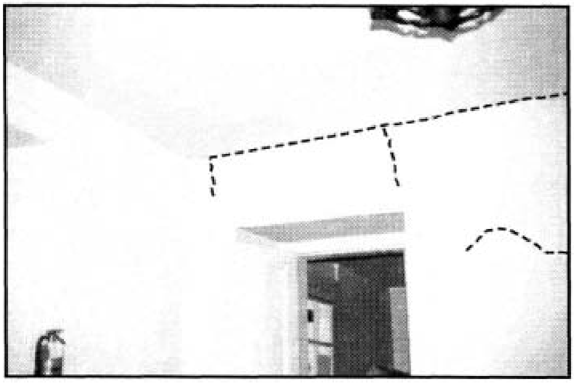

Figure 12.19. *Centinela Adobe. Minor damage to the adobe wall over the doorway (dotted line along crack).*

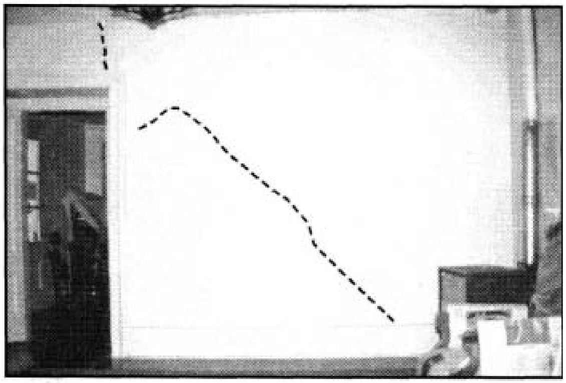

Figure 12.20. *Centinela Adobe. A diagonal shear crack was slightly worsened during the Northridge earthquake in this interior wall (dotted line along crack).*

The building appeared to be in good condition at the time of the Northridge earthquake and, accordingly, suffered slight to moderate damage when exposed to maximum peak accelerations of approximately 0.2g.

Sepulveda Adobe

The Sepulveda Adobe (Figure 12.21) was apparently built by Pedro Sepulveda, a carbonero or charcoal maker who traded charcoal in the nearby pueblo de Los Angeles, harness and saddle maker, in about 1863 on land homesteaded in 1859-63. The adobe building originally consisted of two main rooms; an adobe lean-to is said to have been constructed in 1875–80 by Sepulveda. A wood frame addition apparently was added by Sepulveda's son-in-law at a later date. In about 1927 a portion of the front corredor was enclosed for a bedroom (personal communication, David L. Felton). The building was occupied as a residence until 1980. The integrity of the building has been compromised, yet the siting, outbuildings, features of the site, and lack of nearby development form a rural historic landscape of considerable integrity compared to other buildings visited, which while more intact, have lost historical context.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was between 0.2g and 0.3g. The estimated MMI was VII The damage state is estimated to be moderate to extensive.

Survey team observations were limited to the exterior of the Sepulveda Adobe due to a lack of access to the interior (all openings were boarded up). The building suffered crack damage throughout the structure. The north gable end is braced and the northeast comer collapsed (Figure 12.22).

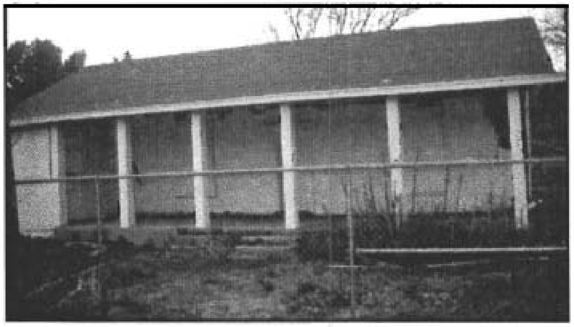

Figure 12.21. *Sepulveda Adobe. East elevation.*

Figure 12.22. *Sepulveda Adobe. Vertical cracks at the comer led to collapse of the comer section.*

Simi Adobe, Simi Valley

The so-called Simi Adobe in Strathern Memorial Park in Ventura County is said to have been erected during the 1820s when Rancho Simi belonged to Jose de la Cuerra y Noriega, a prominent landowner of Santa Barbara County. The Victorian Strathern House was added on to the adobe in 1892 (Hoover et al. 1990:531). The latter building is the centerpiece of an open air museum or pioneer village. The interior of the adobe has been much remodeled over the years, yet retains its original 3-foot-thick adobe walls, excepting an end room of which only foundations remain and buttresses erected at the corners supporting the long walls. The front corredor remains while the rear corredor has been enclosed for a bathroom and sun porch. The original dimensions, massing, and proportions remain intelligible. The one-story adobe had a corn loft or tapanco with its gable access now blocked by the rear wall of the Strathern House. The Simi Adobe is publicly owned and listed in the National Register of Historic Places.

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was 0.4g. The estimated MMI was VII.

