NATIONAL CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
State University of New York at Buffalo

REPORT ON THE WHITTIER-NARROWS, CALIFORNIA EARTHQUAKE OF OCTOBER 1, 1987

by

J. Pantelic and A. Reinhorn
National Center for Earthquake Engineering Research
State University of New York at Buffalo
Red Jacket Quadrangle
Buffalo, NY 14261

Technical Report NCEER-87-0026

November, 1987

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PREFACE

On October 1, 1987, there was held in Buffalo, New York a meeting of the Scientific Advisory Committee of the National Center for Earthquake Engineering research. At about 11:00 AM (EST) notice was received that there had just occurred an earthquake in Whittier, California, a suburb of Los Angeles.

A number of the members of the Scientific Advisory Committee are from California, and communications with the west coast were quickly established. Based upon information received, it was evident that a number of scientists and others in the California area would be conducting post-earthquake reconnaissance studies. Considering the amount of activity underway, and realizing that there are many in California who have participated in other post-earthquake reconnaissance studies, a decision was made that the National Center for Earthquake Engineering Research need not send a "team."

On or about the 12th of November the National Science Foundation in Washington, and NCEER in Buffalo received a number of phone calls inquiring as to when the NCEER reconnaissance team would arrive. It was pointed out to those individuals that there were already a number of qualified individuals collecting data. Having yet another group would not provide that much more information. Nonetheless, based upon those and other communications, it was decided to send to the Whittier area two individuals: one to be concerned primarily with policy issues: and the other, structural behavior.

The two from NCEER in Buffalo sent to the Whittier-Los Angeles area for the week of October 18 through 24 were Ms. Jelena Pantelic, Assistant Director of the Center, and Dr. Andrei Reinhorn, a principal researcher of NCEER, and a faculty member of the State University of New York at Buffalo. This document is an abbreviated report of their findings. An earlier confidential draft was distributed to the NSF, to the Oversight Committee of NCEER, to the various researchers associated with the Center, and to a number of individuals in California.

It is to be noted that this is not the only report available having to do with the October 1 Whittier-Narrows earthquake. The EERI team presented reports in San Francisco (November 6), Washington (November 9), and Pasadena (November 11). The USGS has circulated a document (Open-file report 87-616), and there also have been prepared private reports; for example, "Summary of the October 1, 1987 Whittier Earthquake - An

EQE Quick Look Report." The February, 1988 issue of Earthquake Spectra also will contain reports concerning the event. In late October 1987, the National Science Foundation requested proposals for extensive in-depth studies of the earthquake and its effects. Awards are now being made, and these also will subsequently be made available to the profession.

The data presented in this report has been obtained with the assistance of investigators from government, private agencies, universities and independent consultants, as well as by directly inspecting the site.

Robert L. Ketter, Director
National Center for Earthquake
Engineering Research

TABLE OF CONTENTS

LIST OF FIGURES

SECTION 1
GROUND MOTION, STRUCTURAL AND NON-STRUCTURAL EFFECTS

1.1 GENERAL INFORMATION

An earthquake of magnitude 6.1 (Richter Scale) occurred in East Los Angeles on Thursday, October 1, 1987 at 7:42 AM (P.T.). Based on CalTech measurements and measurements of other seismological stations, the epicenter was located at 34.058^{o} North Latitude and 118.077^{o} West Longitude between San Gabriel and Rosemead Blvds. and between Pomona (Hwy. 60) and San Bernardino (I-10) Freeways near the Whittier Narrows recreation area. Several aftershocks followed the main event, one of Richter magnitude 5.5 occurring on October 4, 1987, and another of 4.3 occurring on October 5, 1987.

The earthquake affected a large area in the north and east side of the City of Los Angeles, at distances of up to 60 Km from the epicenter (see Figures 1-1 and 1-2). The earthquake occurred in an area of several known faults: Raymond Hills, Norwalk, Newport-Inglewood, and Whittier fault. Presumed location of the earthquake was approximately 7 kilometers from the known northwestern end of the Whittier fault, toward Pasadena. The shock was produced at a depth of 14 Km., in a thrust fault.

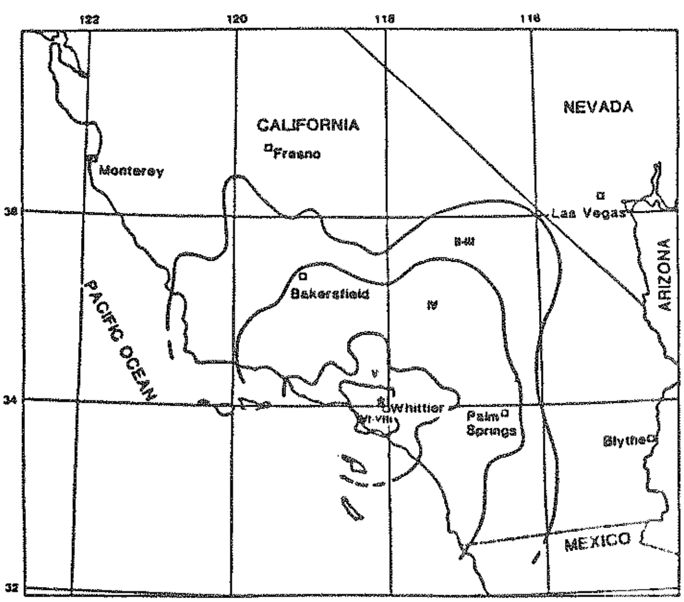

Figure 1-1 Preliminary isoseismal map for the October 1, 1987, Whittier-Narrows Earthquake (Map courtesy of C. Stover).

The soil in the area is alluvium (10 to 20 Km deep) overlaying sedimentary rocks [1]. This soil is a loosely compacted fine/medium grain sand, silt and clay. This type of soil tends to amplify seismic waves.

Severe damage occurred in Whittier Center and Rosemead. These areas as well as some neighborhoods in Pasadena, will probably be rated at MMI-VIII (Modified Mercalli Intensity). Earthquakes of lower Intensity (MMI-VI) occurred in the same area in 1812, 1878, 1903, 1907, 1929, 1933, 1952, and 1971.

