REBUILDING AFTER EARTHQUAKES

Lessons from Planners

INTERNATIONAL SYMPOSIUM ON REBUILDING AFTER EARTHQUAKES
Stanford University, Stanford, CA
August 12 -15, 1990

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This publication summarizes the outcomes of the International Symposium on Rebuilding After Earthquakes, sponsored by Stanford University in August 1990. Approximately 40 planners participated, including presenters from Yugoslavia, Armenia, Italy, Algeria, Mexico, and Nicaragua who illustrated parallels between their country's redevelopment experiences following major earthquakes. The document provides advice for planners who face rebuilding of residential and other properties: the need to work across traditional professional boundaries; advice on pre-earthquake steps, such as assuring consistency between plans and development regulations; and the importance of creating the legal authority, structure and plans for future development. The presenters also stressed the value of regional planning and appropriate site planning considerations for temporary housing, and the worth of identifying geologic, seismic, and structural hazards before an earthquake hits. In addition, they addressed social considerations planners should take into account, particularly when confronted with historic preservation issues; homeowners' safety concerns; the disparate effects on small business owners within the older central business districts; and the reestablishment of neighborhoods following the catastrophe.

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Preface

Much of the United States, including nearly half of its large metropolitan areas, is subject to earthquake damage. California has moved into a period of more frequent small and moderate earthquakes which many scientists believe is the forerunner of a period of large earthquakes. Both the northeast and central U.S. have suffered large earthquakes in the past which experts expect to recur in a future growing closer every day. New studies indicate that Washington and Oregon could have very high magnitude subduction zone earthquakes. Most of the population of Utah lives along a now well-defined fault zone capable of producing large earthquakes. South Carolina is home to one of the most devastating earthquakes in U.S. history considered likely to repeat itself in the future. Alaska continues to rumble and shake from both earthquakes and active volcanoes, and Hawaii's coastline is subject to the danger of earthquake-generated tsunamis, or seismic sea waves. At least one-third of the U.S. population lives in areas susceptible to major damage from earthquakes.

In these vulnerable regions, planners face the possible challenge of rebuilding after an earthquake. Common sense says that it would be wise to prepare for this eventuality. However, we have little experience in this country in rebuilding after large earthquakes and none striking a modern metropolitan area. For knowledge about the tasks planners would face in such instances, we need to look to foreign experiences.

The International Symposium on Rebuilding after Earthquakes provided an opportunity for U.S. planners from earthquake vulnerable cities and counties to hear firsthand accounts of planning after earthquakes from planners and related professionals who participated in planning after foreign earthquakes. The U.S. planners were also exposed to accounts of rebuilding after recent, moderate California earthquakes. We believe the exchange also benefited the foreign participants. They had a chance to learn from each other and the California planners who shared their recent experiences.

This report summarizes the content of the symposium and our conclusions about the most important lessons for U.S. planners. We hope it will alert U.S. planners to some realities of post-earthquake planning and encourage them to prepare for the extraordinary demands of this challenging period.

George G. Mader, AICP
Martha Blair Tyler, AICP

Acknowledgments

This report was generated by the participants in the International Symposium of Rebuilding after Earthquakes. They provided all the raw material – facts, ideas, and illustrations. Our role has been to synthesize this material and extract lessons for other planners facing the tasks of rebuilding following a damaging earthquake. Thus, we gratefully acknowledge our debt to all the participants – the presenters from foreign countries and California cities, the experts from government, private consulting and academia, and the planners from cities around the United States. They have provided rich detail to create a vivid and realistic picture of what it is like for communities to rebuild after being shaken apart by earthquakes.

Specifically, we acknowledge the following people for their contributions.

- ***Tom Tobin.*** Tom Tobin, Executive Director of the California Seismic Commission, welcomed participants and closed the symposium as representative of the Commission, the sponsoring organization. His closing comments capsulized some of the main points of the three-day discussions and are reflected in this report.

- ***Rich Eisner.*** Rich Eisner, Director of the Bay Area Regional Earthquake Preparedness Project (BAREPP), kicked off the symposium with a slide presentation on the Loma Prieta Earthquake, setting the stage for the field trip to Santa Cruz County to view the effects of the earthquake there.

- ***Marjorie Greene, Luis Ramirez Velarde, Roberto Pirzio Biroli, Farouk Tebbal, Jorge Gamboa de Buen (with Daniel Ruiz Fernandez) and Aleksander Krivov.*** These professionals gave the presentations on foreign earthquakes. They accepted our invitation to speak and took time to prepare an illustrated talk based on our outline. Most provided us with the full text of their comments and copies of slides used in the presentations. From this material, we crafted summary accounts of rebuilding after the foreign earthquakes. They also reviewed and commented on drafts of the summaries. Their contributions form the core of this report.

- ***Paul Flores, Dave Bugher, and Elvin Porter.*** Paul Flores, Director of the Southern California Earthquake Preparedness Project, ably moderated the lunchtime panel on the Coalinga and Whittier earthquakes, helping to place these experiences in context of both the foreign earthquakes and larger earthquakes expected in the state. Dave Bugher, Planning Director of Coalinga, and Elvin Porter, Planning Director of Whittier, made presentations on rebuilding after earthquakes that damaged the downtowns in their cities. Their accounts provided necessary perspectives on the experience of rebuilding in the United States and from smaller earthquakes than the foreign examples.

- ***Bill Cole, Burt Hardin, and Paia Levine.*** Bill Cole and Burt Hardin, engineering geologists with William Cotton and Associates, Inc., teamed with Paia Levine, Santa Cruz County staff geologist, to prepare a presentation for a field trip stop in the Santa Cruz Mountains, near the epicenter of the Loma Prieta earthquake. They explained efforts to assess hazards after the earthquake, including trenching on the property we visited. Their comments brought reality to our understanding of the process of seismic hazard evaluation.

- ***Charles Eadie, Dick Stubendorff, and Maureen Owens.*** During the field trip Charles Eadie, Project Manager of the City of Santa Cruz Redevelopment Agency, described early recovery from the Loma Prieta earthquake, and building official, Dick Stubendorff led us on a tour of Santa Cruz's heavily damaged downtown. Maureen Owens, Planning Director of Watsonville, a city badly damaged in the Loma Prieta earthquake, also led us through the hard hit downtown and adjacent residential areas. They provided valuable, on-the-scene accounts of rebuilding in its early stages.

- *Ken Topping.* A consultant and former planning director for the City of Los Angeles, Ken Topping made a luncheon presentation on progress in Los Angeles in developing a recovery and reconstruction plan before the next earthquake strikes. This gave us the important message that it is possible to prepare in advance for some of the typical rebuilding tasks.

- ***Paula Schulz, Ludo van Essche, Henry Lagorio, and Bob Olson.*** These people served as "observers" at the symposium. Each was assigned a topic related to his or her expertise to follow throughout the symposium. Paula Schulz, Assistant Director of BAREPP, commented on government organization and funding; Ludo van Essche, with the United Nations Disaster Relief Organization (UNDRO), on housing; Henry Lagorio, a Program Manager at the National Science Foundation, on restoring infrastructure and public facilities; and Bob Olson, President of VSP Associates, on business and economic recovery. At the closing session, they summarized the main points pertaining to these topics and contributed insight and ideas which are directly incorporated into Chapter 2, *Lessons for Planners.*

All these people contributed directly to the content of this report. Individual contributions are noted throughout the report and we hope we have been faithful reporters. In the end, however, we accept full responsibility for the report's style and content, and, in particular, the interpretations contained in the chapters, *Lessons for Planners* and *Timeline.*

The symposium itself brought together the people with the facts and ideas contained in this report. It owes its being to a number of people and institutions. We gladly acknowledge the following:

- The ***National Science Foundation*** which funded the project, and project manager, ***Dr. William Anderson,*** who continues to encourage research and dissemination efforts under the Earthquake Hazards Reduction Program.

- The ***California Seismic Safety Commission*** for sponsoring the symposium. The commission's support underscored the importance of rebuilding after earthquakes as a public policy concern.

- ***Stanford University*** for making available excellent facilities for the symposium. The university's conference office, headed by ***Kathy Warren,*** and ***Carol Knestrick,*** ably made the on-campus arrangements and helped us with symposium logistics.

And, last, we acknowledge the contributions of our staff at ***William Spangle and Associates, Inc. George Mader,*** President, and ***Martha Blair Tyler,*** Principal Planner, were co-principal investigators and responsible for the overall concept and content of both the symposium and this report. Associate Planner, ***Laurie Johnson*** undertook the huge task of organizing the symposium, coordinating with Stanford University, and arranging travel and special events. She is the one who kept in touch with participants throughout the project. Vice President ***Tom Vlasic*** was "official photographer," taking most of the symposium pictures which appear in this report. Martha drafted the report and Laurie took the lead in creating the layout. All of us were efficiently and cheerfully supported in our efforts by our "front office" staff: ***Joette Farrand,*** office manager, and ***Irmgard Ibara,*** administrative secretary.

These acknowledgments would not be complete without a second thank you to the planning directors from across the country who took time from busy schedules to spend three days discussing rebuilding after quakes. Given the many topics competing for planning attention, we are pleased and gratified that so many came. This report is written especially for them and other planners who could be on the firing line after a damaging earthquake.

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Chapter 1

Introduction

After an earthquake strikes, as planners, you will be thrust into a world of instant life-and-death decisions, mounds of building permit applications, daily dealings with a new bureaucracy with incredible paperwork requirements, and unremitting pressure to get things back to normal. Everyone will want a plan, but few will want to take the time to plan. You will be expected to have answers to problems you have not even thought about before. You will be dealing with new experts – geologists, structural engineers and seismologists with information you will need to understand. If damage is severe, you may be saying, "Let's relocate the entire community." Inadequacies in existing plans and regulations will be glaringly apparent. Nothing in your planning education has adequately prepared you to deal with the problems and responsibilities now on your desk.

Present in this high-pressure situation are opportunities to improve the urban pattern, but these opportunities will soon pass if they are not acted on quickly. With appropriate building and repair standards, a rebuilt city is safer than before an earthquake. Open spaces, wider streets and, perhaps, lower densities can reduce vulnerability to earthquakes. Where damage is concentrated or sites are particularly hazardous, redesign of significant areas may be possible. After an earthquake, you may find you can improve traffic circulation, eliminate non-conforming uses, modernize public facilities, and stimulate the local economy. Some longstanding planning problems can often be resolved as earthquake-damaged cities are rebuilt.

We have studied rebuilding after earthquakes and other natural disasters and know that planners need better information about their roles in reconstruction. Recognizing this, the National Science Foundation awarded a grant for an international symposium on rebuilding after earthquakes. The objective was to expose U.S. planning directors from earthquake vulnerable cities throughout the country to the realities planners face after earthquakes. The California Seismic Safety Commission agreed to sponsor the symposium, and a steering committee was formed to help select the earthquakes to be covered, draw up the invitation list, and design the symposium program. Committee members were:

Richard Eisner, *Director, Bay Area Regional Earthquake Preparedness Project*
Henry Lagorio, *Professor of Architecture, University of California, Berkeley*
Robert Olson, *President, VSP Associates, Inc.*
Thomas Tobin, *Executive Director, California Seismic Safety Commission*

The steering committee and project team met and chose six foreign earthquakes which occurred at different times in different parts of the world. Individuals who had participated directly in some phase of planning for rebuilding after each earthquake were invited to share their experiences with U.S. planners. The symposium focused on learning from foreign earthquakes because most damaging urban earthquakes in the last 30 years or so have been in other countries. Presenters described rebuilding after earthquakes in Skopje, Yugoslavia (1963); Managua, Nicaragua (1972); Friuli, Italy (1976); El Asnam, Algeria (1980); Mexico City, Mexico (1985); and Armenia, USSR (1988).

Each earthquake left its particular signature on a unique urban environment, and the culture, government and economy of each country provided a distinctive context for reconstruction. Yet common problems and issues arose in each case giving us a glimpse of reconstruction as a generic process.

To help planners understand how foreign experiences might relate to U.S. cities, the symposium also included presentations by planners on rebuilding after the Coalinga (1983) and Whittier (1987) earthquakes and a field trip to sites in Santa Cruz County damaged in the Loma Prieta earthquake (1989). Government officials in Santa Cruz County, the City of Santa Cruz and Watsonville described early rebuilding efforts and problems as participants visited their jurisdictions.

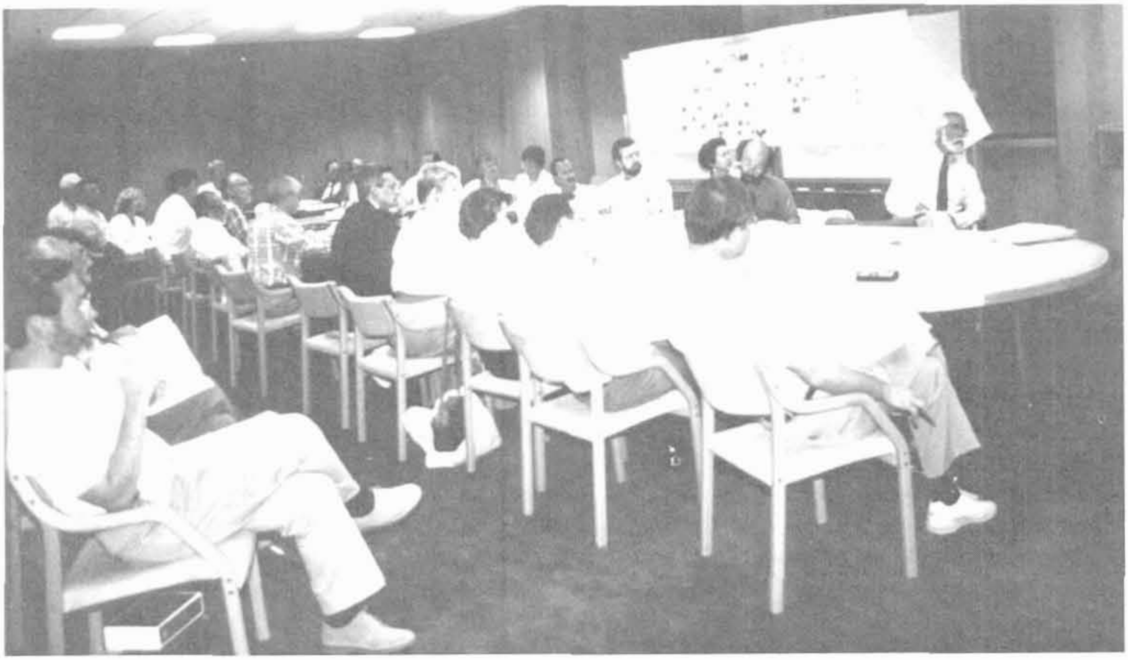


Figure 1.1. Symposium participants around conference table.