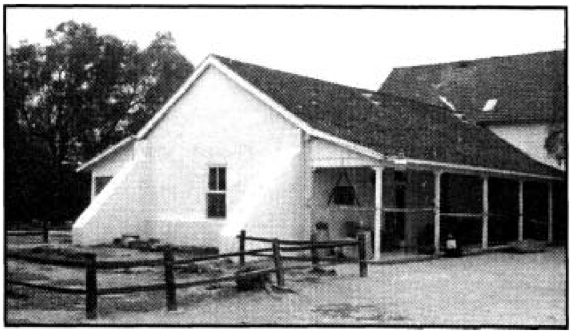

Figure 12.23. ***Simi Adobe. The rear section of the building is one story and constructed with adobe. The front section of the building is two story and wood framed.***

The brick chimney above the roof over the wood-framed section of the building collapsed. Also, a section of the gable-end wall above the tapanco access collapsed and had been largely removed before the survey team's arrival. This gable-end wall is between the adobe section and wood-framed section of the house. Other than these two areas, there were very minor cracks to some of the walls, more visible on the interior of the building. There were also some minor cracks around the two buttresses shown in Figure 12.23. The damage state is estimated to be moderate.

Reyes Adobe, Agoura

The Reyes Adobe in Agoura was reportedly built by Jacinto Reyes in about 1836 and originally occupied by his son, Jose Reyes (Delong 1980:79). It is a one-and-one-half story structure with the tapanco story used as two bedrooms. It may have originally had a corn loft or tapanco accessed from the outside with the current stairway added later, as was frequently the case. The two adobe bedrooms to the south enclosing the ends of the original corredor appear to have been added at a later date as they have narrower walls. As the windows and doors were covered with plywood sheets, it was not possible to observe the detailing. The Reyes Adobe is publicly owned and locally designated.

This adobe was seismically retrofitted in 1990 based on the State Historical Building Code and Division 88 of the Los Angeles Code. The retrofit included completing and interconnecting existing bond beams at the tapanco and roof levels; reconstruction of various portions of the adobe walls; new floor framing and plywood diaphragm at the tapanco-floor level; and anchorage of the tops of the gable walls to the roof framing.

The Reyes Adobe was inspected only from the exterior, being boarded up and not available for interior observation. The building, which is approximately 15 miles southwest of the epicenter, felt a maximum horizontal ground acceleration in the range of 0.2g to 0.3g The estimated MMI was between VI and VII. Some cracking was observed in the exterior walls (Figure 12.24). The damage state, based on observations of the exterior, is between slight and moderate.

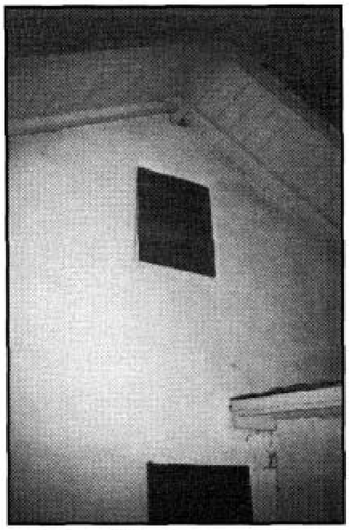

Figure 12.24. ***Reyes Adobe. Gable-end wall suffered minor damage during the Northridge earthquake.***

San Rafael Adobe (Casa Adobe de San Rafael)

Tomas Sanchez, grandson of Vicente Sanchez, married Maria Sepulveda who inherited a portion of Rancho San Rafael after her father's death. Her husband built her an adobe home in Glendale in 1865 near the site of the original rancho residence (Kyle 1990:148,160). The Historic American Building Survey recorded this residence in 1935 and dated it to the 1860s. It consists of four adobe rooms with a corredor around most of three sides (Figure 12.25). When recorded, it was in very good condition and possessed considerable integrity. The San Rafael Adobe de Tomas Sanchez is owned by the city of Glendale and open to the public (Kyle 1990:148).

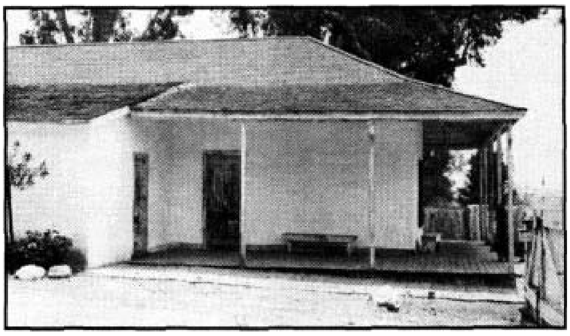

Figure12.25. ***HABS photograph of the San Rafael Adobe.***

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was between 0.3g and 0.4g. The estimated MMI as VII. The damage state is estimated to be moderate.

Catalina Verdugo Adobe

The Catalina Verdugo Adobe is the oldest house in Glendale (1828). It belonged to Catalina Verdugo, the blind daughter of Don Jose Verdugo, who was granted Rancho San Rafael in 1784. Upon his death, the title of the Rancho was passed to his son, Julio, and his daughter, Catalina, according to his will made in 1828. After several changes of hands, it is now owned by Dr. and Mrs. E. G. Bashor. The Verdugo Adobe is now part of the California Historical Landmark Number 637.

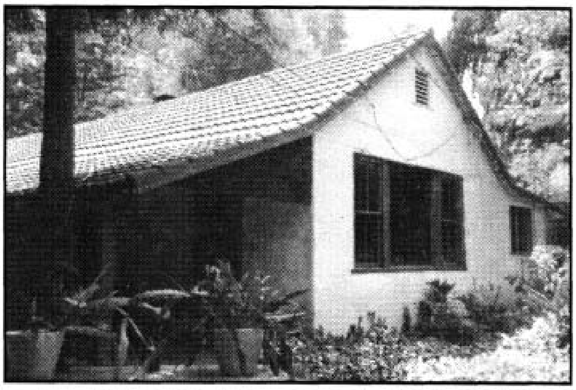

Figure 12.26. ***Catalina Verdugo Adobes.***

This adobe was apparently in serious disrepair when it was purchased by the Bashors in the 1940s and much of the structure was rebuilt. It is a single-story adobe with gable roof with a wood frame addition at the north end. The extent of reconstruction could not be established by the survey team. Access to the interior was not available to the team at the time of the survey.