The earthquake was recorded by a large number of recording stations that are operated by the following agencies:

California Division of Mines and Geology (CDMG), Sacramento, CA
United States Geological Survey (USGS), Menlo Park, CA
University of Southern California (USC), Los Angeles, CA
California Institute of Technology (CALTECH), Pasadena, CA
Southern California Edison Co. (SCE), Rosemead, CA
Metropolitan Water District of Southern California (MWD)
Army Corps of Engineers (ACOE)
Veterans Administration (VA)
Department of Energy (DOE)

USGS has already published a report on the recorded motion [2]. USGS also has digitized records of all triggered instruments (358 records). CDMG has a publication including data from 641 records.

The recordings show unusual high ground accelerations of .40g to .60g with velocities of 10 to 14 in/sec (25 to 35 cm/sec) and ground displacements of 1 to 2 inches. The following stations recorded the largest accelerations (according to USGS [2]):

(a) Garvey Reservoir (3 Km from epicenter): .47g horizontal .38g vertical
(b) Whittier Narrows Dam (4 Km from epicenter): .31g horizontal .46g vertical
(c) Whittier-7215 Bright Ave. Bldg. (10 Km from epicenter): .63g horizontal .20g vertical.

Figure 1-2 shows characteristic accelerograms for the above ground motions. Peaks (exceeding .10g) continued for approximately 5 seconds while the whole event lasted 15 seconds. The earthquake generated unusually high peak accelerations, however, they lasted only a short period of time.

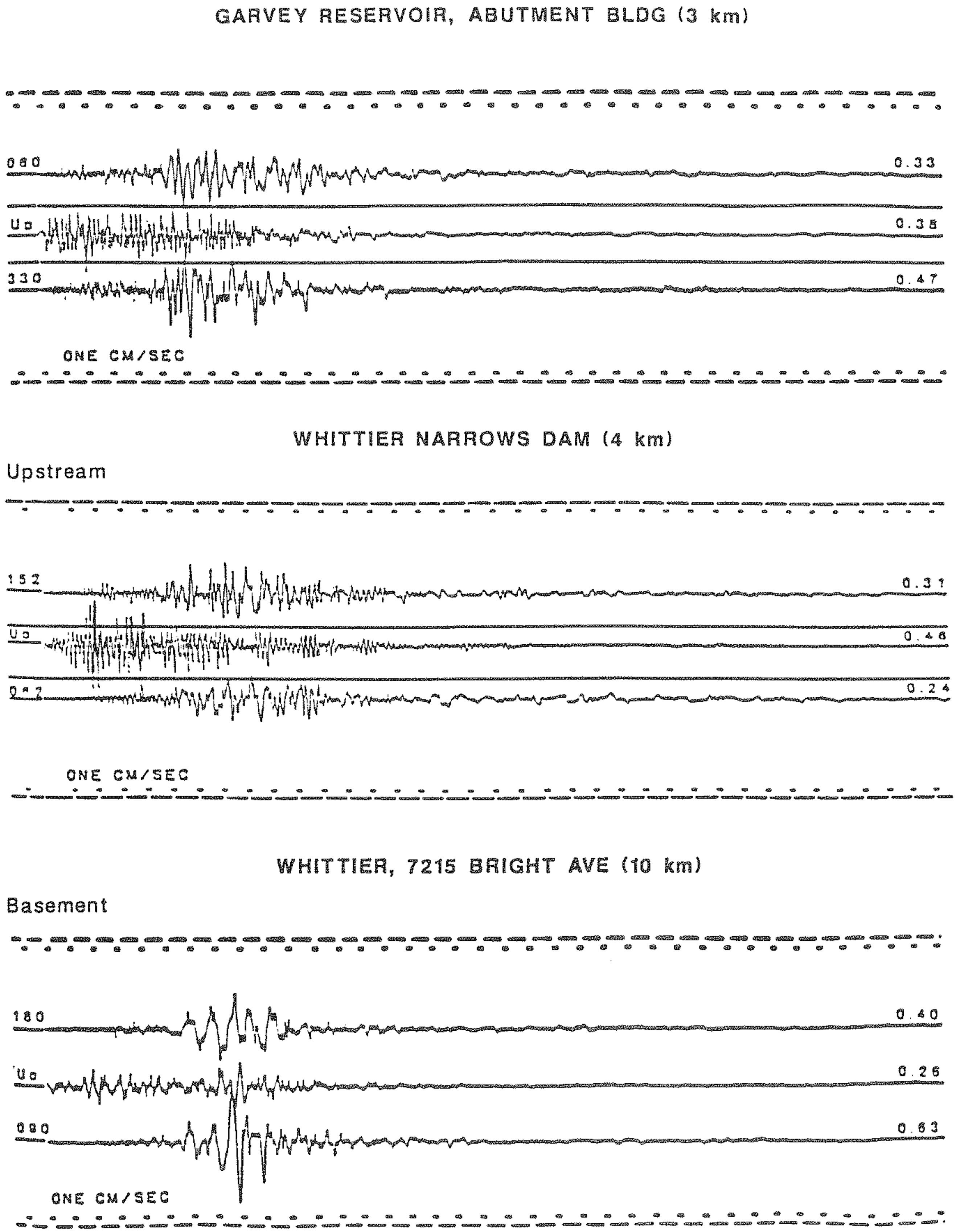

Figure 1-2 Accelerograms of Ground Motion in Whittier Area [2].

1.2 EARTHQUAKE EFFECTS ON STRUCTURES

The earthquake affected a large variety of structural systems. It caused severe vibrations and extensive damage. An early estimate approximated that 9450 dwellings were damaged (according to T. Tobin of State of California Seismic Safety Commission) along with many commercial and industrial facilities. Communities in the east of Los Angeles such as Whittier, Montebello, Monterey Park, Alhambra, Rosemead, San Gabriel, San Marino, and Pasadena were mostly affected.

The severity of damage appears to be a function of the structural type, age of the structure, degree of rehabilitation (where it applies) and local soil conditions. In general, structures not adequately designed or retrofitted according to present codes and ordinances were affected the most.