In order to foster informal give-and-take among participants, the steering committee agreed to limit attendance at the symposium to 40 people – the number that would fit around a large conference table. This meant that only senior planners from large urban jurisdictions were invited. A few researchers and federal and state government officials were also invited to provide a broader perspective to the discussions. Several served as "observers," tracking the discussions from a particular point-of-view and contributing to a summary of observations at the end of the symposium. *Figure 1.1.* shows symposium participants gathered around the table listening to a presentation.

The most remarkable thing about the symposium was the enthusiastic participation of planning directors from around the country in a three-day meeting devoted entirely to the subject of rebuilding after earthquakes. Symposium host, Tom Tobin, pointed out in his concluding comments that attendance at this three-day symposium exceeded total attendance at two sessions on earthquake hazard reduction and rebuilding after earthquakes at a statewide American Planning Association (APA) conference in San Jose in 1989. The symposium was truly a "first".

Participating California planners were from the cities of Coalinga, Los Angeles, Oakland, San Jose, Santa Cruz, Watsonville and Whittier and the counties of Santa Clara and Santa Cruz. Planners also came from Anchorage, Alaska; Charleston, South Carolina; King County, Washington; Little Rock, Arkansas; Memphis, Tennessee; Portland, Oregon; St. Louis, Missouri; and Salt Lake County, Utah. They came, lived in spartan student quarters, and spent three solid days at meetings, social events or in one-on-one conversations with the foreign presenters and U.S. earthquake experts. Most of the planners from outside California had never experienced an earthquake and few had any previous exposure to seismic safety planning. We believe the symposium successfully created a rich learning environment based on the personal sharing of planners' real-life experiences in planning for rebuilding after earthquakes.

We hope this report gives you an opportunity to share in this event. It is not a proceedings in the true sense, but an edited account of the main content of the symposium. And it is not organized in the same order as the program. You will find the lessons we distilled from the symposium at the beginning of the report in Chapter 2. Then, Chapter 3 summarizes the presentations on rebuilding after foreign earthquakes and Chapter 4 presents information from the field trip and luncheon talks on California earthquakes. Finally, Chapter 5 gives conclusions about the timing of rebuilding after earthquakes drawn from the timeline created by participants during the symposium. Copies of the symposium program and list of participants are included as appendices.

Chapter 2

Lessons for Planners

These lessons are drawn from the entire symposium – presentations, field trip, discussions and concluding comments by observers. We reviewed the entire record for lessons relevant to U.S. planners. To some extent, this means the California experiences are weighed more heavily than the foreign ones.

We tend to assume U.S. earthquakes will occur in California which is reasonably well-prepared to withstand a major earthquake without overwhelming losses, such as those experienced in Armenia. It is not at all clear how eastern and midwestern cities in the United States would fare in a major earthquake. The foreign experiences may be more relevant for planners in these parts of the country with huge numbers of earthquake-vulnerable buildings.

Earthquakes as well as communities are unique. This makes it difficult to generalize about the experiences. The most important lessons from each earthquake may arise from circumstances that will never or rarely occur again. In a very real sense, we tend to stay one earthquake behind in our preparations. The problems faced in rebuilding from the last earthquake are the ones we try to anticipate and avert in the next one.

Yet, common themes run through the accounts of rebuilding experiences. If damage is extensive, planners are prone to talk of relocating the entire city or town. While this rarely happens, other opportunities to create a safer and improved urban environment are usually present. Most communities confront a need to provide new housing, restore business activity, and repair or rebuild public facilities. These needs must be met more quickly than would be possible under normal planning and administrative procedures.

Thus, planners need to learn about new subjects or old subjects in new contexts and devise new ways to plan and make development decisions. After an earthquake, planners acquire new tasks, and old tasks acquire a new urgency. Many of the difficulties faced after an earthquake can be eased by preparing ahead for some of the tasks.

The following sections summarize the lessons extracted from the symposium on ***physical rebuilding, planning for rebuilding,*** and ***pre-earthquake steps to prepare for rebuilding.***

Physical Rebuilding

The shape and appearance of the rebuilt city concerns everybody. Exciting visions of a newly designed city compete with strong desires to restore the city exactly as it was before disaster struck. New building is necessary to provide lost housing, commercial and industrial space and public facilities. Accommodating the new building into the existing urban fabric is one challenge of planning for post-earthquake rebuilding. Each rebuilt city embodies a unique solution to this challenge. The following sections summarize observations from the symposium on **urban form and design, housing, business,** and **public facilities.**

Urban Form and Design

Cities and towns are almost never relocated. Planners are apt to look at a damaged, debris-ridden city and say, "Let's leave all this and start all over at a safer site." The idea of starting from scratch with a chance to "do it right" is inherently appealing to planners. However, experience teaches that relocation almost never happens for several reasons:

1) safer sites are hard to find nearby,

2) substantial infrastructure is still intact or repairable,

3) the cost to relocate is usually higher than the cost to rebuild, and

4) people have strong associations with "place" even in economic systems without private land ownership.

Attachments to family, friends, neighbors and work are stronger to most people than imagined benefits of relocating. The wise planner recognizes the durability of the existing city and looks for more realistic opportunities for post-earthquake improvements at the original site.

The rebuilt city is a safer city. Earthquakes remove hazardous buildings, and replacements built to modern building codes will be safer. If appropriate standards for repairs are adopted, seriously damaged buildings will be strengthened as they are being repaired. Changes in the land use pattern can also contribute to seismic safety. Reductions in densities can reduce vulnerability, and open spaces can be identified as safe gathering places for people after an earthquake. Emergency operations and debris removal are easier with wide streets and no culs-de-sac. Such changes may be possible after an earthquake.

Earthquakes offer opportunities for specific urban redesign projects. The alert planner will find a number of opportunities to correct pre-earthquake urban design problems. Perhaps traffic bottlenecks can be removed, architectural compatibility improved, nonconforming land uses eliminated, landscaping added or outmoded facilities modernized. Chances for urban redesign are most likely in old downtowns needing revitalization. An earthquake starts the clearance phase of traditional urban redevelopment. Well-designed rebuilding can reverse deterioration and economic decline, bringing new vitality to old areas.

Neighborhood preservation can aid personal and community recovery. An earthquake is a profoundly unsettling experience leaving many people unwilling to accept more changes and uncertainty in their lives. They will usually fight to preserve the network of personal and business associations and structures that comprise a neighborhood. Planners need to understand the heightened power of neighborhood ties after an earthquake and plan for minimum disruption consistent with seismic safety.

Preserving historic and symbolic buildings helps retain community identity. Earthquakes are hard on historic buildings. The value to the community of those which survive is usually enhanced. The clash of values can be very strong in deciding the fate of historic or symbolic structures. Controversial issues include demolition, standards for repair, extent of preservation, and the effect of retrofit projects on historical building elements.

Design is everybody's business. Design details seem to become important to everyone after an earthquake. All rebuilding requires some blending of new buildings with old, and decisions affecting how the new urban environment will look. It is worthwhile to take time to reach public consensus on major urban design issues, before options are lost by reconstruction.

Defining urban expansion areas helps. After an earthquake, planners usually have the information to plan for urban expansion avoiding clearly unsafe ground. By quickly defining such areas, planners can speed up the relocation of people and businesses from heavily damaged areas which may be a long time in rebuilding. However, regional planning that goes beyond the needs raised by the earthquake may accomplish little and needlessly slow reconstruction of damaged areas.

Housing

Temporary housing sites often become permanent. In U.S. disasters, most people move from emergency shelters to temporary housing of their own choosing, often doubling up with relatives or friends. When needed, "vouchers" are issued to help displaced people pay for accommodations in vacant housing and hotel and motel rooms for a period of time. After that they are on their own to find permanent housing. Sometimes, the Federal Emergency Management Agency (FEMA) brings in trailers to temporarily house earthquake victims. Even if the actual trailers are returned as required by FEMA, land which accommodated them may continue to be used for mobile homes. Such sites need to be carefully chosen with an eye to future uses. Foreign experiences testify to the long-term nature of temporary housing.

Earthquakes aggravate existing housing problems. Many communities across the nation do not have enough affordable housing. The gap will be wider after an earthquake. Because low-cost housing tends to be concentrated in older buildings and sections of town, it is often disproportionately damaged in an earthquake. People displaced by the earthquake may not be able to afford rents in repaired or rebuilt buildings, further increasing the need for affordable housing.

Most damaged houses can be quickly repaired. Damage to the typical wood-frame single family house is usually non-structural, such as fallen chimneys and broken windows. This kind of damage can be repaired quickly and houses reoccupied. The challenge for planners is to identify areas where repairs can move ahead without engineering evaluations and establish streamlined procedures to issue building permits. Quick repairs can alleviate some of the need for temporary housing.

Business

Economic conditions before an earthquake shape recovery. Thriving communities tend to recover and rebuild quickly, while stagnating communities may never fully recover. Land ownership is also a critical factor. Property owners resist changes they think will reduce the value of their property or the profitability of businesses. They make critical investment decisions which can govern the nature and pace of rebuilding.

Earthquakes affect businesses differently. Earthquakes create economic winners and losers. Winners are businesses involved in rebuilding and can include planners, architects, engineers, construction companies, and building materials suppliers. Losers are often marginal local businesses that cannot bear the costs of lost inventory, higher rent, relocation and lost business. Businesses that are part of chains or large corporations can usually bear the costs of temporary dislocation, repair and rebuilding more readily than local businesses.

Business activity usually recovers before business districts. Gains from rebuilding often restore the pre-earthquake level of business activity long before the lost commercial buildings or districts are rebuilt. Sales tax revenues, an important measure of commercial activity, often return quickly to pre-earthquake levels.

Rebuilt business districts usually contain new businesses. Earthquake damage is often heavy in old parts of a community with marginal businesses least able to bear the costs. These areas tend to be rebuilt last. Viable businesses located in these districts may relocate permanently to other cities or outlying areas of a damaged city. Rents of repaired and rebuilt commercial space are often too high for pre-earthquake tenants which usually means that new businesses occupy the central district after it is rebuilt.

Rebuilding may strengthen local business. Rebuilt commercial areas can be more successful than before the earthquake. Marginal businesses usually do not survive the earthquake and subsequent rebuilding process, and they may be succeeded by healthier businesses. Buildings and interiors are often modernized and improved as damage is repaired. Rebuilding may solve district-wide design problems, such as circulation and parking, leading to overall improvement in the business climate.

Public Facilities

Essential lifelines and services are usually restored very quickly. Getting the transportation, communication and utility systems into operation after an earthquake is a high priority. This is usually accomplished with little involvement of city planners except where controversial safety or public policy issues arise, as in deciding whether to tear down or repair the Embarcadero Freeway in San Francisco after the Loma Prieta earthquake.

Critical facilities are quickly repaired or replaced. Facilities needed for emergency response, such as hospitals and fire stations get immediate attention after an earthquake. If the facilities are repaired, all identified safety problems should be corrected in the process. With both repair and rebuilding, there may be opportunities to modernize and improve the functioning of these critical facilities.

Temporary space may be needed for public services. The resumption of regular school and community activities after an earthquake is very important to help families resume normal life. Agencies may need to relocate or provide services from trailers or other temporary structures.

Planning for Rebuilding

Rarely do existing plans provide sufficient guidance for rebuilding earthquake damaged areas. An earthquake changes the planning slate and provides new opportunities which can only be captured through a deliberate planning effort. Although the resulting plans will differ from each other, the planning process used to prepare them seems to have common elements which distinguish planning after earthquakes from conventional planning. The following sections summarize observations from the symposium about the **nature of the process, planning during early recovery, information for planning for rebuilding, organization for planning, timing, and funding.**

Nature of the Process

Planning for rebuilding is a high-speed version of normal planning. Recovery and rebuilding is delayed unless basic land use questions can be resolved quite quickly. This entails streamlining decisionmaking procedures while at the same time safeguarding public participation. It also requires phasing decisions so that planning and rebuilding proceed in tandem.

Planning for rebuilding is dynamic. People begin making repairs and plans to rebuild almost as soon as the ground stops shaking. Nobody wants to wait for land use plans to be revised and new regulations adopted before starting reconstruction. Thus, effective reconstruction planning is a cyclical process, starting with existing and general information to quickly identify areas where repairs and rebuilding can proceed with no further planning. Then detailed studies are done to determine how to rebuild problematic areas – usually those which suffered ground failure, concentrated damage or multiple hazards.

Most repairs can proceed without waiting for plans. As soon as possible, planners need to determine areas of the community that can be rebuilt under existing plans and regulations and provide for rapid processing of permits for repairs and rebuilding in these areas. In the other more problematic areas, clear procedures and time schedules for planning, making decisions, and getting needed geologic and structural engineering information are needed.

Planning for rebuilding is like redevelopment planning. It requires deciding which buildings to keep and which to demolish, designing and financing public improvements, and negotiating with property owners to build according to the plan. In California, redevelopment powers with tax increment financing have been used in rebuilding after every significant earthquake in the last two decades. Redevelopment is particularly useful in rebuilding damaged downtowns.