Although the interior was not inspected, the exterior was found to be in good condition, with little obvious earthquake damage to the walls (Figure 12.26). Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was between 0.3g and 0.4g and the estimated MMI was between VI and VII The damage state is estimated to be between none to slight.

Miguel Blanco Adobe

Michael White was an English sailor who came to California in 1829. He married a daughter of famed Doiia Eulalia de Guillen of Mission San Gabriel in 1831 (Parks 1928:51). Miguel Blanco was granted 77 acres near San Gabriel in about 1843 and went there to live (Kyle 1990156; Parks 192851). In 1929just one section of the building was adobe with a two-story wood-framed building attached. The property was sold by Blanco to L. H. Titus whose nearby Titus Ranch featured a larger adobe, La Ramada (Parks 1928:51). In 1935, when recorded by the Historic American Buildings Survey, three adobe rooms survived, one with exceptionally thin walls. The adobe may have been flat roofed originally as were many in the Los Angeles vicinity.

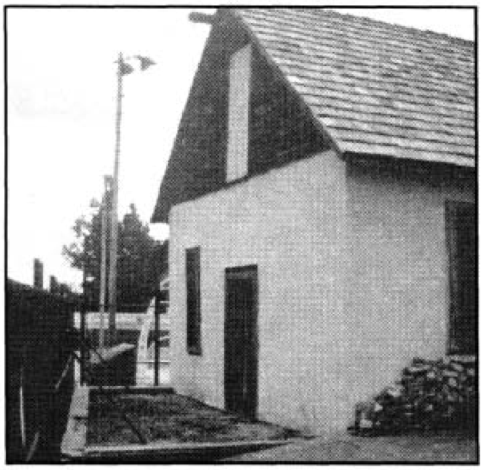

Figure 12.27. ***Miguel Blanco Adobe. No visible damage from exterior inspection.***

Based on the isoseismal map, Figure 2.4, it is estimated that the maximum horizontal ground motion at the site was

Figure 12.28. *Miguel Blanco Adobe.*

between 0.1g and 0.2g. The closest strong motion recording station was the Southwestern Academy where the north-south, east-west, and vertical peak ground accelerations were 0.16g, 0.12g, and 0.09g, respectively. The estimated MMI was between VI and VII.

The damage state is estimated to be none. Visual inspection was made of all sides of the building (from outside a protective fence) but no damage was observed (Figures 12.27 and 12.28).

Chapter 13

Conclusions

Summary

The Northridge earthquake showed on a large scale the vulnerability of historic adobe buildings to seismic ground shaking. Depending upon the location, the seventy of the ground motions ranged from weak to very strong at the different historic adobe sites. It also showed the effects on performance brought about by certain preexisting physical conditions. This study surveyed Northridge earthquake damage to nineteen historic adobes located in Los Angeles and Ventura counties. Eight buildings were selected for in-depth study by the survey team who:

- compiled historical and structural data;
- identified historic fabric;
- documented structural damage; and
- evaluated seismic performance.

The remaining eleven buildings were subjected only to a cursory historical survey. No systematic attempt was made to identify historic fabric or damage. However, an overall view of seismic performance was estimated.

Seismic performance of each building was described in detail in Chapters 4 through 12 and rated on the scale provided in Table 3.2. A summary of certain key findings is also provided in Table 13.1, which includes the following information for each of the buildings:

- Name / Location—name of the historic adobe and the name of the community or town where it is sited;
- Ground Motion Intensity—the earthquake ground motion intensity is estimated in terms of peak ground acceleration (PGA) and Modified Mercali Intensity (MMI);
- Damage State—the estimated earthquake damage to the structural system is defined as none (A), slight (B), moderate (C), extensive (D), and complete (E);
- Preexisting Conditions—the physical conditions of the adobe that existed prior to the earthquake that influenced the structural behavior of the building, including water damage, poor materials, unrepaired crack damage, repaired crack damage, and seismic retrofit measures;
- Comments on Observed Damage.