The damages which occurred can be classified as:

- Structural - producing damage to load carrying systems
- Non-structural - producing damage to architectural/functional components such as suspended ceiling tiles, pipes, sprinklers, veneer, stucco, and partitions.

Structural Damage

Load bearing unreinforced masonry walls constructed of hollow or solid blocks had a large number of failures and caused collapse of entire walls and roofs. The extent of damage varied from minor cracks to complete collapse of walls. Several commercial buildings in Whittier suffered damage. Some collapsed over vehicles parked next to them. Older, unreinforced masonry walls failed due to in-plane cyclic shear cracking (see Figure 1-3), out-of-plane instability and impact with adjacent buildings (pounding). Several streets with commercial buildings had to be closed in Alhambra, Whittier Center and South Pasadena. Several buildings in San Gabriel Mission (constructed in 1791) were severely damaged. In particular, the bell tower failed and brought about the collapse of part of the adjacent 1500-seat Civic Auditorium. (This tower survived a large number of previous earthquakes.) In areas of Whittier, piers of unreinforced masonry that were acting as shear walls showed flexural failures between windows combined with some diagonal shear cracking.

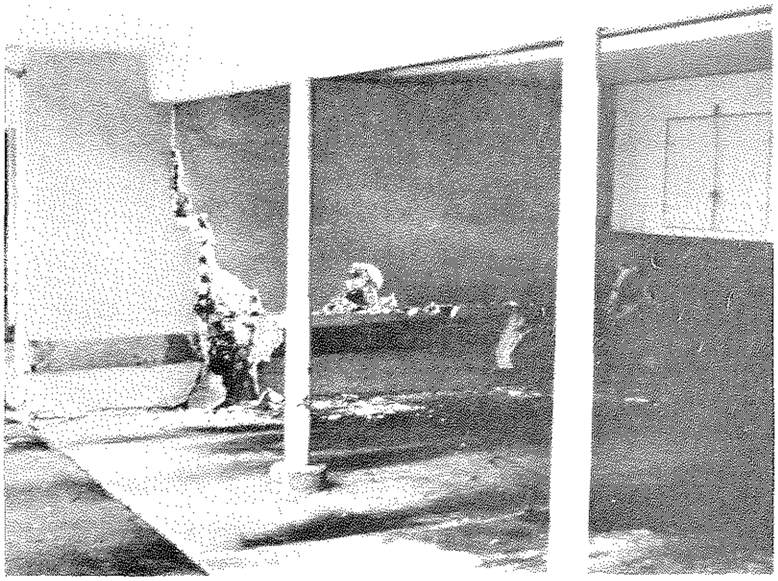

Figure 1-3 Masonry walls cracked severely in-plane due to high shear and compression at the first story (Photo from the Bay Area Regional Earthquake Preparedness Program (BAREPP) collection).

Tilt-up structures are common building types in California and other parts of the country. The buildings are constructed of precast panels that are connected in place by anchors. No spectacular collapses in this type of structure were recorded, however a number of buildings experienced partial roof collapse, anchor pull-out and concrete spauling at connections. In one case, a tilt-up structure housing a computer facility in Rosemead had larger damages in the form of cracked panels. In Santa Fe several buildings experienced partial roof collapse due to failure of connections between the roof and walls. (The out of plane anchoring was also a major problem in the 1971 earthquake at San Fernando Valley and the examples mentioned above are repetitions of similar failures.)

R/C frames and shear walls are extensively used in large structures in the Los Angeles area. Several buildings, bridges and other structures constructed according to the engineering practice before 1971 sustained heavy damage and lost their carrying capacity. For most cases the shear capacity of elements was not sufficient, due to insufficient shear reinforcement and inadequate confinement. It is apparent that the elements could not dissipate the energy input due to their reduced ductility and lack of alternative mechanisms for energy dissipations.

Major damage was caused to the supporting columns of a large highway overpass at the junction of I-5 and I-605. The columns suffered several load reversals and developed sizable diagonal cracks (see Figure 1-4). The columns have large diameter bars (#18) tied with small diameter hoops (#3) with large spacing (12"). Shear failure was expected in this type of structure (communicated by Mr. Ray Zelinski, Caltrans). Presently, investigations are being carried out by researchers at UCLA and Caltrans to clarify the details of these failures.

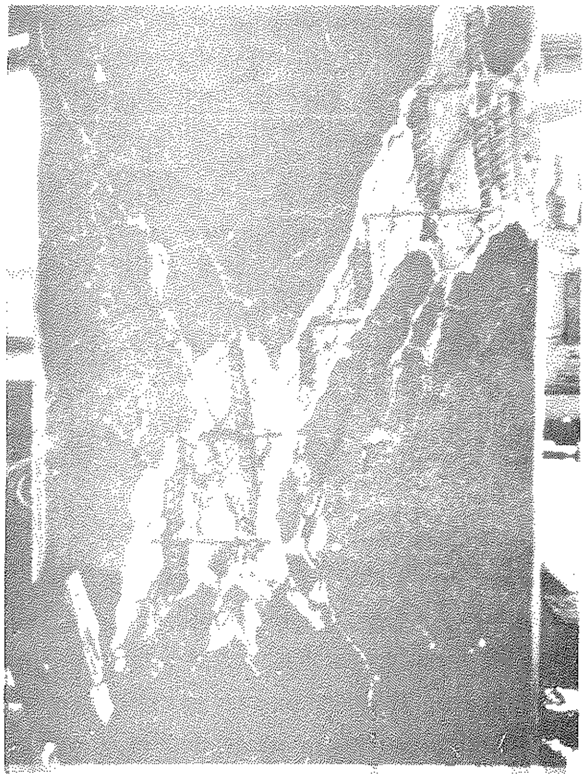

Figure 1-4 Cyclic shear produced x shear cracks in center columns of the I5 - I605 highway overpass (Photo courtesy of State of California, Department of Transportation).