Planning for rebuilding is sharply focused. After an earthquake is the time for specific plans; not for regional plans. Ideally, regional planning should be done before the earthquake. Planners need to identify immediately specific opportunities for land use changes to improve the community or increase safety and focus planning efforts on these few areas. Good candidates for attention are areas with ground failure, concentrated damage, and multiple hazards. Objectives other than rebuilding can be achieved, if they are directly relevant to repairing the damage.

Planning for rebuilding is realistic. After earthquakes, false expectations are easily raised by unrealistic planning schemes. Comprehensive evaluation of funding sources and economic studies are essential plan components. Disaster assistance funds are available after an earthquake, but they are rarely sufficient to meet all community needs, let alone desires.

Planning for rebuilding is based on pre-earthquake planning. This is not the time to start over. Even with extreme damage, most rebuilding will be guided by existing plans and regulations. An earthquake provides a good test of a planning system. Up-to-date, realistic and carefully-conceived plans and regulations can reduce the number of land use decisions to be made in the high-pressure, post-earthquake period.

Planning for rebuilding is a local function. Although federal, state, and regional organizations may be involved, the context for planning is local and the key planning interactions are with local staff, decisionmakers, earthquake victims, property owners, employees and residents.

Planning During Early Recovery

Planners' tasks begin immediately after an earthquake. Although the main planning effort often does not start until several weeks after an earthquake, planners can contribute to early recovery in several ways. Planners know land uses and occupancy – valuable information to guide search and rescue. Also, they are trained to place the crisis in a context, and thus, able to help others in local government anticipate needs and next steps. Planners may be assigned to coordinate with FEMA and other state and federal agencies providing assistance for rebuilding. Planners may help estimate damages and identify temporary sites for housing, businesses, and public facilities.

Demolition and clearance set the stage for planning to rebuild. The earthquake plus decisions to demolish create the canvas for rebuilding. Local governments make the early decisions to demolish based on engineering evaluations of safety. Later, property owners may request demolition permits, judging that rebuilding will be less expensive or result in a better building than repairing. Decisions about demolition are often controversial, particularly if historic or symbolic buildings are at stake.

Information for Planning for Rebuilding

Accurate damage assessments are essential. The initial information about the pattern and severity of damage helps define the areas needing planning attention. A second phase of damage assessment determines the causes of damage through geologic and seismic studies and structural engineering evaluations. As this information becomes available, planning tasks can be more precisely defined.

Geologic studies are essential. Unlike planning after other disasters, post-earthquake planning requires geologic information. Geologic studies are needed to delineate areas where ground failure occurred. These areas need special evaluation so that repaired or rebuilt structures can be designed to withstand the hazard or relocated to new and safer sites.

Engineering information is needed. Most earthquake damage is caused by ground shaking and is best averted by properly designing structures. Structural engineers are needed to evaluate building damage, establish standards for repairs and rebuilding, and design strengthening projects. Structural engineering evaluations determine which buildings can be saved and which must come down.

Earthquake vulnerability studies are helpful. Areas undamaged in one earthquake may be particularly vulnerable to damage from a different earthquake. After an earthquake, it is often possible to get support for a general evaluation of earthquake vulnerability. Such studies can identify hazards beyond those revealed by the particular earthquake. They contain evaluations and maps of potential natural hazards including areas of enhanced ground shaking, fault rupture, landslides, rockfalls and liquefaction. The hazard evaluation is combined with information about buildings, infrastructure and lifelines to identify areas susceptible to heavy damage. Such studies pinpoint possible future problems and allow planners to anticipate reconstruction needs before an earthquake strikes.

Organization for Planning

Planning after an earthquake usually requires special organization. After an earthquake, the existing organization and procedures for planning and managing development are usually too cumbersome to handle quickly the large volume of work generated by rebuilding. Immediately after a damaging earthquake, emergency powers are usually granted to existing agencies to expedite decisions. But special needs remain long after the emergency period, and most jurisdictions find that some new organization is needed to plan and manage rebuilding.

Organization for planning may take many forms. The organization may be entirely new or an existing organization with newly assigned powers and responsibilities. An existing or newly-formed redevelopment agency often directs rebuilding after an earthquake. Other communities have used ad hoc reconstruction commissions, public-private partnerships, and committees to oversee rebuilding. Most organizations encompass both staff work and a process for decisionmaking. Staff assigned to the organization, whether new or reassigned from other positions, need relief from other duties to devote full-time to the tasks at hand.

The best organization for planning is streamlined and accountable. Whatever the form of organization, it usually operates under procedures to make decisions more quickly than normal. To do this, the organization needs well-defined authority and a clear structure for making decisions. Responsibility for both staff work and policy decisions must be specific so that the organization can be held appropriately accountable for its actions.

An effective organization provides for public participation. Public participation is an essential ingredient of successful planning under normal circumstances. After an earthquake, when people are suffering from a strong sense of powerlessness, it is even more important. Business owners, employees, homeowners and tenants all have a direct stake in rebuilding and a need to be involved in decisions about rebuilding. Public participation takes time, but increases the chances that plans will be carried out.

Speed in planning at the expense of public participation can result in delays in rebuilding if opposition to projects develops.

The organization needs to coordinate with other public agencies. An important function of an organization for rebuilding is coordinating the efforts of other public agencies operating within the jurisdiction. It also has a major role in interacting with regional, state and federal agencies with programs, funds or requirements affecting rebuilding. Dealing with FEMA is a critical task demanding knowledge of its programs, funding criteria, and accounting procedures.

Timing

Taking time to plan may delay rebuilding. Planning takes time. After an earthquake, victims pressure to rebuild quickly; they rarely want to wait for plans to be completed. This often puts planners in a very difficult position. They are challenged to streamline approval procedures and administer regulations flexibly to encourage quick rebuilding. On the other hand, they are the ones recommending delays in rebuilding in specific areas to allow time for planning. Balancing the two needs is a critical task planners face after an earthquake.

Planning and rebuilding can occur simultaneously. The timeline *(Chapter 5)* shows that much rebuilding takes place before master plans are completed. This suggests that planning and rebuilding occur together. As noted above, it is reasonable to repair and rebuild most damaged areas without replanning or redesign. Repairs and rebuilding can proceed in these areas while planning for specific problem areas is going forward. Even within the areas being replanned, rebuilding that does not preclude options under consideration can be permitted before planning is completed.

Funding

Government funding is not enough. Public investment alone is not sufficient to bring about recovery. The economy of the damaged area must be strong enough to attract significant private investment for full recovery to occur.

Aid can inhibit recovery efforts. Generous government funding does not by itself guarantee effective rebuilding. The anticipation of government aid can undermine necessary private efforts to rebuild.

Ideally, a rebuilding plan guides public and private investments. This does not always happen. For example, private investors and property owners may feel the plan's assessment of the economic potential of the damaged area is too optimistic and decide not to rebuild. Public investments may not follow the plan. In the United States, FEMA funds the repair and rebuilding of public facilities, but funding criteria emphasize replacing what was there before the earthquake, not making improvements, even for future safety. Thus, public funds are available for some projects, but not for others.

Rebuilding costs can be reduced by reusing materials. After an earthquake, it is important to clear debris very quickly to gain access to damaged areas. But by moving too quickly, reusable building materials are not retrieved. Reusing original materials encourages restoring historic features and architectural character to rebuilt areas.

Pre-Earthquake Steps to Prepare for Rebuilding

Planners can take a variety of actions to lighten the burdens of rebuilding after earthquakes. By far the most important action is to implement programs to avert damage in earthquakes. Less damage means less to repair and rebuild. Reducing earthquake damage was not a symposium subject, although participants recognized its importance, and it is not discussed in this report. Several other publications are available to help planners and other local government officials develop and implement earthquake hazard reduction programs.* The following sections, on **plans and ordinances, redevelopment, information, standards for rebuilding, housing, procedures,** and **staff training,** list some actions that planners can initiate before an earthquake, not necessarily to reduce damage, but to ease planning for rebuilding the inevitable damaged areas.

*Two available publications are:

California At Risk, Steps to Earthquake Safety for Local Government is available for $10.00, including postage and handling, from the California Seismic Safety Commission, 1900 K Street, #100, Sacramento, CA 95814.

Putting Seismic Safety Policies to Work, published by the Bay Area Regional Earthquake Preparedness Project, is available for $10.75, including postage and handling, from the Association of Bay Area Governments, P.O. Box 2050, Oakland, CA 94604-2050.

Plans and Ordinances

Have a clear and up-to-date general plan. Good normal planning practices including an up-to-date, clear general plan are great helps after an earthquake. The plan should be simple yet comprehensive, flexible yet specific; visionary yet realistic. It should be based on solid information including an assessment of geologic and seismic hazards. Most important, it should express a public consensus about where the community is going. Such a plan, with perhaps minor amendments, will be effective in guiding rebuilding and reduce the need for generating new plans after an earthquake.

Be sure plans and regulations are consistent. Together the plans and development regulations, such as zoning and subdivision ordinances, need to form a coherent system to guide building and, after the earthquake, rebuilding. Confusion over inconsistencies can cause needless delays and general frustration during post-earthquake rebuilding.

Take particular care in approving land subdivisions. Once land is divided and lots sold, it is very difficult to prevent building or rebuilding on a lot no matter how unsafe it may prove to be. It is important to remember that the subdivider originally agreeing to accept the risk is usually not the person exposed when disaster strikes.

Carefully regulate new development. It is easier to regulate new development to prevent unsafe location of buildings than to prevent the repair or replacement of existing buildings. A good planning job before an earthquake can avert the most difficult problems afterwards.

Participate in regional planning. Damaging earthquakes affect entire regions and, although the major tasks of planning for rebuilding fall to local governments, regional plans are important in many ways including designating safe urban expansion areas, designating safe and redundant transportation and utility systems, and identifying rubble disposal sites.

Redevelopment

Create the authority and plans for redevelopment. Redevelopment powers, plans and financing mechanisms are useful tools for rebuilding after earthquakes, particularly in heavily damaged, older downtowns. All the California cities discussed during the symposium used redevelopment powers to help plan and finance rebuilding. Even if redevelopment areas need to be expanded or new ones added after the earthquake, it is very helpful to have the basic authority in place. Redevelopment with tax increment financing is useful for funding public investments in areas to be rebuilt.

Information

Create and maintain a data base. After an earthquake, detailed information and maps are needed to describe and locate land uses, buildings, occupancies and other factors affecting earthquake vulnerability. Parcel maps and building data are essential aids in assessing damage and in identifying options for rebuilding. Increasingly such information is on computer and may be combined with hazards data and other information allowing rapid tailoring to meet particular needs after an earthquake.

Identify and evaluate geologic and seismic hazards. Where earthquakes are a possibility, planners need maps, at the largest possible scale, of fault zones, lands susceptible to landsliding, liquefaction, or other forms of ground failure, and areas which may experience enhanced ground shaking. These provide the basis for regulating land use and reducing hazards in developed areas before an earthquake and are a necessary starting point for post-earthquake hazards assessments.

Identify and evaluate hazardous structures. Obtaining this information is the first step in reducing risks in such structures before an earthquake. Afterward, information about the location of potentially hazardous buildings can guide initial search and rescue efforts. It also simplifies post-earthquake damage assessments and demolition decisions by detailing pre-earthquake building conditions.

Identify particularly vulnerable areas. These might include areas with concentrations of unreinforced masonry buildings, areas where toxic materials are stored, or lands below dams. Areas such as these can be the targets of hazard reduction measures before an earthquake and may be areas needing planning for rebuilding after an earthquake. Knowing this in advance gives planners an opportunity to think through some rebuilding options before the earthquake.

Standards for Rebuilding

Establish appropriate standards for repairs and rebuilding. Planners can ask structural engineers and building officials to recommend up-to-date building standards appropriate for the level of risk facing the community and the importance of structures. Applying such standards before the earthquake can dramatically reduce damages; after the earthquake they are essential. It is difficult to delay repairs and rebuilding while standards are being developed. Particularly needed are standards for repair of earthquake damaged buildings.

Housing

Designate temporary housing sites. Sites used for temporary housing after an earthquake will have been outfitted with utilities and infrastructure and are likely to continue to be used for housing. Selecting sites before an earthquake can avoid planning mistakes and speed the rehousing of displaced families.

Plan for adequate affordable housing. Displaced low-income tenants have the greatest difficulty finding permanent housing after an earthquake. Communities with adequate stocks of affordable housing are in a good position to assist. Experience with relocation assistance, rent subsidies and other state and federal housing programs also helps local governments deal with people displaced by earthquakes.

Procedures

Establish an organization to plan for rebuilding. Post-earthquake coordination can be greatly improved by establishing beforehand a single organization representing all pertinent local government agencies to plan for rebuilding. Within this organization, responsibilities for planning and related rebuilding tasks can be preassigned to the appropriate staff positions.

Prepare and adopt emergency ordinances. Emergency ordinances, ready before the earthquake, are essential to establish the framework for planning and rebuilding. They establish emergency powers and how they are to be used. Much confusion can be avoided if responsibilities and the process for making planning decisions after an earthquake are clearly defined beforehand.

Plan how to process building plans and permits. After an earthquake, planning and building departments are overloaded with applications for repairs and rebuilding. Normal procedures for plan checks and issuing building permits can significantly delay recovery. Streamlined procedures, developed before the earthquake, can be quickly applied afterward.

Staff Training

Prepare your staff for earthquakes. Like emergency responders, planners need training to prepare them for their roles after an earthquake. A first step is to construct scenarios of likely earthquake impacts, and then, learning from the experiences of cities that have gone through earthquakes, define needs and options for responding.

Learn the federal and state disaster assistance programs. Much confusion and controversy can be avoided if staff is informed and up-to-date about disaster assistance programs. To help your jurisdiction take advantage of the assistance available, it is important to know how to qualify and the requirements for record keeping.

Chapter 3

Presentations on Foreign Earthquakes

The following accounts are taken from presentations on foreign earthquakes made by people who participated in planning for rebuilding. They are accounts of rebuilding from the perspective of the presenter; they do not give definitive or comprehensive views of all facets of planning and rebuilding after the particular earthquake. More complete and technical descriptions of all the earthquakes are available in other publications, and good accounts of rebuilding are available for some.