Table 13.1. *Seismic performance of historic adobe buildings.*

Name Location	PGA (est.)	MMI (est.)	Damage State	Preexisting Conditions	Comments on Observed Damage
Andres Pico Adobe Mission Hills	0.5g	VIII	D-E	Significant moisture damage; building in poor condition; severely precracked walls; some retrofitting and anchorage improved performance.	Very extensive damage south gabled wall collapsed; extensive damage throughout structure; preexisting cracks; previously inspected by GSAP survey team.
Centinela Adobe Winchester	0.2g	VII-VIII	B-C	Good condition.	Slight to moderate damage; minor cracking in walls and some slippage between ceiling framing and the walls.
De la Osa Adobe Encino	0.4g	VIII	D-E	Cross-ties at five interior walls; three cross-ties either cut or anchorage was inadequate.	Very extensive damage; east gable end collapsed; significant damage to all walls; in-plane damage to cross-walls more serious than out-of-plane damage to long walls.
Leonis Adobe Calabasas	0.3-0.4g	VII-VIII	C-D	Building in good condition before the earthquake. Retrofit on first floor installed after 1971 earthquake.	Moderate to extensive damage primarily restricted to upper portions of second floor adobe walls; damage most severe in southwest corner.
Lopez Adobe San Fernando	0.4-Q.5g	VIII	C	Bond beam at top of second floor. Building otherwise in good condition. Exterior walls have wire mesh and thick stucco.	Moderate damage; chimney collapse; very little damage apparent from exterior inspection; interior cracking at openings, at the base of the bond beam, and at the tops of the second floor walls.
Lopez-Lowther Adobe San Gabriel	0.2g	VI-VII	C-D	Substantial moisture contributed to failure patterns; unknown preexisting crack damage.	Moderate to extensive damage; cracking in numerous walls; much of the cracking caused by slumping at the base of the walls.
Miguel Blanco Adobe San Marino	0.1-0.2g	VI-VII	A	Good condition.	No observed damage.
Pio Pico Adobe Pio Pico State Park Whittier	0.1-0.2g	VI-VII	B-C	After 1987 Whittier earthquake, building cracks repaired; anchors added at wall intersections anchors added into gabled end walls, one interior wall, and ties attaching the gable-end wall to the roof and attic floor.	Slight to moderate; repaired crack performed well; attic anchorage partially pulled out on the north gable-end wall.
Purcell House San Gabriel	0.2g	VI-VII	B	Some moisture damage; otherwise, in good condition.	Minor cracking of some walls.

Table 13.1. *Seismic performance of historic adobe buildings (continued).*

Name Location	PGA (est.)	MM) (est.)	Damage State	Preexisting Conditions	Comments on Observed Damage
Rancho Camulos Piru	0.3-0.4g	VII-VIII	D-E	Significant moisture damage may have influenced collapse of walls; poorly repaired preexisting cracks and low -strength adobe material.	Very extensive damage; collapsed walls on south side of building; damage throughout the structure.
Reyes Adobe Agoura Hills	0.2-0.3g	VI-VII	B-C	Retrofit in 1988.	Slight to moderate damage observed from exterior inspection.
Rocha Adobe Park La Brea	0.3g	VII	B-C	Good condition.	Some cracking of the walls in several locations; beginning separation between gable-end walls and long walls.
San Fernando Mission Convento	0.5g	VII	C-D	Good condition; partial retrofit after 1971 San Fernando earthquake.	Moderate to extensive damage; cracks in long walls and gable -end walls; exterior inspection only.
San Gabriel Mission Convento San Gabriel	0.2g	VI-VII	D	Building cracked and damaged from 1987 Whittier and 1992 Landers earthquakes; building unstabilized or repaired prior to the Northridge earthquake.	Extensive damage to adobe convento; worsening of preexisting damage; permanent offsets in several locations.
San Rafael Adobe Glendale	0.3-0.4g	VII	C	Good condition.	Moderate damage to walls with some cracking and damage near the tops of the walls.
Sepulveda Adobe Calabasas	0.2-0.3g	VII	C-D	Poor condition; heavily altered and poorly maintained.	Moderate to extensive damage; collapse of corner section and cracking of walls. Exterior inspection only.
Simi Adobe Simi Valley	0.4g	VII	C	Good condition.	Moderate damage with cracking to some walls. Collapse of chimney over wood-framed section.
Verdugo Adobe Glendale	0.3-0.4g	VI-VII	A-B	Good condition.	Very minor wall cracking.
Vicente Sanchez Adobe Crenshaw	0.2-0.3g	VI-VII	C	Good condition except some lower-wall moisture damage on two walls.	Cracking in many of the walls; worst cracks occurred in the two-story section of the building.

Documentation

An important part of this survey was the documentation of the structures that were investigated. The purpose of the documentation was: (1) to establish the actual conditions at the time of the survey so that future changes and alterations can be compared; and (2) to record information about the building and site to aid in interpretation of the performance of the buildings during the Northridge earthquake. An example of the value of being able to compare conditions before and after a seismic event is the south gable wall of the Andres Pico Adobe. Documentation of preexisting conditions resulted in a more accurate interpretation of the actual effect of the earthquake (e.g., Figures 3.4 and 3.5).

The documentation primarily consisted of collecting visual images of all aspects of the building and site. This was done through small format (35 mm) black-and-white and color photography, videotape, and drawings and sketches. Black-and-white photographs were taken of all wall surfaces; later the photographs were assembled into entire wall elevations (e.g., Figure 5.7). The videotape was used to record visual images of all building features along with spoken observations. The black-and-white photographs and videotape were supplemented with occasional color photography.

Drawings and sketches were utilized to record conditions that could not be shown clearly in a photograph or videotape image. One example is demonstration of the extent of wall leaning that was determined by dropping a plumb line from the top of a wall. Another example is showing the relative difference between the interior floor level and the outside ground level. Presentation of construction details is'yet another example. Drawings were also an important tool in interpreting the damage by showing the entire building in a perspective or projection drawing (e.g., Figure 5.8).

Of the approximately five hundred black-and-white photographs and four hours of videotape taken of the subject buildings, only a relatively small number were used in this report. While valuable in illustrating the report and in the study for the report, the most important value of the documentation is the baseline information about building conditions that can be made available to others in the future. All of the documentation, photographs, videotape, and field notes will be permanently stored in the library of the Getty Conservation Institute.