A two-story parking structure adjacent to a department store (May Co.) at Whittier Quad suffered severe damage and partial collapse due to the shear failure of columns (see Figure 1-5). Large girders had much stronger sections than the supporting columns, creating conditions for a catastrophic collapse (strong beams vs. weak columns) (see Figure 1-6). The damaged and the collapsed columns (interior columns) were braced by deep spandrel beams and developed shear failure that is characteristic of short columns [1]. The outside columns were widely tied by #2 and #3 bars without confinement of the beam column connections.

Several structures with internal shear walls also were damaged. Large diagonal cracks developed in the Tycor Building and in the Edison Building in Rosemead. Both buildings require an indepth evaluation before rehabilitation work can be started. Numerous buildings at the California State University, Los Angeles Campus, suffered heavy damages of shear walls and columns. One bridge between two parts of the library building was rendered non-functional due to extensive damage to the first story columns of the building, primarily generated due to pounding of the bridge into the adjacent buildings. Diagonal shear cracks as well as transverse cracks indicate low ductility shear-flexural capacity. Several nearby buildings developed structural cracking in walls, columns and diaphragms forcing closing of entire buildings!

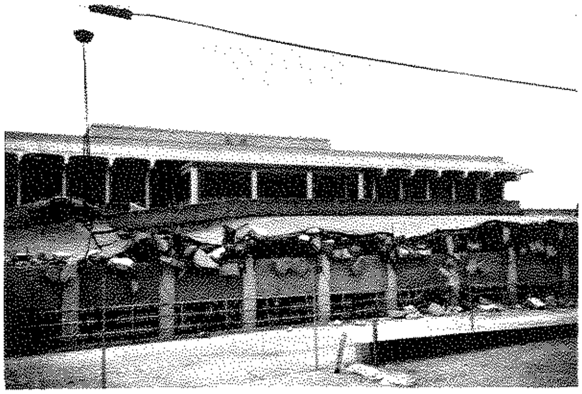

Figure 1-5 (above)
Shear failure of columns and joints led to the complete collapse of the roof of the parking garage at the Whittier Quad.

Figure 1-6 (right)
Typical strong beam-weak column connection and "short" column failure due to the lack of stirrups and properly anchored bars (Photo from the BAREPP collection).

The Tycor Building in Rosemead suffered extensive damage to almost all its structural components. A combination of precast construction (walls) with cast in place elements and highly irregular diaphragms without adequate reinforcement produced severe damage to beams, columns and walls. The nonsymmetric locations of shear walls contributed to the severe damage of all other elements.

In spite of numerous damages to older structures, recently constructed reinforced concrete buildings did not experience severe damage, except for the Tycor Building. The majority of R/C structures sustained the earthquake motion without collapse but with minor damage.

Building foundations constructed of reinforced hollow masonry and unreinforced concrete sustained many failures in Whittier, Rosemead, Alhambra and Pasadena. Failure of such foundations led to damages in the superstructures, usually single family homes.

Bridge abutments experienced moderate to minor damages by spauling of concrete underneath the supporting pads. No damages were noticed in abutments, columns and piers of bridges that were retrofitted by cable restrainers.

Structural steel frames and truss systems performed well in this earthquake. In some instances, however, truss roofs lost stability and eventually failed due to lack of proper support. In one reported case (see EQE report [1]) the braces in the upper story of a four story building buckled without any other structural damage.

Woodframe structures - Older woodframe, residential structures sustained some damage, mainly from inadequate bracing of cripple walls and insufficient bolting of walls to the foundations. These structural problems frequently resulted in houses sliding off their foundations. In addition to this, toppling over of unreinforced brick chimneys onto roofs in some cases caused collapse of roof and upper floor structures. Relatively new woodframe construction performed quite well.

1.3 NON-STRUCTURAL DAMAGE

It is apparent that the major cause for losses is nonstructural damage. In many instances, buildings "survived" the major vibrations with little or no structural damage, however, the content of these buildings was lost due to failure of architectural components or functional appendices. A brief classification of nonstructural damages follows:

Masonry chimneys and unreinforced masonry towers were severely damaged due to lack of ductility. Residential buildings were not directly damaged by the failure of these structures but by the falling debris from the chimneys.

Masonry parapets and facades inappropriately anchored to the structural system roofs or frames collapsed and damaged adjacent buildings or caused broken glass. In commercial areas, the uncollapsed or dislocated parapets and facades became a threat and access had to be restricted until demolition was completed.

Suspended architectural ceilings, light fixtures and ducts failed in many occasions while the structural system did not have any damage. In a few instances, falling ceiling tiles and light framing destroyed expensive computers, furniture and office accessories (see Figure 1-7).

HVAC and fire sprinkler systems attached to buildings collapsed due to the interaction with the vibrating suspended ceiling tiles. This was the case in several office buildings in downtown Los Angeles where the damage caused to the contents by the broken sprinkler system was more expensive than the damage to the ceilings itself (e.g., California Federal Savings - Computer Center).

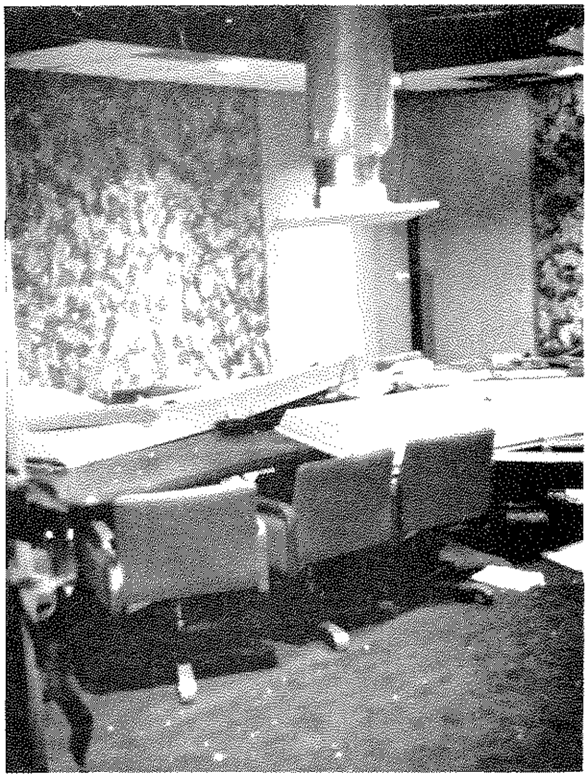

Figure 1-7
Considerable damage was done by falling ceiling tiles, light fixtures, pipes and vents (Photo from the BAREPP collection).