In some cases, we checked other sources to clarify particular points, but the basic content of the presentations has been preserved. We have tried to maintain the flavor of the individual presentations through the use of occasional direct quotes, photographs, and close adherence to the presenters' notes. The findings listed at the end of each account are the presenter's; however, in some cases, we have reworded or generalized to provide a more consistent format from section to section.

As at the symposium, the presentations are given chronologically according to the date of the earthquake. The accounts cover from 27 years to 2 years with each succeeding account spanning less time. The last account on the 1988 Armenian earthquake covers only the early stages of reconstruction.

All the presenters received a suggested outline to help them prepare their material. Each did an excellent job of following the outline. This helped greatly in comparing experiences. However, content varied enough from earthquake to earthquake to require some variations in summary formats.

We have given each rebuilding experience a theme, stated as part of the heading for each account. In most cases, other themes could apply equally well, but we selected the one that seemed to epitomize the experience from a planning perspective.

The symposium sessions were tape recorded, but most of the summaries were written from notes taken at the sessions. Four presenters furnished written copies of their full presentations and the other two provided detailed notes. All six reviewed and commented on drafts of the summaries.

The rebuilding accounts are illustrated with photographs. Excepts as noted in the captions, all the photographs are from slides used by the presenters in their presentations.

Each presentation offers new perspectives on the overall subject of rebuilding after earthquakes. Together they create a kaleidoscopic view of the myriad bits and pieces that make up the experience of rebuilding after an earthquake. Each experience is unique, with its own damage pattern, institutional context, and difficult decisions. Each also has something to teach us, as planners, about how to effectively navigate this incredibly complex time.

Skopje, Yugoslavia, 1963, An Earthquake as an Opportunity

Marjorie Greene, Project Planner with the Bay Area Regional Earthquake Preparedness Project, was in Skopje in 1983 and 1984 to study reconstruction as part of a National Science Foundation grant. She graciously and effectively told the Skopje story on short notice after Dr. Blagoje Kolev from Yugoslavia became ill and was unable to attend.

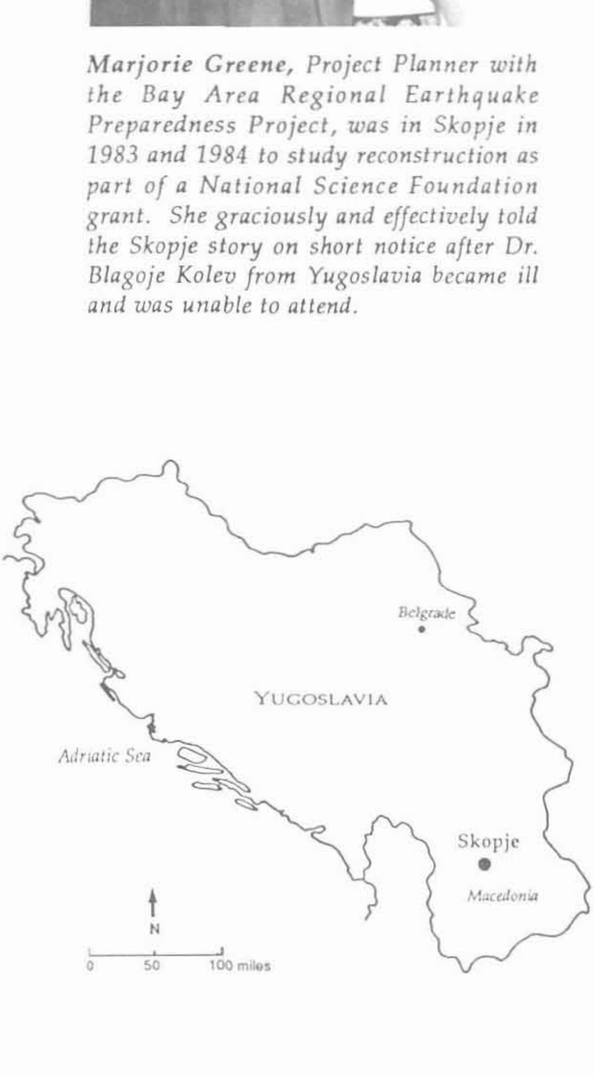


Figure 3.1.1. Map of Yugoslavia showing the location of Skopje.

Skopje Earthquake Data

Time: July 26, 1963, 5:17 a.m.
Magnitude: 6.1   Intensity: VIII 1/2
1,070 people killed, 3,700 injured, 150,000 homeless
Lost or seriously damaged:
25,000 buildings; 50% of total;
20,000 housing units; 75% of total
Minor damage to infrastructure
Factories lost labor force to rebuilding
Estimated total damage: $.5 to $1 billion – all from ground shaking

Setting and Earthquake

Skopje is the economic and government center of Macedonia, a republic in southern Yugoslavia. *Figure 3.1.1* shows the location of Skopje. It is home to six distinctive ethnic groups, each with its own religious tradition, leading to an often tumultuous history. As typical of communist countries, land was owned by the central government. Worker enterprises and cities could buy land at market value, and individuals could own and sell houses, but not the land.

At the time of the earthquake, Skopje had 200,000 people; by 1990, the population had more than tripled to 650,000, making Skopje the country's third largest city. This rapid growth, based partly on an evolving tourist industry, was spurred by reconstruction after the 1963 earthquake, and has led to sprawl, air pollution, and traffic congestion.

A magnitude 6.1 earthquake struck early in the morning on July 26, 1963. Although a moderate earthquake, the epicenter was close to the city with a shallow focus, and the earthquake proved to be very damaging. Small structures and buildings on alluvial soils were particularly damaged. Prior to the earthquake, Skopje applied a 1948 building code which had lateral force provisions, but these were commonly ignored in local practice. Many buildings were constructed of masonry with inadequate reinforcement.

In the earthquake, Skopje lost 75 percent of its housing units and many of its public buildings (*see Figure 3.1.2*). As a government center, the city had 395

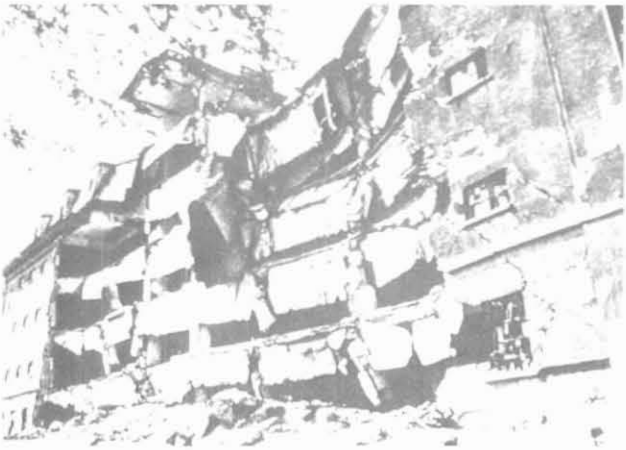


Figure 3.1.2. Crumbled apartment building.

government and administrative buildings of which 282 were destroyed or heavily damaged. Factories generally survived, but had difficulty maintaining production because they lost their workers to the tasks of rebuilding. In total, about half of the city's buildings were lost or seriously damaged. Damage estimates ranged from $.5 to $1 billion (1963 dollars).

Early Recovery

Women and children were evacuated to other provinces for six months while the men stayed to start repairs. About 30,000 local men worked on repairs, joined by 30,000 workers from other provinces *(see Figure 3.1.3).*

Damage assessment was an early task, leading to difficult decisions about what buildings to demolish. The larger buildings in the city were tagged red, yellow and green depending on their damage status. The initial evaluation was conservative and was modified in April 1964, removing some buildings from the higher risk categories. Some unnecessary demolition may have occurred under the initial designations.

The Skopje earthquake occurred at a time of east-west detente and aid flowed into Yugoslavia from all over the world. East and west block nations vied with each other to give the most assistance. The United Nations offered assistance a few days after earthquake and several programs evolved from this. President Tito saw the rebuilding as an opportunity to build a model socialist city, "to build, with world help, a more beautiful and joyful Skopje as a symbol of the fraternity and equality of the Yugoslav people. . ."

Figure 3.1.3. Repairs underway.

Planning and Rebuilding

Skopje had a master plan written in 1948 and revised in 1962. It was not useful for rebuilding because it was based on gradual change from the status quo. The federal government initially talked about relocating the city, but the idea was rejected because early geologic studies completed in October 1963 found no convincing reason to do so, particularly if flooding from the Vardar River were controlled. The government decided to rebuild at the original site in phases starting with housing and later rebuilding the city center.

An earthquake engineering institute was established in 1965 and a seismic zonation project undertaken to guide rebuilding. Development of the hillsides and floodplain of the Vardar River was limited as a result of the seismic zonation studies, and soils information was used in siting new structures.

The rebuilding of the city was partly financed by a special tax imposed from 1965 to 1970 on everyone in Yugoslavia outside of Macedonia. Macedonia and Skopje also contributed. The United Nations provided technical assistance and funding specifically for preparing reconstruction plans.

Housing Reconstruction

Tent settlements provided emergency shelter for large numbers of homeless people *(see Figure 3.1.4)*. To encourage people to repair rather than abandon buildings, the president of the Town Assembly authorized minor repairs to houses and small businesses without permits. About 16,000 apartments were repaired right away.

Figure 3.1.4. Emergency shelter in tents in front of mosque.

Countries from around the world donated prefab housing, some building entire neighborhoods to rehouse displaced people. This housing, intended as temporary is still in use today, and, in fact, where it is well-designed, it is the preferred housing of privileged families. The prefab houses were placed in less earthquake vulnerable, low-density housing tracts spreading out from the central city *(see Figure 3.1.5)*. Americans donated quonset huts which were used as schools and as homes for extended gypsy families *(see Figure 3.1.6)*.

Figure 3.1.5. Temporary housing tract outside Skopje.

For two years after the earthquake, the top priority was restoring housing and the plans called for building 14,000 units in the first year. Each republic in Yugoslavia was given the goal of financing and building a subdivision for 15,000 people in Skopje. Much of the new housing was provided in "block-style" multistory apartments – a new kind of housing for the region. Densities were kept quite low to reduce the earthquake risk. Residents paid rent for the new housing for 15 years after which they had the right to purchase it from the government. They did not have to prove that they lost their homes to qualify for the housing.

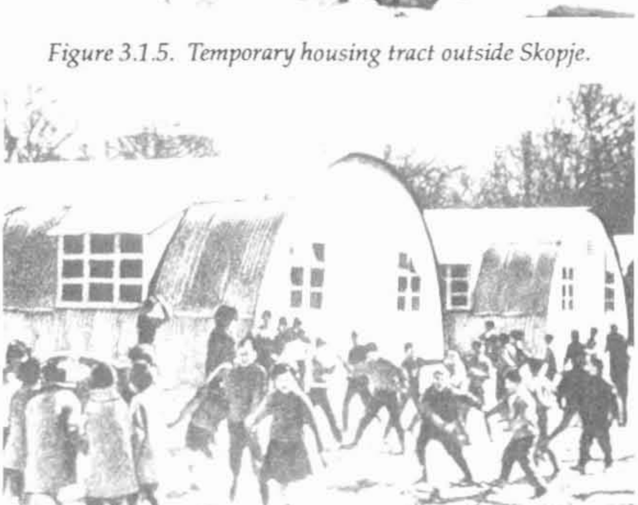


Figure 3.1.6. American-donated quonset hut used as a school.

Vardar River

The Vardar River runs right through the center of Skopje. In 1962 it flooded causing much damage. Some thought the flooding had weakened building foundations, exacerbating the earthquake damage. Soon after the earthquake, the United Nations started a flood control project on the

Figure 3.1.7. Park along Vardar River.

river. As part of this project, a park was created on lands along the river most susceptible to flooding *(see Figure 3.1.7)*.

Planning a New City Center

After about two years, the focus of rebuilding shifted to the city center. The UN brought in a team headed by Adolf Ciborowski to create a master plan. Part of the process was an international design competition won by a Japanese firm (Kenzo Tange). Among the features of the winning plan was using housing blocks to form a city wall. The plan also called for wide boulevards and a large central plaza, partly to reduce earthquake risk *(see Figure 3.1.8)*. Some of the ideas were used in rebuilding, but the only building actually designed by the firm was the new train station.

An attempt was made to create the city wall using housing blocks; however, the city grew more rapidly than expected and most of the city today is outside the wall. The damaged train station was left standing as a reminder of the earthquake *(see Figure 3.1.9)*. In spite of efforts to retain historic buildings and design new buildings for compatibility with old ones, designers had difficulty blending the new and old buildings and some of the new buildings appear out-of-scale.

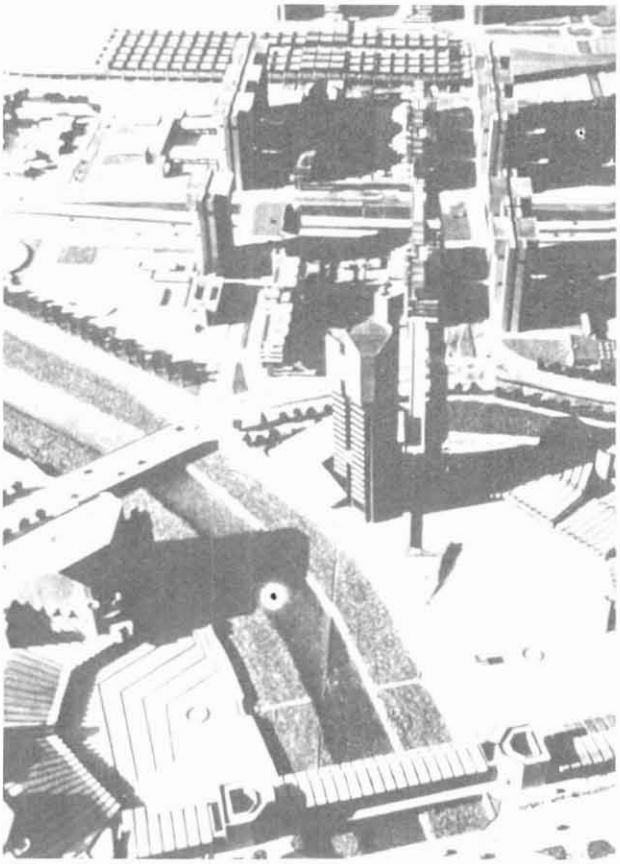


Figure 3.1.8. City Center plan showing Republic Square, City Gate and Central Railway Station.