Preexisting Conditions Versus Damage

The influence of preexisting conditions, both positive and negative, on the structural behavior of historic adobe structures is clearly evident in the performance of several of the buildings studied in the survey. The preexisting conditions include: (1) moisture damage to adobe walls from rising damp, water splash back, improper drainage at the foundation level, and erosion caused by water infiltration at the roof level or other areas of neglected maintenance; (2) previous crack damage; and (3) previous repairs and retrofit measures.

Moisture damage

Preexisting moisture damage is one of the more insidious physical conditions that can increase the level of damage from earthquake ground shaking. The adobe material is considerably weakened by cycles of soaking and drying or by continuous saturation. Surface ground water, if allowed to wick up into the base of the walls, will cause:

(1) a plane of weakness at or near the base of the wall about which the wall can rotate out of plane during an earthquake (Andres Pico Adobe, Del Valle Adobe, and Mission San Gabriel convento); (2) excessive spalling of plaster and adobe; (3) slumping and/or disintegration of adobe (Lopez-Lowther Adobe); or (4) a weak shear plane across the thickness of the wall (Andres Pico kitchen wall, Ramona's room at Rancho Camulos). Water intrusion from a leaking roof, gutter, or other sources can erode areas of adobe walls and cause cracks to form prior to an earthquake, or influence the location of new cracks (De la Osa and Lopez-Lowther Adobes).

Unrepaired cracks

Preexisting cracks often define the structural behavior and performance of adobe buildings during ground shaking. Cracks that have not been repaired (or inappropriately repaired with incompatible materials) will generally enlarge more than repaired cracks and cause premature deterioration of the adobe masonry. Preexisting vertical cracks allow adjacent sections of a wall to move independently at earlier stages of an earthquake, allowing increased pounding and frictional damage. Diagonal cracks caused by in-plane shear forces will continue to enlarge as gravity forces tend to make the upper wall section move downward and away from the lower section. Preexisting horizontal cracks are generally not a problem, unless there has been permanent relative displacement between adjacent sections, in which case sliding will continue and instability may result.

Previous repairs and retrofit measures

Just as preexisting moisture damage and unrepaired crack damage are detrimental influences on the structural behavior of historic adobes during earthquakes, appropriate preexisting repairs and retrofit measures produce positive influences on the structural behavior and earthquake performance of these buildings. Repair and retrofit measures that restrain the relative movement between adjacent building elements are usually quite effective in reducing the amount of damage caused by earthquakes. This was clearly illustrated in the Andres Pico, De la Osa, Lopez, and Pio Pico Adobes.

Andres Pico Adobe

The Andres Pico Adobe, with its through-wall anchorage of the floor joists at the second-floor level, illustrates the positive effect that anchoring the floor diaphragm to the walls has in keeping the longitudinal load-bearing walls tightly in contact with the transverse walls. The longitudinal walls did not separate from the transverse walls below the second floor, but did so above the second-floor level, where they were not tied across in the transverse direction. The south gable-end wall, which had sustained severe crack damage at some time in the past, had several through-wall anchors and plates installed at the second-floor level, but no anchorage of the wall at the roof level. As a result, a third of the wall above the second floor collapsed outward and severe separation cracks opened at the intersections with the long walls. Below the second floor, the wall remained intact as a result of the presence of anchors.

De la Osa Adobe

In the De la Osa Adobe, it is clear that properly anchored and maintained tie rods kept the longitudinal walls from separating from the transverse walls and decreased the amount of pounding and separation damage at the wall intersections. The cross ties that failed because either the anchor was partially pulled through the long walls, or because an inadvertent discontinuity, caused by cutting the tie beam, allowed an increased level of damage to the transverse walls.

Lopez Adobe

The Lopez Adobe was repaired after the 1971 San Fernando earthquake and retrofitted with the addition of a concrete bond beam at the top of the exterior walls and a stucco wire lath and stucco exterior surface. Damage to the Lopez Adobe was moderate, even though it experienced strong ground motion, which suggests that preexisting repairs and retrofit measures significantly influenced the building's performance.

Pio Pico Adobe

The Pio Pico Adobe suffered extensive damage during the Whittier earthquake of 1987. It has since been repaired and much of the structure seismically stabilized. Wall cracks were injected under low pressure with an adobe-flyash grout and the intersections of walls were reinforced with fiberglass rods. The gable-end walls were anchored to the attic floor diaphragm and the roof structure with grouted-in steel straps and fiberglass rods, respectively. Additional damage was slight to moderate, with some pullout of the steel strap anchors in the north gable wall.

Although the repair and retrofit measures of the Pio Pico for the most part performed well in this earthquake, there are lessons to be learned from their performance. The slight pullout of the steel strap anchors embedded at 22% degrees in the north gable wall during the relatively weak ground shaking indicates that a more positive anchorage is needed. Also, movement at the tops of the gable-end walls indicates that greater restraint may be necessary at the roof level.

Expected Damage Levels

Based on the information generated during this survey, estimates can be made regarding expected damage to historic adobe buildings as a function of peak ground acceleration. The conclusions presented in this section are based on the observations made following the Northridge and other earthquakes.