Mechanical equipment, improperly anchored, failed causing major damage and even evacuation of buildings (e.g., Downey Hospital closed due to water damage).

Building contents including storage racks, books, laboratory chemicals, etc., suffered extensive damage in buildings which did not have structural damage (see Figure 1-8). Moreover, flying objects caused extensive damage to walls, claddings and other building contents. In one case, at California State University, chemicals spilled and reacted with each other creating toxic materials. Buildings had to be closed and clean-up operations took several days. The replacement of nonstructural components and building contents was estimated at approximately 50% of the retrofit costs at California State University. According to reports of structural engineers and architects these costs may be exceeded in some tall buildings.

Fortunately, most of the buildings which had nonstructural damage were not occupied at the time of the main shock (7:42 AM) or aftershock (4:00 AM) and, thus, many injuries were avoided.

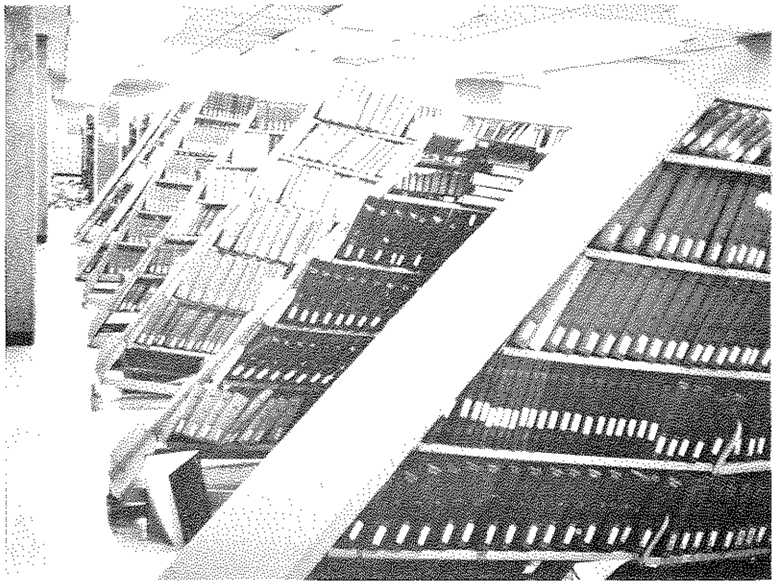

Figure 1-8 Damaged shelves at California State University at Los Angeles library are supported by the confined books.

1.4 LIFELINE DAMAGE AND PERFORMANCE

The lifeline systems in the Los Angeles area performed well with only minor damages.

Water Supply System - The System was operational after the earthquake due to adequate back-up pumping units. Only in a few cases underground pipes (buried lines) suffered damage at joints -- as reported in Los Angeles, Alhambra, Rosemead and Whittier. Most of the damages were repaired shortly after the earthquake.

Electric Power System - The power system did not suffer any major damage and only local low voltage failures were reported. In some cases, high voltage equipment (circuit breakers, transformers, etc.) was damaged. Rigid bushings of 220 kv air-blast circuit breakers cracked or moved releasing the seals and the gas content. Several high voltage transformers rolled on their rails causing damage to adjacent buildings. However, the friction roller-stopper provided a good displacement control in the other direction of movement of these transformers.

Transportation was not disturbed except for the damaged overpass mentioned in the previous section of this report. Structural shoring and other repairs were completed within 20 hours from the earthquake occurrence and the roads were open to traffic.

1.5 GENERAL REMARKS

The earthquake occurred in an area of concentration of structural engineers and architects with well known experience in the field of earthquake engineering. Due to this fact, a large number of professionals were involved in reconnaissance work for clients, for state or private agencies or simply because of professional curiosity. The list of acknowledgements provided as an appendix includes only some of these investigators; many others could be added. EERI is performing the formal task of coordinating efforts of investigations and reporting. Several Technical Briefings (Seminars) were organized approximately one month after the earthquake in Los Angeles, Washington, D.C. and San Francisco. A future issue of "Earthquake Spectra", published by EERI, will be dedicated to a review of this earthquake. In parallel, EQE, Inc. of San Francisco is preparing a more detailed report on this earthquake to replace the preliminary report mentioned in reference [1].

Performance of retrofitted buildings and bridges was according to expectations. Most of the 1000 retrofitted buildings in Los Angeles (out of 8000 suggested for upgrading) performed without any damage. Only some buildings in the Whittier area suffered damage due to improper or incomplete retrofit (20%). Bridges which had displacement restrainers installed as a retrofit measure did not sustain any damage.

A recently base-isolated bridge (Santa Ana River Bridge) supporting a water piping system with 180 ft. trusses, was subjected to a peak ground acceleration of .15g. The bridge developed only .13g above the isolators as measured by USGS [2].

The ground motion showed unusually high peak accelerations; however, the whole motion lasted only several seconds. Thus, the burst of energy into the structures was not too high. It is surprising to note the extent of the damage to buildings in which this energy source created a large energy input but were without dissipation mechanisms. This must alert engineers to the required retrofit to supply this energy dissipation mechanism in form of traditional strengthening or by addition of protective systems.

SECTION 2
EMERGENCY RESPONSE, RECOVERY AND RECONSTRUCTION

*This part of the **NCEER Report on the Whittier-Narrows, CA, Earthquake of October 1, 1987**, will focus on earthquake emergency response, recovery and reconstruction, as well as its economic and social implications. The first part will report on the actual post-earthquake activities in the area of impact, while the second will point out important lessons to be learned from this earthquake.*

2.1 POST-EARTHQUAKE ACTIVITIES

Emergency Response

Public response to the October 1, 1987 earthquake developed in two stages: the first occurred after the main shock on Thursday, October 1, and the second following the aftershock of Sunday morning, October 4. In both cases, the response was brief, comprehensive and according to existing plans. On Thursday, the response was over by 10 PM, while on Sunday it ended by 3 PM. All entities involved, such as Office of Emergency Service, Federal Emergency Management Agency, Fire Departments, Police, and so forth, responded promptly. Affected jurisdictions were able to contain the magnitude of the disaster with their own capabilities, referring only rarely to the mutual aid agreements they had with their neighbors. A total of about 90 fires was reported following the earthquake. They were local incidents and soon contained [1]. Several thousand gas leaks were found by the Southern California Gas Company, about 25% of which were directly caused by the earthquake [4].