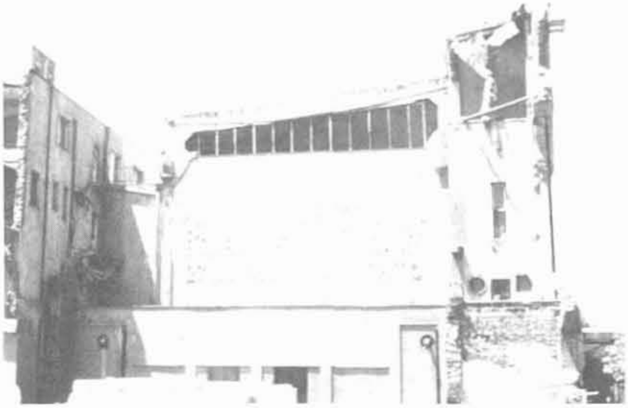


Figure 3.1.9. Damaged train station with memorial plaque left as a monument to the earthquake.

Figure 3.1.10. Building in historic area of Skopje, waiting to be rehabilitated and strengthened.

Historic Skopje

The older section of the city was not as badly damaged as the more modern city center, but the old buildings are vulnerable to damage in future earthquakes with different ground shaking characteristics. After the earthquake, the city drew up a renovation proposal for each shop in the historic area, but some shop owners did not have the money to carry out the renovations and some simply did not want to make the changes. Many buildings in this area are still potential earthquake hazards *(see Figure 3.1.10).*

Status of Rebuilding

Today, 28 years after the earthquake, the city is functioning normally, but some parts of the central district have not yet been rebuilt. The city finds it progressively more difficult to find funds for rebuilding projects as time passes since the earthquake. The rebuilt city is safer from both earthquakes and floods with buildings constructed to better standards, some completed renovation projects, wider streets and a riverside park. *Figure 3.1.11* shows part of the new city center.

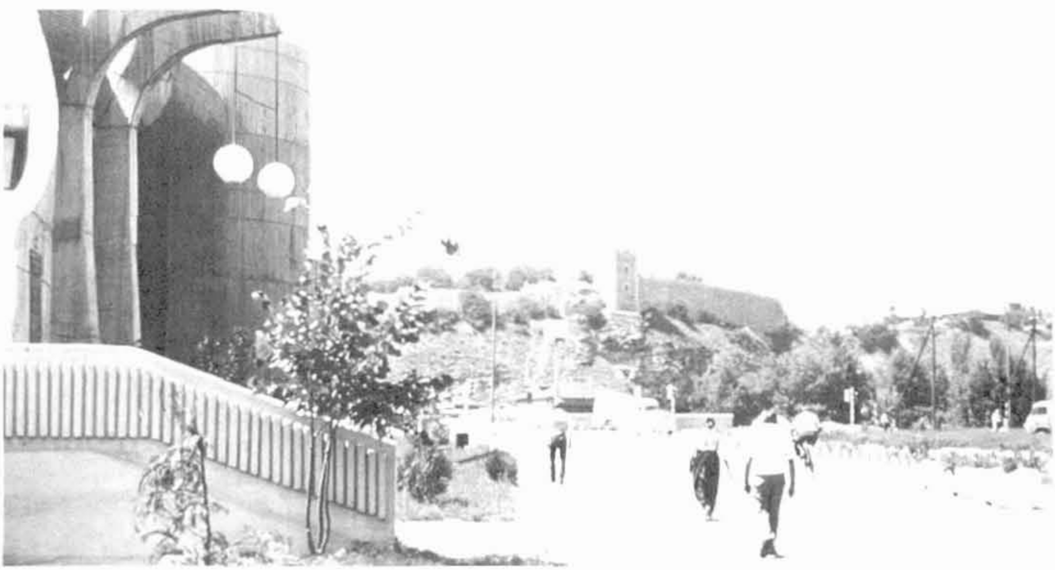


Figure 3.1.11. City center rebuilt with wide streets, open space and new train station on the left.

Skopje Rebuilding Timeline

1 week	*Debris removal begins*
2 weeks	*Women and children evacuated* *Infrastructure repairs start*
1 month	*Businesses start to reopen* *Infrastructure in operation*
4 months	*Most debris cleared before winter*
5 months	*Clearance completed* *14,000 housing units constructed*
7 months	*Industry/commerce back on line*
8 months	*UN General Plan started*
1 year	*Planning for public facilities begins*
2 years	*Most prefab subdivisions in place* *City Center planning begins*
4 years	*New master plan adopted*
5 years	*City wall constructed*
6 years	*University constructed*
25 years	*Reconstruction still not completed*

Findings

1. **Relocation.** Relocation of the city after the earthquake was considered, but rejected because other possible sites did not offer better seismic safety.

2. **Opportunities.** Rebuilding provided a tremendous opportunity to redesign and modernize the city.

3. **Urban growth.** Growth stimulated by the rebuilding activity has created sprawl and its associated problems of air pollution and traffic congestion; the city has grown way beyond its walls.

4. **Design.** Design of the city center illustrates a problem blending new buildings with old. This is a problem typical of rebuilding after earthquakes since earthquakes almost always leave some old buildings with which new ones must be blended.

5. **Hazardous buildings.** The relatively undamaged historic city may be particularly vulnerable to damage from a different kind of earthquake. Thorough soil investigations are required for new development in this area, but it remains difficult to get owners of existing buildings to reinforce them in spite of technical help.

6. **Temporary housing became permanent.** The housing, intended as temporary, is still in use today and, in fact, where it is well-designed, it is the preferred housing of privileged families. These homes were placed in less earthquake vulnerable, low-density housing tracts spreading out from the central city

7. **Mitigation during reconstruction.** Wide streets, open spaces and low densities were planned to reduce loss of life. Seismic zonation was used to prevent building on slopes and require soils investigations where potential problems were indicated.

8. **Central city.** The focus of planning was to create a design plan for the central district. Other aspects of rebuilding were decided without a formal plan or planning process.

Managua, Nicaragua, 1972, Integrated Planning – Incomplete Rebuilding

***Luis Ramirez Velarde** was planning advisor to the Nicaraguan Institute for Territorial Studies (INETER) for the past 11 years. He is a native Bolivian who, after the earthquake, went to Nicaragua as a regional planning adviser to the Vice Ministry of Urban Planning. For two and a half years, he assisted in planning for the reconstruction of Managua.*

Figure 3.2.1. Map of Nicaragua showing the location of Managua.

> ### *Managua Earthquake Data*
> *Time: December 23, 1972, 12:30 a.m*
> *Magnitude: 6.25 Intensity: IX*
> *10,000 people killed, 20,000 injured, 200,000+ homeless*
> *Lost or seriously damaged:*
> *53,000 housing units – 75% of total*
> *Industry – 25%; small factories and shops – 95%; business – 80%*
> *Heavy damage to schools, hospitals, other public facilities and infrastructure*
> *Estimated total damage: $845 million – from ground shaking and fire*

Setting and Earthquake

Nicaragua spans central America and, like the United States, has coastlines on both the Atlantic and Pacific oceans *(see Figure 3.2.1)*. The country is at the mercy of volcanos, hurricanes, floods and earthquakes. It is also at the mercy of an explosive political history. Most of Nicaragua's 3.5 million people are poor and over 60 percent live on 15 percent of the land.

Managua, the country's largest city, is on the Pacific side of the country along the shores of Lake Managua. The population of Managua was 450,000 in 1972; now it is 788,000. Population, government, industry and commerce in the country were, and are, concentrated in Managua. The city was damaged in 1870 and 1931 by earthquakes. After 1931, adobe construction was discontinued in favor of buildings with wood frames filled with mud ("Taquezal" construction). These fared poorly in the 1972 earthquake.

The December 23, 1972 earthquake measured 6.25 on the Richter scale. Ten thousand people lost their lives and 20,000 were injured. Ten city blocks burned to the ground. Twenty-seven of Managua's 33 square kilometers were seriously damaged and the 13 square kilometer central district was destroyed. Gone were 75 percent of the city's housing stock, 72 percent of the schoolrooms, 11 large factories and almost all of the the small factories and commercial buildings. Public facilities, including all four hospitals, and utility services were lost. Total damage was estimated at $845 million (1972 dollars). The earthquake ravaged the heart of the nation *(see Figures 3.2.2)*.

Figure 3.2.2. Earthquake destruction in central Managua.

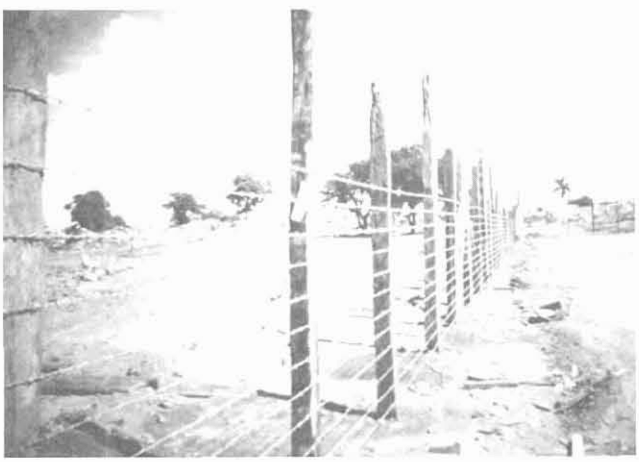


Figure 3.2.3. Cordoned-off area.

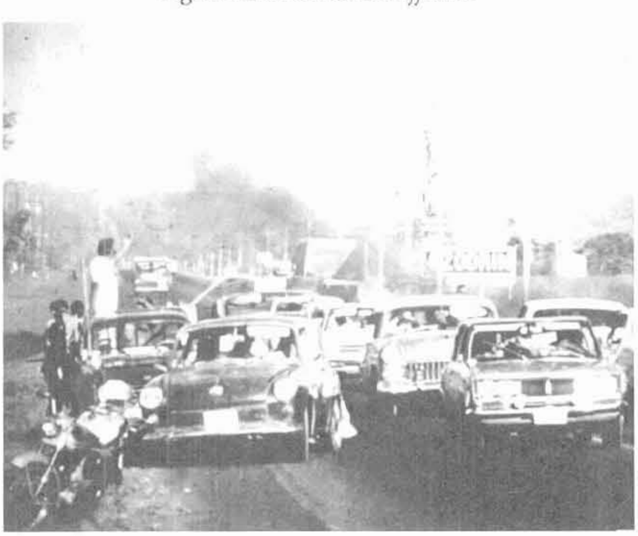


Figure 3.2.4. People evacuating the city.

Early Recovery

At the time of the earthquake, the Somoza dynasty had been in power in Nicaragua for almost 50 years. Anastasio Somoza, Supreme Chief of the Armed Forces, appointed himself president of the National Emergency Committee and personally directed recovery and rebuilding. With international assistance, he established refugee camps, and began damage assessments within days of the earthquake. Most buildings in the central district were found unsafe and had to come down. Debris was removed and the central area was cordoned off for one and a half years *(see Figure 3.2.3)*.

People who could, about 200,000, evacuated the city to live with family members or others in the small towns surrounding Managua *(see Figure 3.2.4)*. The city quickly selected a site outside the city for temporary housing which eventually became converted to 10,000 low-cost housing units. Other than this, displaced families were left to solve their own housing problems after the earthquake.

Early recovery actions included constructing a by-pass around the city to serve as the "axis of reconstruction" and beginning repairs and rebuilding of infrastructure and public facilities, particularly hospitals. Private developers began to build modern commercial centers and housing projects around the old and destroyed city center.

A team from Mexico helped establish new building standards for repairs and rebuilding. With the team's help, an emergency building code was available one month after the earthquake. An office was set up to review building plans and supervise construction, and by May 1973, a more complete code was available. Six months after the earthquake, a guidebook explaining good construction techniques for simple one-story houses was published.

Planning for Rebuilding

Managua had a master plan adopted in 1954. It described land use and zoning, but did not address the city's geologic problems or building standards. It did not provide adequate guidance for the rebuilding of the city. At the time of the earthquake, Managua had only two urban planners and few other professionals with the needed technical skills. After the earthquake, the city relied on foreign expertise provided through the United Nations, Organization of American States and the U.S. Agency for International Development. The foreign experts filled a real need and provided valuable training for Managuans, but needed time to become familiar with Managua. The lack of trained Nicaraguan planners slowed down reconstruction planning.

In the first six months after the earthquake, three important planning decisions were made. The first was to rebuild the city on its original site. Relocation was briefly considered, but preliminary geologic studies showed similar conditions throughout the western part of the country. Other, safer sites were not found. The second decision was to reduce exposure to future earthquakes by dispersing central city population and services to various subcenters within the city ("deconcentration"). The third decision, to control excessive population growth throughout Managua, was to encourage development of secondary cities outside of Managua ("decentralization"). A scheme for decentralization was articulated in a plan completed in 1973. The plan was not adopted, but the idea of decentralization was retained in most subsequent plans.

Another important decision was to create the Vice Ministry of Urban Planning to plan for reconstruction. This organization was formed in October 1973 and started work in January 1974 with a staff of 278 including about 40 professionals from 17 different disciplines. The ministry grew to a peak in 1975 of 746 employees, including about 150 professionals. The ministry had four divisions: planning, planning implementation, special studies, and administration. To support the decentralization policy, the vice ministry prepared both regional and city plans. A dynamic, three-phased planning process was developed to allow successive refinements to the regional and city plans as information and analyses became available *(see Figure 3.2.5)*.