For well-maintained historic adobes Figure 13.1 shows the relationship between ground shaking and damage. Ground shaking in the range of 0.1g to 0.2g PGA seems to be necessary to initiate damage in well-maintained adobe buildings. At this level of ground motion, cracks begin to form at door and window openings and at the intersections of perpendicular walls. At the adobe sites studied where the PGA was in this range, the Miguel Blanco Adobe was undamaged, the Purcell House suffered slight damage, while the Centinela Adobe suffered slight to moderate damage. These adobes were well maintained, but were without reinforcement or retrofits.

At PGA levels of about 0.4g, the damage becomes more extensive. In the case of the De la Osa Adobe, the Andres Pico Adobe, and the Del Valle Adobe at Rancho Camulos, the damage to walls was extensive throughout the structure.

Preexisting conditions are also seen to greatly affect the resulting damage level. In Figure 13.1, all data on buildings with preexisting water and earthquake damage are found above the expected damage line for well-maintained adobes, indicating that severe damage can be expected for buildings in poor condition. Even for ground motions of moderate intensity (0.1g-0.2g), poorly maintained buildings are likely to suffer substantial damage.

Also plotted in Figure 13.1 are data for retrofitted adobes. It appears that the real value of retrofitting does not become apparent until relatively high PGA levels are reached (i.e., above 0.4g-0.5g). At lower levels of ground shaking, it appears that the

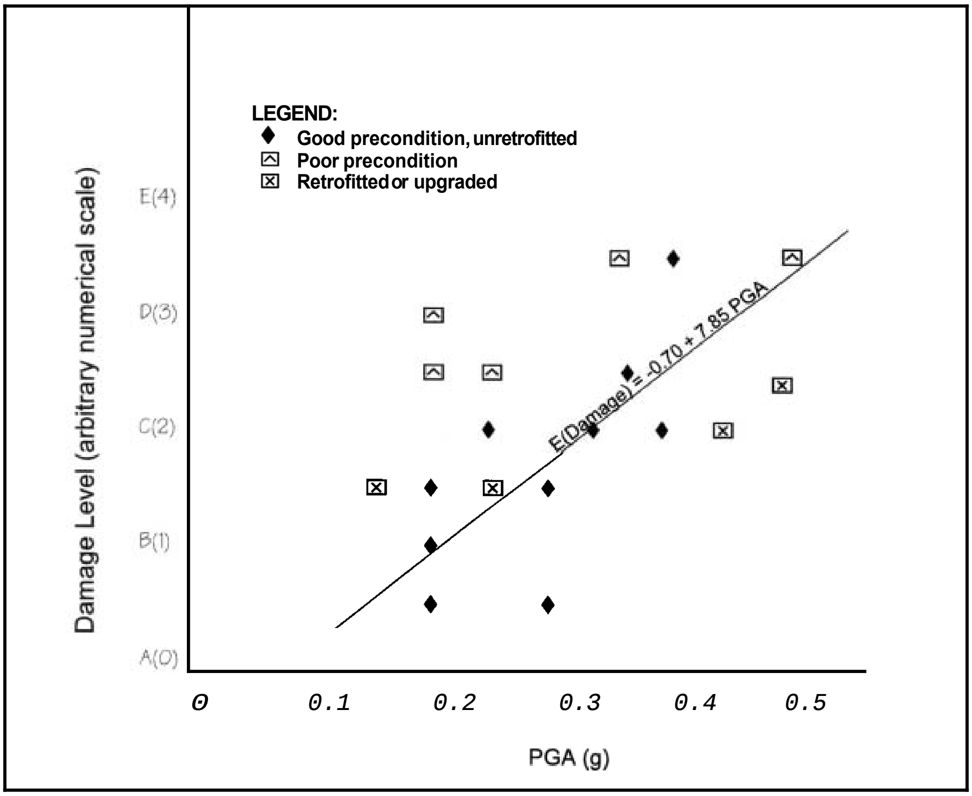

Figure 13.1. *Damage level vs. estimated horizontal peak ground acceleration for historic adobe buildings after the Northridge earthquake, Januay 17, 1994.*

retrofits do not markedly affect performance; these buildings behave much like the well-maintained unretrofitted adobes.

Predicting Future Performance of Historic Adobe Buildings

While the Northridge earthquake has provided many insights into the vulnerability of historic adobes to strong seismic events, it does not represent the entire range of damage that can be sustained during major earthquakes. Ground motions can be stronger and with longer durations and the resultant damage would be greater.

The Northridge earthquake had a Richter magnitude of 6.4. Because the fault surface was shallow, the peak ground accelerations were high, but the duration of the strong motions was only 10 to 15 seconds. The 1992 Landers earthquake had ground motions lasting approximately 30 seconds. Earthquakes with Richter magnitudes between 7 and 7.5 generally last 15 to 30 seconds while earthquakes with Richter magnitudes over 8, may last more than a minute.

During the Northridge earthquake the maximum Modified Mercalli Intensity was IX. On a scale ranging from I to XII In the Los Angeles area, MMI values can be at least X or XI during major earthquakes. Clearly, the extent of damage to historic adobe buildings could be more than that observed after the Northridge earthquake.

The significance of these observations is that earthquakes larger than the Northridge earthquake may occur in many parts of California, including the Los Angeles Basin. Damage to historic adobes may be greater and some additional damage types may occur. For example, during the Northridge earthquake, no load-bearing walls failed due to out-of-plane overturning. During larger earthquakes that have larger dynamic displacements and longer durations, this type of failure might occur and cause extensive damage that would include not only the collapse of the wall itself, but also the collapse of the roof and/or floor framing supported by that wall. This type of failure would be catastrophic.