Traffic was interrupted on the interchange of I-605 and I-5 because of structural damage to the supporting reinforced concrete columns. Some of the affected areas, especially Uptown Whittier, had local traffic interruptions, because of building debris which blocked the streets, or because of danger of further building collapse. Telephone communications, especially line 911, were overloaded.

Many high-rise buildings in downtown L.A., several convalescent homes and hospitals, and a number of apartment buildings and private homes were evacuated. Some hospitals were damaged, but were able to provide emergency medical care to earthquake victims. School buildings also sustained damage estimated at approximately $24 million. Much of the damage is reported to be non-structural. Many small businesses and several corporations had serious damage, and are still out of operation.

Rapid damage assessments provided enough information for Governor Deukmejian to declare disaster in the affected areas on October 2. The President did the same on October 7 following more extensive damage evaluations. As a consequence of this, the Disaster Field Office was established in Rosemead on Friday, October 9. Assigned representatives from the Federal Emergency Management Agency, and the Governor's Office of Emergency Services had been charged to jointly coordinate disaster assistance. In an initial briefing for public officials from the affected areas, they outlined the scope of the Federal and State disaster assistance, and announced opening of regional Disaster (Assistance) Applications Centers, known as "DACs". They were established to advise and assist applicants in submitting requests for loans, grants and general assistance. On Sunday, the 11th of October, seven DACs were opened in the areas of highest earthquake impact: Alhambra, Bellevue, Highland Park, Hollenbeck, La Habra, Rosemead and Whittier.

Figure 2-1
Residents of lesser damaged homes moved into mobile homes parked in their front yards for emergency housing.

Figure 2-2
The American Red Cross extended help not only in the 21 emergency shelters, but also through the numerous mobile units.

Emergency Shelter

It is estimated that about 12,000 family and individual households, or approximately 30,000 people, were made homeless after this earthquake. Many camped in tents and trailers in the yards of their damaged homes (see Figure 2-1). Twenty-one emergency shelters provided by the Red Cross (see Figure 2-2) and other relief groups housed 2,534 families, or almost 10,000 people, at the peak of their occupancy. In contrast to experiences from other disasters, following this earthquake the use of shelters grew with the passage of time. It reached its peak approximately a week after the first shock, and dramatically increased following the Sunday aftershock.

Due to spotty damage over a relatively large area, a cross-section of income groups was affected. The most seriously hurt were low-income groups, such as members of ethnic populations, and low-income retired and elderly people. Recent Hispanic immigrants appear to be the relatively most affected ethnic group due to language barrier and lack of their traditional, extended family support systems.

Residential Damage

Tentative statistics of November 10 indicate that a total of 123 single family buildings were destroyed, while 513 and 2,655 sustained major and minor damage respectively (see Figure 2-3). In the category of multifamily apartment buildings, the number of destroyed

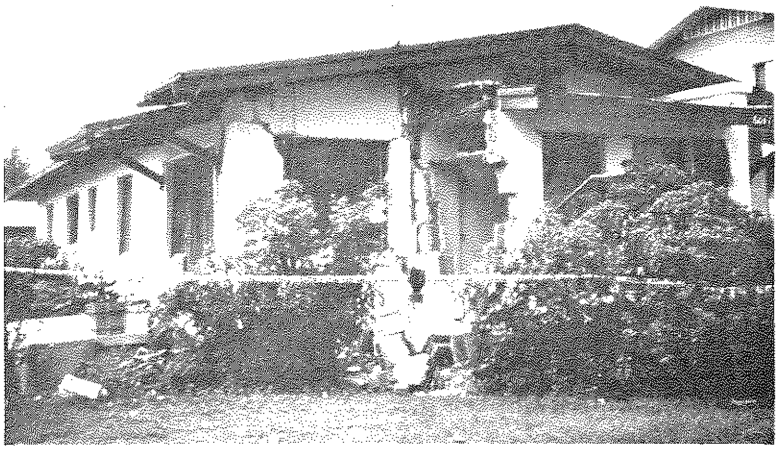

Figure 2-3
Many single family residences such as this hollow-tile home on Painter Avenue in Whittier were damaged in the earthquake. They were cordoned off as unsafe for occupancy, while the residents sought shelter elsewhere.

apartment units is 1,347; 2,040 apartments were seriously damaged; and minor damage was sustained by 7,872 apartments [6].

Economic Effects

As of November 11, direct damage to structures was estimated at $358 million: $349 million sustained by the private sector, and $9 million by the public sector [4]. It must be borne in mind that these figures account only for the losses caused by physical damage, while losses caused by business interruption are not included.

Especially affected are small and medium businesses, for which building and capital loss mean interruption of entire business operation, displacement, and potential loss of clientele (see Figure 2-4). It is uncertain whether many of such businesses will be able to survive this earthquake. First reports show that the businesses that had earthquake preparedness plans fared much better in this earthquake than those that did not.

Death, Injury & Health Issues

This earthquake caused 8 deaths, three of which are directly related to earthquake effects. Five deaths (direct cause of which were heart attacks) are arguably attributed to earthquake. 1,349 emergency patients were seen in 47 hospitals in the area of highest impact [6]. 400 people were injured in the aftershock.

Figure 2-4
Many businesses and retail stores had to relocate - if only temporarily. This furniture shop is organizing an "earthquake sale" at their new location. Whether they will be able to return to the prime retail area of Greenleaf Boulevard is uncertain.