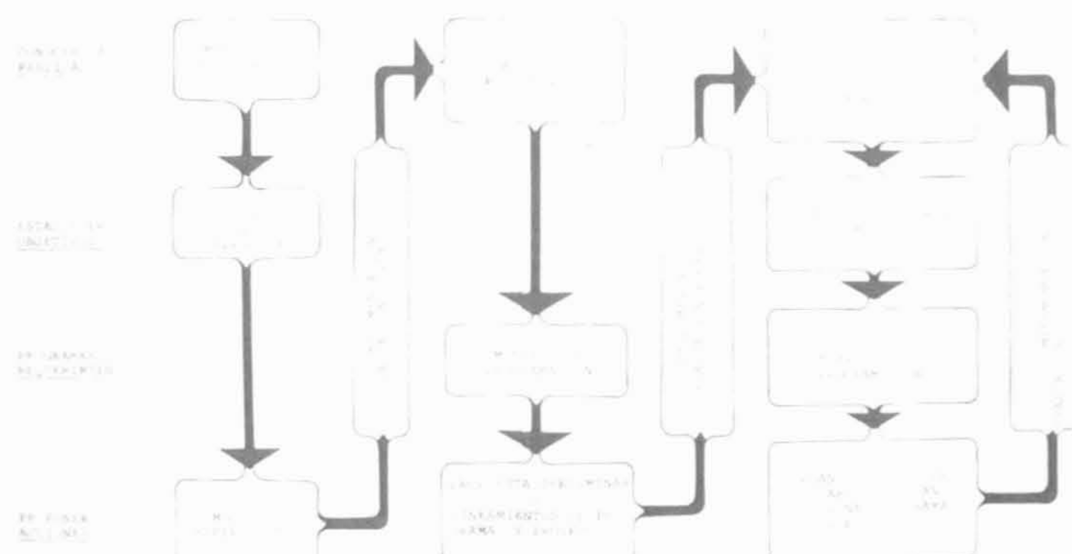


Figure 3.2.5 Diagram of the three-phased planning process showing successive iterations of information gathering, setting objectives, developing programs and proposing actions.

Regional Planning

The first phase of the regional plan was completed by the end of 1975, setting forth background data, objectives and policies. It recommended decentralization in stages starting with increased development in the other cities within the Managua metropolitan area, spreading to the rest of the Pacific regions, central regions and, then, to the Atlantic regions *(see Figure 3.2.6)*. Studies continued, but no significant decentralization took place.

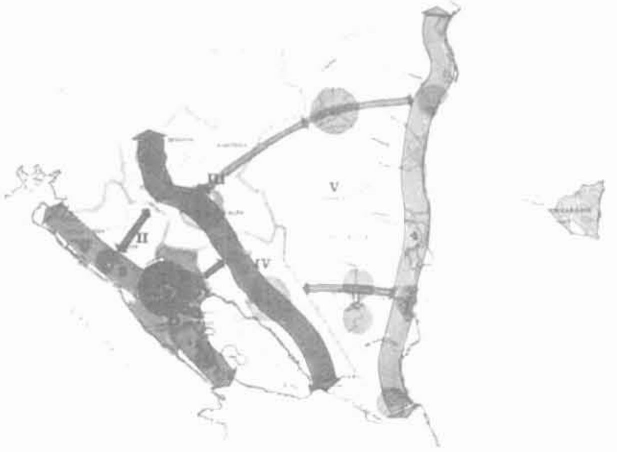


Figure 3.2.6. Diagram of regional development plan showing phased decentralization of population.

Urban Planning

Planning for the reconstruction of Managua started with a Mexican team which was in Managua at the time of the earthquake working on a transportation study. In September 1973, the team presented a plan featuring a "radial concentric scheme" with growth extending from the city center in successive rings linked to the center by roads "radiating" out from the center like spokes in a wheel. The scheme favored expansion of the city to the southeast toward the lake. An entirely new city center was proposed near the lake along with a large recreation area encompassing the lake shore, lagoons and the area of active faults. The plan was not officially adopted, but many of its basic elements kept appearing in subsequent proposals.

Then, as with regional planning, the vice ministry took over, and, using its dynamic process, produced its first phase plan in 1975 to integrate immediate action projects. Geologic studies were completed in 1975 showing that Managua was sprayed with faults *(see Figure 3.2.7)*. The urban development plan showed parks and open spaces along these faults and included a matrix restricting certain uses and building types on and near the faults. This plan kept the radial concentric scheme of the Mexican plan. The outer extent of urban development was marked by a new highway bypass being constructed around Managua. Under this version of the plan, population that could not be accommodated within this area would be dispersed to secondary cities around the metropolitan area *(see Figure 3.2.8)*.

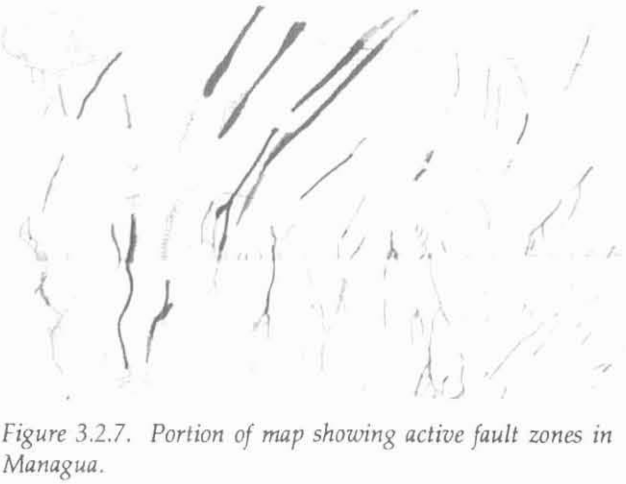


Figure 3.2.7. Portion of map showing active fault zones in Managua.

Figure 3.2.8. Diagram showing part of the urban development plan. Boundary at bottom is highway bypass and irregular vertical lines are faults designated for open space. The top of the diagram is the shoreline of Lake Managua.

Figure 3.2.9. 1987 urban development plan. Note expansion areas are outside of bypass highway shown in center of diagram.

Simultaneously with the long-range planning, the vice ministry prepared immediate action plans for specific areas of the city and emergency evacuation and shelter plans for future earthquakes. These plans were not successfully implemented. Then, after the 1979 revolution, a new master plan project was initiated to guide rebuilding from damage caused by both the earthquake and bombing during the revolution. The resulting plan, again based on the radial concentric scheme, was completed in 1982.

Population continued to grow faster than anticipated, leading to a new planning effort in 1987. The 1987 urban development plan provides for more and larger expansion areas and three new activity centers *(see Figure 3.2.9)*. A new design for central Managua was created, still featuring parks and open spaces along the faults, the civic center, commercial buildings and some housing.

Rebuilding

Plan proposals to construct new avenues, roads and infrastructure were carried out. A public housing project and two new hospitals were constructed. Private enterprise replaced housing for higher income groups and many commercial buildings, but progress lagged on public sector projects. It was not until after the 1979 revolution that plans to decentralize and rebuild the central city began to be implemented.

New building generally conforms to the radial concentric pattern, but a vital ring between two bypass roads was skipped over. The Somoza family held large acreage in the ring and withheld it from development waiting for its value to increase as it benefitted from the infrastructure extensions to the outer ring. The result is a discontinuous urban development pattern with new building occurring on the city's far periphery *(see Figure 3.2.10)*.

"Reconstruction programs in general were great business for the Somoza clan." The Somoza family held land, and land development and real estate companies. Other Somoza assets included a bank, insurance company, cement factory, asbestos tile roof factory, and bathroom fixtures business – the types of businesses that benefit from reconstruction. An incredible amount of international aid flowed into Nicaragua after the earthquake, but "too much was siphoned off to various Somoza family enterprises, and too little went to rebuilding."

After the Somozas were ousted from power, efforts to rebuild Managua resumed with new vigor.

Figure 3.2.10. Somoza lands on the outskirts of Managua withheld from development.

Today, central Managua contains mostly new public buildings and old buildings which were repaired. The high rise Banco de America was repaired and the old Central Bank was practically rebuilt as a new Presidential House. A new Convention Center now stands over the ruins of an old school building *(see Figure 3.2.11)*. The city has replaced infrastructure and constructed broad new avenues. Some new housing projects have been built in the old downtown, and three city subcenters have been developed around the downtown area *(see Figure 3.2.12)*.

These projects have not required huge investments, but are providing Managua with amenities it did not have before. In addition, the parks and open spaces, wide streets and low densities contribute to the seismic safety of the rebuilt city. To handle the rapidly growing population, serious attention is now being given to the growth of secondary cities.

Figure 3.2.11. Convention center and Banco de America.

Figure 3.2.12. New apartment building.

Managua Rebuilding Timeline

1 week	*Electricity restored; others later* *Emergency tent camps set up*
2 weeks	*Clearance begins*
1 month	*Mexican plan started*
2 months	*Temporary business center opened* *Started restoring public facilities*
10 months	*Mexican plan presented*
1 year	*Vice Ministry organized*
18 months	*Clearance completed*
3 years	*10,000 housing units built*
4 years	*Reference models adopted*
9 years	*New plans prepared* *Implementation intensified*
20 years	*Reconstruction not completed*

Findings

1. **Assistance in planning.** At the time of the earthquake, Nicaragua had few planners and needed to rely on international experts for planning. This international assistance was crucial to Nicaragua which benefitted from well-coordinated assistance from international agencies.

2. **Integrated planning organization.** Nicaragua created a single strong organization to take charge of reconstruction planning. The organization was effective in integrating plans and development both in terms of subjects (housing, employment, services) and jurisdictions (local and regional).

3. **Iterative planning approach.** Nicaragua used a cyclical, iterative planning process allowing planning to start immediately with the information at hand, followed by more detailed planning as more information became available.

4. **Public participation.** Public participation is an important element of reconstruction planning, but in Managua it was not fully realized because of the dictatorship in power in Nicaragua at the time of the earthquake.

5. **Corruption.** Corruption and politics impaired the reconstruction process. Aid from other countries intended for the people was often diverted to the benefit of a corrupt few. It is important that international disaster assistance have appropriate controls and mechanisms for community participation to prevent corruption of the process.

Friuli, Italy, 1976, Rebuilding to Restore Historic Towns

Roberto Pirzio Biroli, is an architect in Udine, Italy, who participated in the post-earthquake damage assessment and designed rebuilding projects in several small towns damaged by the earthquake.

Setting and Earthquake

Friuli is a region, with a population of about 500,000, on a high plain between the Adriatic Sea and the Alps in the northeastern corner of Italy *(see Figure 3.3.1)*. In

Figure 3.3.1. Map of Italy showing the location of the Friuli region.

Friuli Earthquake Data

Time: May 6, 1976, 9:00 p.m.
Magnitude: 6.4 Intensity: IX-X
989 people killed, 3,000 injured, 80,000 homeless
Lost or seriously damaged:
38,000 buildings; 30% of total
58,300 housing units; 21% of total
Heavy damage to infrastructure; business, public and cultural facilities
Estimated total damage: $3.7 million – all from ground shaking

the earthquake of May 6, 1976, the most heavily damaged area was where the plain meets the Alpine foothills. This area is underlain by a large aquifer and the presence of ground water increases its vulnerability to earthquake damage.

The region has a long history of settlement going back to Roman days. This history is reflected in the land use pattern, architecture and community life of the region's 100 to 300 villages, each with a local economy and often with a distinctive language and culture. New industrial and residential buildings are scattered among centuries-old churches and homes. The same region had been heavily damaged by an earthquake in 1928. At that time houses were restored only to be destroyed again in 1976, a generation later.

The May 1976 earthquake killed almost 1,000 people, injured 3,000, left 75,000 homeless, and destroyed about 30 percent of the buildings in the damaged area of Friuli *(see Figure 3.3.2)*. Two additional magnitude 6 earthquakes hit the area on September 15, 1976, leaving another 7,000 people homeless and completing the destruction of several medieval villages. One village was swept away by a landslide and eventually rebuilt at a new site.

Early Recovery

Between June 7 and July 27, the central government sent 6,000 tents for 75,000 homeless people. At the same time, the regional government sent a telegram to architects and engineers from Friuli living in Europe and the United States, saying, "You must come immediately, because we must estimate the damages." No pay was offered, but those who did

Figures 3.3.2. Damaged church in Forgaria with campanile amazingly still standing. Photo courtesy of the Earthquake Engineering Research Institute (EERI).

not come, were not in good favor with the other architects, engineers, and geologists.

The volunteers were organized into interdisciplinary groups and, using a simple form, went building to building to assess the damage. The effort covered 80,000 houses and constituted a very important social and political action, establishing contact with individual households and giving the regional government the information it needed to ask for assistance. Damage was estimated at $3.7 million (1976 dollars).

In March 1975, one year before the earthquake, the Italian government approved a new law for anti-seismic construction. As a result, "we had in hand a manual telling us about construction techniques, but nothing to tell us about where to build." People began repairing their houses without regard for the safety of the site. To help with larger rebuilding projects, the regional government brought in an expert from Yugoslavia to instruct local architects and engineers in techniques of constructing to reduce earthquake risks. The professional organizations encouraged all members in the region to take the instruction.

Then the September 15, 1976 earthquakes struck, increasing the size of the damaged area and bringing down buildings spared by the May shock. It was clear that buildings needed to be more resistant to earthquakes. So the regional government, immediately after the September earthquake, assembled a task force of experts (including Yugoslavians) to write a booklet with good drawings showing how to make both minor and major repairs. It was similar to 19th century manuals showing how to build a home.

Planning and Rebuilding

The reconstruction experience varied from village to village in the region, but all were affected by actions of the central and regional governments. Right after the earthquake, the regional government enacted a law providing immediate assistance for the repair of damaged buildings – "the law of small repairs." This was particularly effective in the villages where damage was not very severe.