The truth about the seismic performance of historic adobe buildings cannot be learned from studies following one large earthquake. Nevertheless, this study represents the most detailed study ever performed on earthquake damage to these buildings and there are many important lessons to be learned from both the successes and the failures. This information should be combined with the historical record from past earthquakes, such as the 1906 San Francisco earthquake, the 1925 Santa Barbara earthquake, and the 1952 Taft earthquake, along with research results and professional judgment to form a more complete picture.

Finally, what can we do to improve the performance of historic adobe buildings during future events without significantly compromising the historic fabric of these important resources? This is undoubtedly the most important question for the future.

Glossary

adobe	An outdoor, air-dried, unburned brick made from a clayey soil and often mixed with straw or animal manure. Also a structure made of adobe bricks.
basal erosion	A coving-type deterioration at the base of an adobe wall, which reduces the effective bearing surface of the wall.
bond beam	A wood or concrete beam added to a wall at the roof level around the perimeter of a building, the purpose of which is to strengthen the structure.
cocina	Kitchen (Spanish).
comedor	Dining room (Spanish).
contrapared	Apron or curb at base of an adobe wall (Spanish).
convento	Priests' residence (Spanish).
corredor	Covered (roofed) exterior corridor or arcade called a portal or portico in New Mexico, also referred to as a veranda or porch (Spanish).
cracked wall section	A section of an adobe wall (or other reinforced masonry wall) that is defined by a boundary of through-wall cracks.
CSMIP	California Strong Motion Instrumentation Program. **A** large network of strong-motion recording stations controlled and operated by the Division of Mines and Geology of the California Department of Conservation (see Chapter 2).
diaphragm	A large, thin structural element, usually horizontal, that is structurally loaded in its plane. It is usually an assemblage of elements that includes roof or floor sheathing, framing members to support the sheathing, and boundary or perimeter members.
EERI	Earthquake Engineering Research Institute in Oakland, California.
EPGA	Estimated peak ground acceleration.

epicenter	The point on the ground surface directly above the hypocenter, which is the location where the ground break initiated at the beginning of an earthquake.
flexure	Bending.
flexural stresses	Stresses in a object that result from bending.
foundation settlement	Downward movement of a foundation caused by subsidence or consolidation of the supporting ground.
free-standing walls	Walls, such as garden walls, that are only supported laterally at the ground level. They have no roof or floor framing attached.
g	Acceleration due to gravity at sea level. 1g = 32.2 ft/sec^2 or 980 cm/sec^2.
ground motions	Lateral or vertical movement of the ground, such as in earthquakes.
HABS	Historic American Building Survey. An ongoing federal documentation program of historic buildings in the United States initiated as part of the WPA in the 1930s.
headers	Adobe blocks placed with the long direction of the block perpendicular to the plane of the wall.
hypocenter	The point below the earth's surface at which the ground begins to rupture at the beginning of an earthquake.
in plane	Parallel to the plane of a wall.
joists	Closely spaced beams (approximately 2 feet on center) that horizontally span an area, such as a floor or ceiling.
load-bearing	Building elements, such as walls, that carry vertical loads from floors or roofs.
mezcla	Adobe mortar (Spanish).
MMI	Modified Mercalli Intensity (see Chapter 2).
nonload-bearing	Building elements, such as walls, that do not carry vertical loads from floors or roofs.
out of plane	Perpendicular to the plane of a wall.
overturning	Collapse of a wall caused by rotation of the wall about its base.

PGA	Peak ground acceleration. The maximum recorded acceleration that is often used to quantify the seventy of ground shaking during an earthquake at a particular site.
psi	Pounds per square inch; a unit of pressure.
rafters	Timbers or beams giving form, slope, and support to a roof (*pares* in Spanish).
sala	Living room or parlor (Spanish).
shear forces	Typically, shear forces in adobe walls are those that occur in the plane of the wall and cause diagonal cracking. In a more literal sense, shear forces can develop both in plane and out of plane in a wall and are caused by forces that produce an opposite, but parallel, sliding motion of a body's planes.
slenderness ratio (S_L)	The ratio of the height of a wall to its thickness. Many historic adobe buildings have relatively thick walls, S_L=5. Thin adobe walls, S_L=10, are more susceptible to out-of-plane damage or collapse.
slumping	Settlement of an adobe wall resulting from loss of strength at the base due to increased plasticity caused by moisture intrusion.
stretchers	Adobe blocks placed with the long direction of the block parallel to the plane of the wall.
tapanco	Attic, loft, garret, or half story of a building that is accessed by stairs or a ladder in a gable-end wall.
USC	University of Southern California.
USGS	United States Geological Survey.
wet-dry cycles	Repeated cycles of saturation and drying can lead to a loss of cohesion of the clay particles in adobe that results in a weakened adobe wall.

References

Anonymous

n.d. Andres Pico Adobe. Brochure of the San Fernando Valley Historical Association, Andres Pico Cultural Heritage Center.

n.d. California's Mission San Gabriel Arcangel. Published for the Claretian Missionaries.

n.d. Lopez Adobe brochure. Friends of the Lopez Adobe. San Fernando.

n.d. Los Encinos State Historic Park Self-Guided Grounds Tour and Map.

n.d. Leonis Adobe. Brochure of the Leonis Adobe Association. Calabasas.