In contrast to the high level of hospital capability to continue operations and provide assistance to physically injured, health services in the earthquake affected area were not prepared to deal with significant psychological problems that resulted after the Thursday, October 1, earthquake and especially its major aftershock on Sunday, the 4th. A wide-spread need for disaster counseling was noted, but the county offices of mental health, which normally provide such service, were unprepared for an increased load of people needing assistance. Existing non-disaster crisis hot-lines were inundated by emergency calls. A special program coordinated by the State Department of Mental Health is being prepared to fund special disaster counseling service in the counties. Again, it was noted that the members of some ethnic groups, such as recent Hispanic immigrants, tended to need this assistance more than others.

2.2 RECOVERY & RECONSTRUCTION

Inasmuch as the jurisdictions responded very well to the post-earthquake emergency needs, without relying on mutual aid, actual losses, especially of the private sector, surpass the long-term recovery capability of affected communities. The Governor's and President's declarations of disaster paved the road for establishing Federal and State mechanisms for assistance in recovery and reconstruction.

As of November 10, 1987, two tiers of assistance packages have been made available to applicants. Disaster Field Office and the Disaster (Assistance) Applications Centers coordinate the process of application for and disbursement of assistance for both tiers. As of October 17, all illegal aliens in the pending amnesty status were also encouraged to come forward and apply to DACs if they suffered losses, since citizenship is not a prerequisite for assistance. A total of 22,622 individuals and businesses had applied for assistance by November 13 [4].

The **first tier** of Federal and State assistance is a regular package of aid programs that are normally offered following disasters in the U.S., and it includes:

- O *Disaster Loans to Individuals and Businesses* are administered by the Small Business Administration and are based on uninsured disaster-related losses (see Figure 2-5); individuals may be eligible for low-interest rate loans (8% or 4%) of up to $100,000/$20,000 for home/personal property losses; businesses may get up to $500,000 of the same low-interest loans. By mid-November, 13,877 homeowners and 4,200 businesses applied for loans [4].

- O *Disaster Housing Assistance Program*, administered by the Federal Emergency Management Agency (FEMA), provides temporary housing arrangements for any family whose permanent residence has been made uninhabitable. According to the statistics of November 13, 1987, 15,579 applications were registered for this program [4].

- O *Grants to Individuals and Families* of up to $5,000 are available to eligible disaster victims. Individual and Family Grant program is funded 75% by the Federal government and 25% by the state, and is administered by FEMA. It is usually considered to be the last resort for low-income families, and 4,609 applications for this program were on record by November 13 [4].

The processing of assistance applications was very fast, with the first 170 checks worth $140,000 in the mail only six days after opening of the DACs. Since many of the seriously affected low- and middle-income families and small businesses could not qualify for the low-interest disaster loans, the State created the **second tier** of disaster assistance. This package *supplements*, not *supersedes*, the existing package. At the special session of the State of California legislature on November 9 and 10, 1987, a Bill was passed to create the **Emergency Relief Act of 1987**. An open-ended pool of funds (currently worth $91 million) is made available for continuing appropriation by the State, as long as the applications for assistance are made and the applicants qualify. The breakdown is as follows:[1]

[1] The information on the State **Emergency Relief Act of 1987** are based on Ref. [5].

- A total of $10 million will be made available for $10,000 grants to families and individuals for uninsured losses;

- $15 million will be given in low-interest (3%) loans to low- and middle-income homeowners for rebuilding of homes;

- $5.7 million is reserved for 3% interest loans for rental housing owners to reconstruct their properties; in both cases, payments are deferred for 5 years, or until the property is sold;

- Property tax relief provides for deferment of payment until April 10, 1988, if the property loss is $5,000 or 10% of property value (whichever is less);

- It will be possible to write off losses from income tax for a period of 5 years if losses exceed annual income.

Another $100 million of the State grant money has been allocated for repair of government buildings, schools and private non-profit organizations' buildings. This money will serve to finance 60% of the cost, while the Federal government will support the other 40%. The State monies will be allocated as follows:

- $34.5 million for city, counties and special districts;

- $10.2 million for school districts;

- $13.5 million for the California State University;

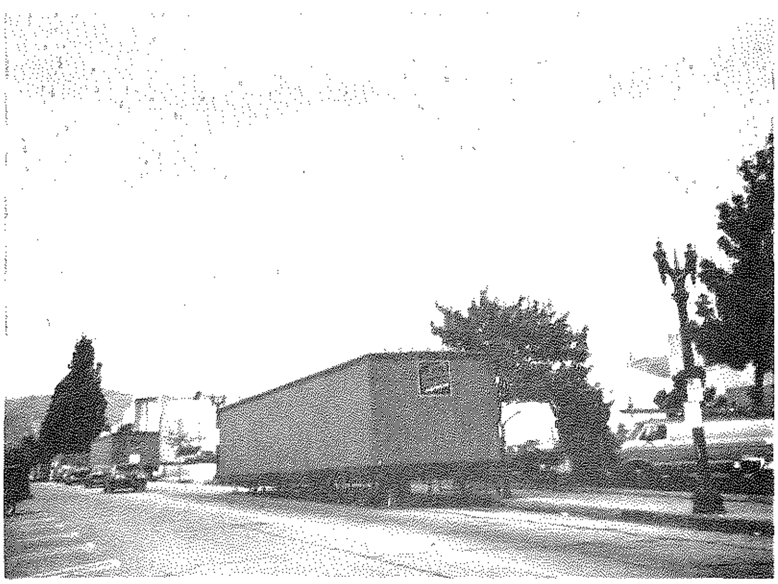

Figure 2-5
Frequently, the displaced businesses moved into temporary locations, such as this row of trailers on an avenue just west of Greenleaf Blvd. The City of Whittier assisted with water connection and portable toilets.

- $ 1.8 million for community colleges;
- $ 1.8 million for other State losses;
- $ 2.5 million for private non-profit organizations' building losses.

Insurance Issues

In the State of California, only about 15% of the homes are insured for earthquake damage, and approximately 20-25% of the small businesses. Unreinforced masonry buildings in California which have not been retrofitted are not insurable. However, a large number of homes and other buildings are insurable, but are not insured. Two principal reasons for this are: earthquake insurance cost per annum, which is about $2 per $1,000 of what the home is worth, and the requirement for 10% deductible.