Many people applied for money for repairs and few people claimed total destruction. The area where damages were generally minor was much larger than the area with heavy damage. In these villages, residents invited the homeless to "come live with us" making good use of the local stock of housing for at least temporary housing. The law encouraged rapid recovery in these towns, helping to allay depression among the victims. It soon became clear that these lightly damaged towns were the key to recovery; not the heavily damaged ones. With quick assistance and the construction manual, the villages with good land and with housing in repairable condition became resettlement sites.

And then in early 1977, the government, reacting to the slow pace of reconstruction, approved a "law of big repairs" authorizing a single large contract for rebuilding bridges, roads, infrastructure and housing. Now, residents stopped investing their time and money making minor repairs, and waited for government to make the critical decisions about infrastructure and provide them with a whole new house. People, who had begun to resettle in the less damaged villages, also began to go back to the heavily damaged towns. After that point, there was no going back and government was committed to rebuilding the towns. People who had begun to repair their houses now requested demolition, initiating the literal destruction of historic villages.

The question of how to start is very important. In October 1976, the regional government decided, without the help of the central government, to restore industries immediately. From a political point of view, it took great courage to do that, because the people said "my house first. I don't care about the work." The priests also opposed the government position, saying "first the houses; then the churches." At that time, 70 churches were damaged and the priests' position helped create a difficult political problem.

Then, the September earthquake intervened, leaving another 7,000 people homeless. This earthquake diverted resources being used to repair damage from the May earthquake to deal again with housing problems. The government housed 32,000 people temporarily in beach hotels. By the end of 1976, only 25,000 people were relocated in prefabricated houses in the towns and 18,000 were living in repaired houses. Under the assistance system, many of these people had two houses – a repaired one in a village and a demolished one in the heavily damaged area.

The zoning system in place in May 1976 was absolutely worthless after the earthquake, because it provided for the separation of uses, in spite of the fact that many people lived and worked in the same building. People were not willing to change that pattern. "We learned that we had to respect neighborhood unity, economic realities and the history of the town in planning to rebuild with less earthquake vulnerability."

The regional government decided to pay for housing projects involving several families. Although opposed by the big developers and owners, this law permitted the cooperative planning and rebuilding of blocks of houses, encouraging the retention of the historic land use pattern and character of neighborhoods *(see Figures 3.3.3 and 3.3.4).*

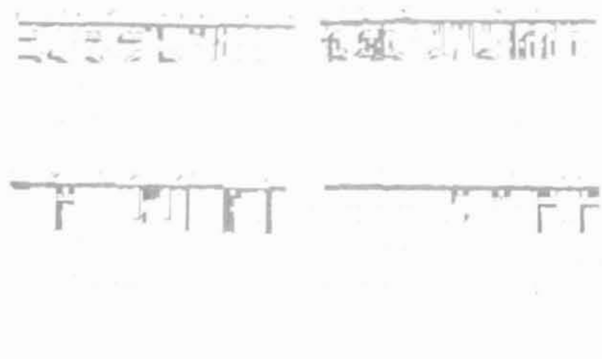


Figure 3.3.3. Plan for block housing in Portis.

Figure 3.3.4. New housing block in Portis, featuring rounded doorways, arches and balconies characteristic of the region's architecture.

"In Resiutta, the mayor gave us the chance to rebuild the village." The village had been evacuated and the government had started rebuilding the center, but the people refused to stay away. So they were housed in a single structure and participated in the planning and rebuilding of the new village. "We used the original building materials and designed the new buildings to preserve the traditional architecture and lifestyle of the village" *(see Figures 3.3.5, 3.3.6 and 3.3.7).*

Figure 3.3.5. Plan for new housing block superimposed on original plan. Units are larger to accommodate garages and modern features, but basic layout echoes the original.

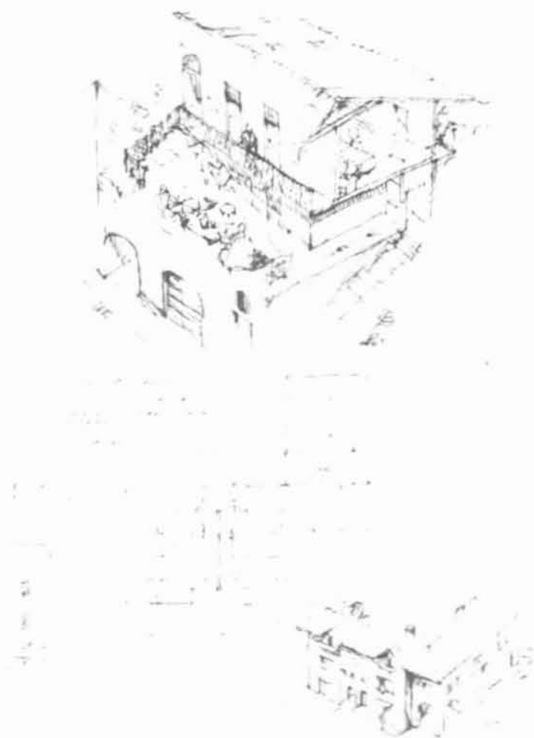


Figure 3.3.6. Plan and sketch for new housing block in Resiutta. Design includes arched garage doorways and entrances from breezeways typical of the region. Resident's of Resiutta participated in the design of the blocks, as well as of the individual units.

Figure 3.3.7. Housing block in Resiutta built according to the plan shown above left. New town center in the background.

To encourage the use of original stones and other building materials, the government enacted a law distinguishing between "dismantling" and "demolishing" a building. An owner could not qualify for "repair" funds if he demolished the building, but could if he dismantled it and used the materials on his block. On any building site, there is incredible moving with materials coming and going. Using the materials on the site saved money and labor. The original stones were used with reinforcing to improve earthquake resistance *(see Figures 3.3.8 and 3.3.9)*.

In Venzone, the city hall and central piazza were completely destroyed. The piazza was relocated and completely redesigned, and the city hall rebuilt at the beginning of the project *(see Figure 3.3.10)*. Drawings were used to show residents what was planned for their community. In this town, each stone was numbered; this took a year and a half. The people of the village wanted the gate to the village rebuilt before anything else. Symbols are very important.

Figure 3.3.8. Arch stones of a Gemona villa numbered for accurate replacement when the gate is rebuilt. Photo, taken in 1978, is courtesy of the Earthquake Engineering Research Institute.

By 1985, most of the towns damaged by the Friuli earthquakes had been rebuilt *(see Figure 3.3.11)*. A few had been relocated and some redesigned. The most successful rebuilding projects were not necessarily the first to be completed. They were those which preserved key elements of the historic land use pattern and architecture, and these projects were all done with strong participation by the residents to determine land use and design elements to be preserved and priorities for rebuilding. By using improved building standards and some relocation from hazardous sites, Friulians hope the next generation will not face the same disaster.

Figure 3.3.9. Rebuilding sites in Venzone with materials being reused.

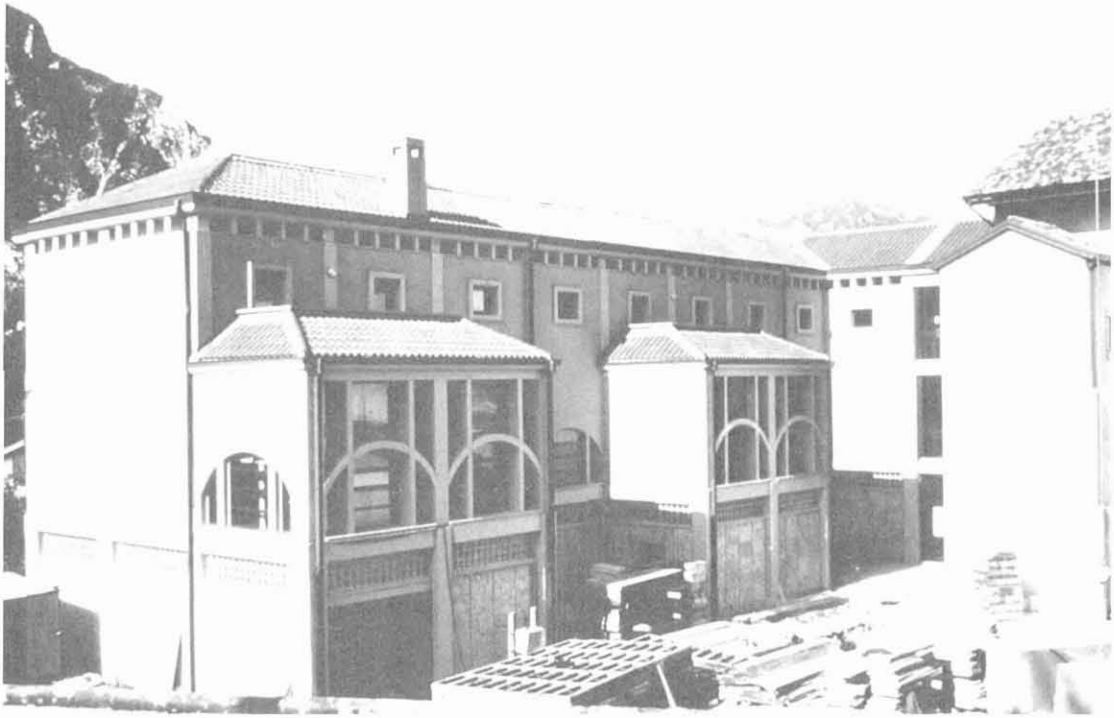


Figure 3.3.10. New city hall nearing completion in Venzone.

Figures 3.3.11 Opening ceremony for a new housing block.

Friuli Rebuilding Timeline

1 week	*Special Commissioner appointed* *Debris removal, dismantling and demolitions begin*
2 weeks	*Set up prefab schools* *Regional services reestablished (telephone, water)* *Local services temporarily restored*
3 weeks	*Start repairs of public facilities* *Temporarily repair hospitals and city halls* *Begin classifying salvaged materials* *Clearance completed in some villages* *"Law of small repairs" enacted*
1 month	*6,000 tents begin to arrive to shelter 75,000 people* *Interdisciplinary team begins damage estimates* *Dismantling begins in Resiutta, Venzone, Portis*
2 months	*Factories, offices repaired* *Shops, businesses in temporary space*
4 months	*Business activity in permanent space*
5 months	*Damage estimates completed* *Infrastructure restored*
Two New Magnitude 6.0 Earthquakes – September 15, 1976	
6 months	*Special Commissioner returns* *Beach hotels used to shelter homeless* *Clearance restarted*
7 months	*Infrastructure restored again* *Manual for repairs finished* *Second clearance completed* *Public facilities restored* *Business recovery from new earthquakes*
8 months	*"Law of big repairs" enacted* *Start of local planning* *Non-historic buildings repaired* *Start restoring historic buildings*
1 year	*National reconstruction law passed*
18 months	*25,000 prefab houses in place* *18,000 houses repaired*
3 years	*Begin reconstruction of city halls* *Reconstruction plans adopted by region*
4 years	*Villages and cities without landmarks adopt plans*
9 years	*Reconstruction completed*

Findings

1. **Transferring experience.** The rebuilding experience of each town damaged in the Friuli earthquakes was different, highlighting the difficulty of transferring experience from one city to another, let alone one country to another.

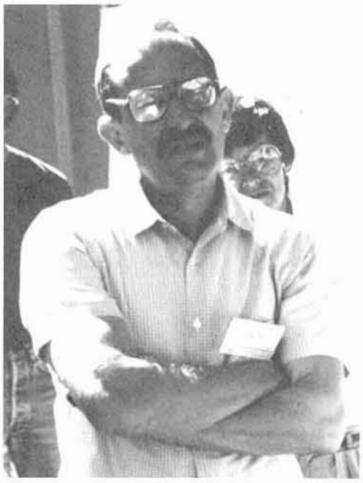
2. **Public/private investments.** Generous government funding does not necessarily make it easier to develop an effective strategy for rebuilding. The public expenditure on reconstruction after the Friuli earthquakes was three times the private, yet 85 percent of the rebuilding was done with private funds.

3. **Influence of funding strategies.** Government funding for minor repairs effectively mobilized private initiative and fostered individual decisions to relocate in less damaged areas. Once the government decided to fund large rebuilding projects, private efforts to repair houses and resettle ceased. The decision, in effect, determined that heavily damaged towns would be rebuilt.

4. **Citizen participation.** Village residents insisted on participating in decisions about rebuilding. Where this happened, it took time, sensitivity and organization, but the result was a rebuilt village with land use and architecture strongly reminiscent of the historic village.

5. **Cultural symbols.** Residents wanted to preserve the basic form of the pre-earthquake villages and emphasized restoring rapidly symbolic structures such as arches and churches.

El Asnam, Algeria, 1980, Seismic Studies for Rebuilding



***Farouk Tebbal**, Head of Staff of the Ministry of Equipment in Algeria, is an engineer who was formerly head manager of the C.T.C., the government agency with technical control of construction. After the earthquake, he was in charge of seismic studies and development of new seismic resistant building standards (RPA83) used in reconstructing the El Asnam area.*

El Asnam Earthquake Data

Time: October 10, 1980, 1:25 p.m.
Magnitude: 7.3 Intensity: X
3,000 people killed, 10,000 injured, 40,000 homeless
Lost or seriously damaged:
- *1,200 buildings – 23% of total;*
- *6,500-7,000 housing units – 18% of total;*
- *business – 21%; industry – 10%;*
- *public facilities – 20%-34%.*

Estimated total damage: $2 billion – all from ground shaking

Setting and Earthquake

Algeria, on the north coast of Africa, was a French colony until 1962. Most of the country is in the Sahara Desert, but the population lives in a habitable strip along the Mediterranean Sea. El Asnam, with 120,000 people at the time of the earthquake, is located in this strip about half way between Algiers and Oran – Algeria's two largest cities *(see Figures 3.4.1 and 3.4.2)*. The city's economy is based on agriculture and a growing industrial sector. After the earthquake, its name was changed to Ech Chelif for the nearby Chelif River. Moslems objected to the name El Asnam which means statue – a forbidden art form.