Beck, Warren A., and Ynez D. Haase
1974 *Historical Atlas of California.* Norman, Oklahoma and London: University of Oklahoma Press.

Bariola Bernales, Juan J.
1991 Dynamic Stability of Adobe Walls. Doctoral thesis. Urbana, Illinois: University of Illinois at Urbana-Champaign.

Bolt, Bruce A. et al.
1970 *Earthquake Engineering.* Edited by Robert L. Wiegel. Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Cutter, Donald C.
n.d. Report on Rancho El Encino for State of California Division of Beaches and Parks. Sacramento, California: California Department of Parks and Recreation.

Delong, David, editor
1980 *Historic American Buildings: California.* Volumes I, 11, and III. New York and London: Garland Publishing, Inc.

Earthquake Engineering Research Institute
1994 Expected Seismic Performance of Buildings. Oakland, California: Earthquake Engineering Research Institute.

Earthquake Engineering Research Institute
1994 Northridge Earthquake January 17, 1994: Preliminary Reconnaissance Report. Edited by John F. Hall. Oakland, California: Earthquake Engineering Research Institute.

Elliot, John F.

n.d. Rancho El Encino History. Sacramento, California: California Department of Parks and Recreation.

Feynes, Eva Scott, and Isabel Lopez de Fages

1950 *Thirty-two Adobe Houses of Old California.* Los Angeles: Southwest Museum.

Giffen, Helen

1955 *Casas and Courtyards: Historic Adobe Houses of California.* Oakland, California: Biobooks.

Harrington, Marie

1976 Andres Pico Adobe. *The Branding Iron,* December, Number 124. Los Angeles Corral, Westerners.

Holter, Howard

1986 PicoPico State Historic Park. Sacramento, California: California Department of Parks and Recreation.

Knill, Harry

1984 *Early Los Angeles.* Santa Barbara, California: Bellerophone Books.

Kyle, Douglas E.

1990 *Historic Spots in California.* 4th ed. Stanford, California: Stanford University Press.

May, Antoinette

1989 *The Annotated Ramona.* San Carlos, California: Worldwide Publishing/Tetra.

Motz, Lee et al.

1990 Pio Pico State Historic Park Pio Pico Adobe Historic Structure Report. Sacramento, California: California Department of Parks and Recreation.

National Center for Earthquake Engineering Research

1994 The Northridge, California Earthquake of January 17,1994: General Reconnaissance Report. Edited by J.D. Goltz. Buffalo, New York: State University of Buffalo.

Office of Historic Preservation

1990 California Historical Landmarks. Sacramento, California: California Department of Parks and Recreation.

Parks, Marion

1928-9 *In Pursuit of Vanished Days. Parts I and II.* Historical Society of Southern California. Los Angeles: McBride Publishing Company.

Robinson, W. W.
1966 The Spanish and Mexican Ranchos of San Fernando Valley. Los Angeles: Southwest Museum Leaflets. Number 31.

Seismic Advisory Board
1994 The Continuing Challenge: The Northridge Earthquake of January 17, 1994. Report to the director. Sacramento, California: California Department of Transportation.

Shakal, A. et al.
1994 CSMIP Strong-Motion Records from the Northridge, California Earthquake of 17 January 1994. Sacramento, California: California Department of Conservation. Division of Mines and Geology. Office of Strong Motion Studies.

Smith, Wallace E.
1977 *This Land Was Ours: The Del Valles and Camulos.* Edited by Grant W. Heil. Ventura, California: Ventura County Historical Society.

Structural Engineers Association of California
1991 Reflections on the Loma Prieta Earthquake October 17, 1989. Sacramento, California: Structural Engineers Association of California. Ad Hoc Earthquake Reconnaissance Committee.

Stuart, Jonathan P., Jonathan D. Bray, Raymond B. Seed, and Nicholas Sitar
1994 Preliminary Report on the Principal Geotechnical Aspects of the January 17, 1994 Northridge Earthquake. Berkeley, California: Earthquake Engineering Research Center, College of Engineering, University of California at Berkeley.

Thiel, Charles C., E. L. Tolles, Edna Kimbro, F. A. Webster, and William S. Ginell
1991 Getty Conservation Institute Guidelines for Seismic Strengthening of Adobe Project: Report of First Year Activities. Marina del Rey, California: Getty Conservation Institute.

Tolles, E. Leroy, E. E. Kimbro, C. C. Thiel, Frederick A. Webster, and William S. Ginell
1993 Getty Conservation Institute Guidelines for the Seismic Retrofitting of Adobe Project: Report of Second Year Activities. Marina del Rey, California: Getty Conservation Institute.

Tolles, E. Leroy, and Helmut Krawinkler
1990 *Seismic Studies on Small-Scale Models of Adobe Houses*. Stanford, California: The John A. Blume Earthquake Engineering Center, Department of Civil Engineering, Stanford University.

Turner, Burnett C.

1966 Architectural Survey and Report: De La Osa Adobe, Los Encinos State Historical Monument. Sacramento, California: California Department of Parks and Recreation.

Wallace, William J.

1960 Archaeological excavations at Los Encinos State Historical Monument. Sacramento, California: California Department of Parks and Recreation.

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9 780892 363919 90000