It is estimated that out of those 12,000 homeless households which did have earthquake insurance, only a small number will be able to collect on their policies, because of the large deductible. The main insurance compensations will come later, from the claims for business interruption.

This moderate damage, "threshold" earthquake, and the huge losses it created, gave an impetus to reconsidering the basis for earthquake insurance in this country. It appears that the insurance industry will press Congress in 1988 to create a semi-public agency to finance national earthquake insurance.

2.3 FEDERAL/STATE HAZARD MITIGATION PLAN[2]

The Presidential disaster declaration made some affected areas eligible for federal disaster assistance. However, "Section 406 of the Disaster Relief Act (Public Law 93-288) requires that repairs be done in accordance with applicable codes, specifications and standards." In addition to that, a "major product of the Section 406 process is a State Hazard Mitigation Plan which describes state and local actions that have been and will be taken to mitigate the hazards."

In conformance with the requirements of the Section 406 of the Disaster Relief Act, a joint Federal/State Hazard Mitigation Survey team was formed to: identify and evaluate

[2] The contents of this section is entirely based on the Introduction chapter (pp. 1-2) of Ref. [4].

areas affected by earthquake; review and evaluate applicable land use and construction requirements, emergency, preparedness and response plans; identify and evaluate measures to reduce future hazard effects; and identify hazard mitigation areas that need future attention.

The team has already completed these tasks, and is now in the process of preparing the **State Earthquake Hazard Mitigation Plan**, which will: analyze the earthquake hazard in the disaster area; analyze the existing laws dealing with earthquake hazard reduction; evaluate existing state and local earthquake hazard mitigation programs; and finally, propose earthquake hazard mitigation measures. According to the law, the team has six months following the disaster to perform these tasks and write the Plan. Coordination and monitoring of the implementation of the State Earthquake Hazard Mitigation Plan will be done by FEMA.

2.4 LESSONS LEARNED

The major lesson provided by the Whittier-Narrows earthquake is the importance of earthquake preparedness planning, education and implementation of earthquake hazard reduction measures. Their relative significance was demonstrated either in terms of positive experience, where existence of preparedness efforts created an adequate framework for coping with earthquake effects. Or, conversely, their absence showed the need for such planning activities (see Figures 2-6 and 2-7).

Similarities in building types and methods of construction make it possible for other communities across the country to learn from the Whittier-Narrows earthquake. This is especially important for the areas that have inadequate, or lack entirely seismic building code requirements; or, those that have no, or have only a low level of earthquake preparedness planning. Other earthquake-prone communities in California and other parts of the country, especially Eastern U.S., should make a point of translating as much as possible of the Whittier-Narrows' post-earthquake lessons to practical earthquake hazard reduction measures in their communities.

Although a formal evaluation process of the earthquake preparedness efforts in Southern California is only pending, it is a shared opinion that the promptness in response and general knowledge of what to do in this earthquake were a consequence of a multi-year earthquake preparedness planning program performed by the Southern California Earthquake Preparedness Project. This project involves earthquake awareness raising, education and earthquake mitigation activities in several Southern California counties.

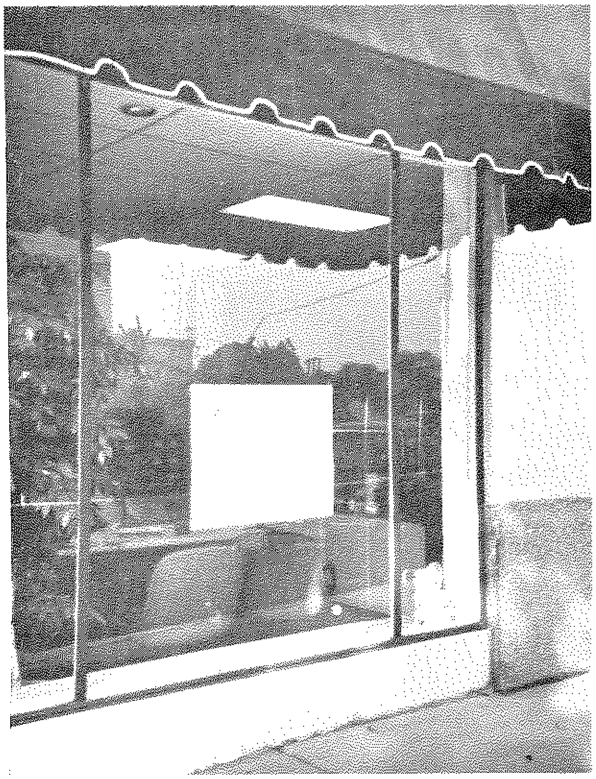

Figure 2-6
Not all the businesses were affected by the earthquake. Here is an example of a travel agency that emerged unharmed from the October 1 shaking.

From among many lessons learned from this earthquake, three are singled out below:

O *Serious level of vulnerability of businesses and corporations to the effects of moderate earthquakes.* In the Whittier-Narrows earthquake, small and medium-sized businesses sustained great losses, many were displaced, and as a consequence, may become marginalized, and/or totally disappear from the market. Since the current earthquake insurance system appears to be unsatisfactory for both the members of the industry and those to be insured, Federal and State policies should examine options for earthquake insurance, as well as incentives for application of more concerted earthquake hazard reduction measures.

- O *Importance of ethnicity in earthquake preparedness planning and recovery efforts.* Many sectors of population in earthquake vulnerable areas may be impaired to cope with earthquake hazard in this country because of their different cultural, ethnic and linguistic backgrounds.

- O *Earthquake-related psychological problems merit the same seriousness of approach and long-term planning effort as physical injuries do.* It will be necessary to incorporate these issues into pre-earthquake education, as well as to motivate the states to prepare for post-earthquake counseling programs.

Figure 2-7
Example of another Uptown Whittier business which was displaced after the October 1, 1987 earthquake. Businesses which were not adequately prepared for an earthquake suffered serious economic setbacks.

SECTION 3
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SECTION 4
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