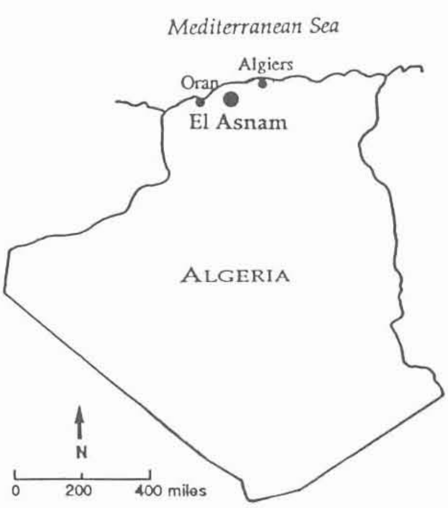


Figure 3.4.1. Map of Algeria showing the location of El Asnam.

Figure 3.4.2. Countryside near El Asnam showing fault rupture associated with the earthquake.

Earthquakes struck this area in 1853, 1856, 1922, and 1934, but caused little damage because the city was small. In 1954 an earthquake killed 1,250 people and destroyed the city. The French decided to rebuild at the same location according to a hastily-drawn plan taking no account of earthquake hazards. New building code standards with anti-seismic features were used (AS 1955).

The earthquake on October 10, 1980 again destroyed El Asnam, revealing that both land use planning and building standards after the 1954 earthquake were inadequate to prevent heavy losses. The magnitude 7.3 earthquake killed 3,000, injured 10,000, and left 40,000 homeless. About one-quarter of the city's buildings were destroyed or heavily damaged, including approximately 7,000 housing units *(see Figure 3.4.3)*.

The worst damage occurred in part of the city built over a filled ravine. This area was also badly damaged in 1954. Many of the buildings constructed after 1954 to the new code collapsed in the 1980 earthquake, particularly buildings supported by slender columns and topped with heavy roofs used in the region for insulation from the intense heat *(see Figure 3.4.4)*. Damage was estimated to be $2 billion (1980 dollars).

Figure 3.4.3. Building damage in El Asnam.

Figure 3.4.4. Damage to buildings supported by slender columns.

Early Recovery and Planning

Within days after the earthquake, the Algerian government called a conference of international experts in seismology, earthquake engineering, urban planning and other disciplines to advise about rebuilding. The experts suggested the following actions:

- Shelter displaced people in tents.
- Inspect buildings to determine extent of damage.
- Find temporary housing sites and design prefab housing projects for them.
- Conduct geologic and seismic studies.
- Evaluate and improve building standards.
- Prepare a new urban plan based on the geologic and seismic studies.
- Start reinforcing buildings and rebuilding.

The military evacuated the city and the entire population (120,000) was resettled in huge tent settlements *(see Figure 3.4.5)*. Buildings were evaluated and tagged red, yellow, or green, ranging from unsafe to safe to occupy. At three to six months after the earthquake, urban planning consultants were brought in to design four temporary settlements of prefab housing on the periphery of the city.

Construction of the first prefabs started in January 1981. Although they sheltered the homeless, some types were not compatible with either local architecture or the climate. In one case, a few concrete, igloo-like houses were built as a trial and rejected because they acted like ovens in the hot climate *(see Figure 3.4.6)*. Projects were started to develop new building standards, identify the best

Figure 3.4.5. Tent settlement.

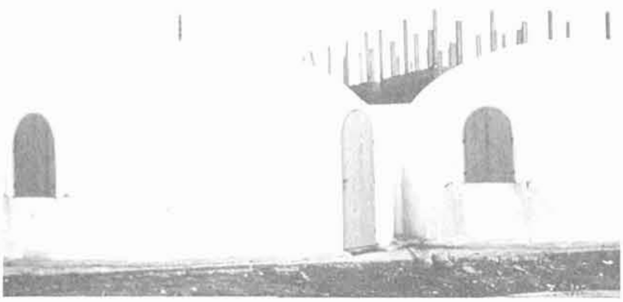


Figure 3.4.6. Igloo-style temporary housing.

locations for permanent settlements, and prepare an urban plan.

Local authorities decided to prohibit any rebuilding in the damaged area until completion of geologic and seismic studies. This unusual decision stemmed from the history of frequent earthquake damage in this area. The government wished to avoid the errors of the past and rebuild a city that would withstand inevitable future earthquakes. No actual rebuilding was started until 1985, five years after the earthquake.

Planning for Rebuilding

At the time of the 1954 earthquake, 24,000 people resided in El Asnam; by 1980, the number had grown to 120,000. This rapid growth led to increased densities in the urban core and extension of the city into areas with alluvial soils which can amplify earthquake ground shaking and sometimes liquefy causing ground failure. After the earthquake, the government rescinded previous plans and land development regulations and decided that new plans and regulations must be predicated on the best information available on seismic resistant building standards and the seismic performance of soils. A major concern was a plan to locate a freeway through the area. The government knew that the freeway would strongly influence the pattern of settlement and wanted good geologic and seismic information to be sure it was encouraging settlement in reasonably safe locations.

Geologic and seismic studies, supported by UNESCO and conducted by Woodward Clyde Consultants, a U.S. geotechnical firm, were started in mid-1983. The studies included an assessment of earthquake potential in the region plus detailed evaluation and mapping of earthquake hazards (liquefaction, landsliding, surface fault rupture, and settlement) at nine urban sites. The hazard maps defined three zones, each judged to have similar overall hazard potential, ranging from conditions posing significant earthquake threat to ordinary buildings to conditions generally safe for building *(see Figure 3.4.7)*. The map legends specify the additional geologic investigations and building practices, including special foundation designs, that should be required in each zone.

After the earthquake hazard maps were completed, William Spangle and Associates, working with Woodward Clyde Consultants, developed a land

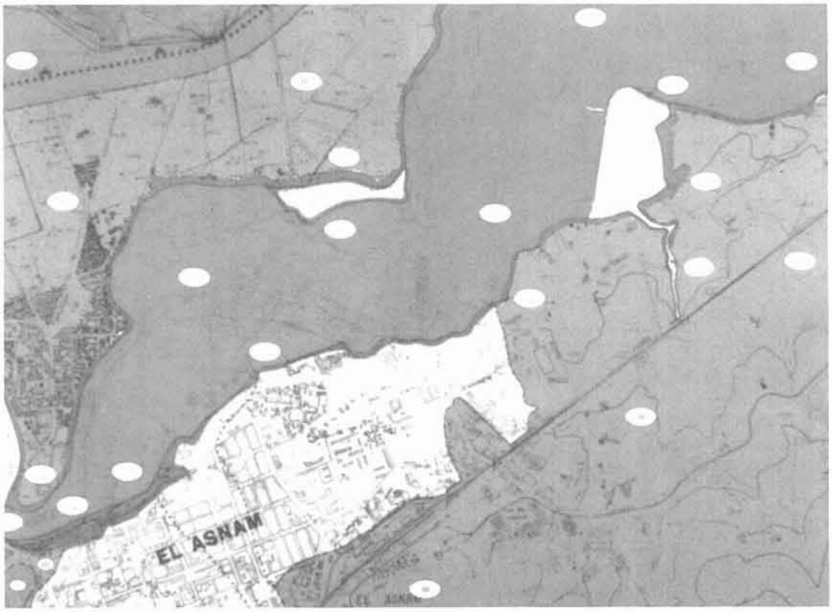


Figure 3.4.7. Seismic hazard map of El Asnam and vicinity showing three seismic hazard zones. The darkest areas (I) are the most hazardous, the lightest areas (II) are moderately hazardous, and the medium tone areas are the safest. Subscripts in the ovals further identify the specific hazards present.

capability system for using the hazard information in preparing a rebuilding plan and applied the system on a pilot basis in part of El Asnam. The heart of the system was a matrix rating the acceptability of specific land use types in each of the mapped hazard zones *(see Figure 3.4.8)*. Each rating, called a "capability rating," was then multiplied by a weight indicating the importance of the hazards present in the zone to yield a "weighted capability rating." Land capability maps were then derived from these ratings. These maps showed the capability of specific areas to accommodate housing, commercial development, infrastructure and other types of development with reasonable assurance of surviving future earthquakes. They also showed areas in which stricter building standards should be applied to ensure safe construction *(see Figure 3.4.9)*.

Table 3.4 WEIGHTED CAPABILITIES FOR LAND USE CATEGORIES

I B Dwellings, Moderate Density

Designation on Seismic Microzonation Map (1)	Weighted Capability				
	Fault Rupture (f) (2)	Compaction (t+Note 4,t,t') (3)	Land slides (g) (4)	Lique faction (l, l') (5)	Total (6)
I g	80	80	0	70	0
I l	80	80	100	7	267
I t, g	80	32	0	70	0
I t, l'	80	32	100	35	247
I t, g, l	80	32	0	7	0
I t+note 4	80	8	100	70	258
II t	80	32	100	70	282
II l'	80	80	100	35	295
III t'	80	56	100	70	306
III	80	80	100	70	330

Figure 3.4.8. Matrix showing the weighted capability of specific hazard zones for moderate density housing.

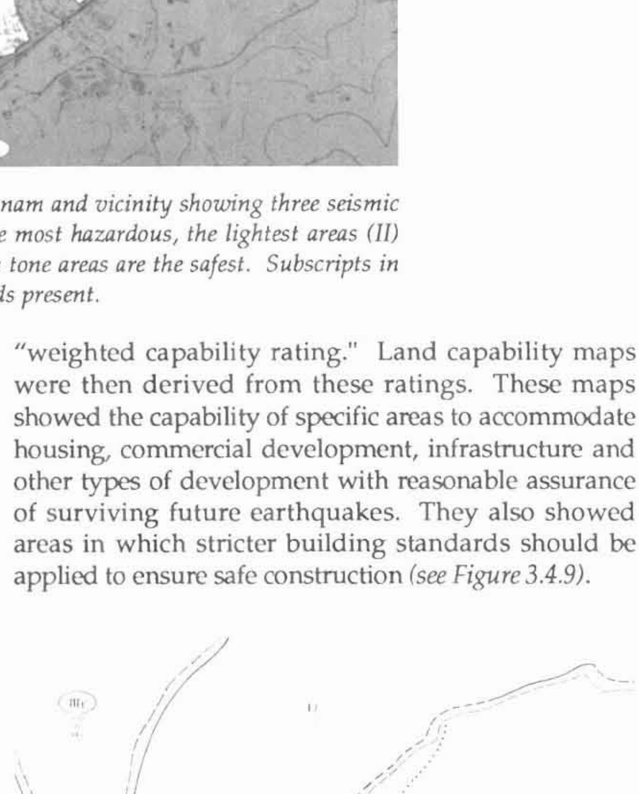


Figure 3.4.9. Land capability map for essential buildings or facilities. The most capable areas are the darkest.

Figure 3.4.10. Portion of the plan diagram showing locations of activity centers. C1 is the 1954 center, C2 is the 1980 center, and Cf is a future center based on seismic hazards study results.

These studies showed that the sites selected right after the earthquake for temporary housing were indeed good for that use. This was fortunate because these settlements had become permanent by 1985 when the studies were completed. The destroyed city center kept its "attracting power", gradually "pulling back" people from the prefab houses to a clearly unsafe area.

To counteract this, an urban plan adopted in 1987 for El Asnam, based on the geologic and seismic studies, shows the urban center located in the foothills south of the old center *(see Figure 3.4.10)*. The plan also provides for repairing and strengthening buildings if the cost is less than 60 percent of the replacement cost. Under this criterion, about 1,500 houses were found to be repairable.

The national government, which prepared the 1987 plan for rebuilding El Asnam, also decided to reduce the earthquake risk by slowing the growth of the city. To do this, it is encouraging the growth of small cities located in the southern foothills of the Chelif River valley, an area shown as reasonably free of earthquake hazards in the regional assessment done as part of the geologic and seismic studies *(see Figure 3.4.11)*.

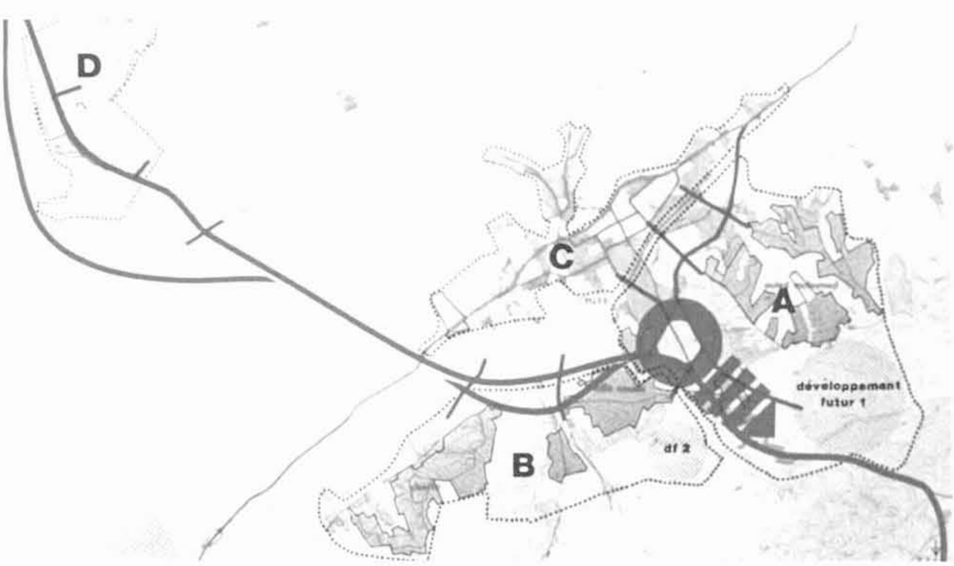


Figure 3.4.11. Diagram showing urban expansion areas. A, B, C, and D are existing urbanized areas. The arrow points to expansion toward the southeast away from the more hazardous river valley.

Rebuilding

Rebuilding has occurred much as set forth in the 1987 plan, except for the city center, which remains in its original location. By summer 1990, 1,100 of the 1,500 repairable houses had been repaired and the rest were expected to be done by the end of the year. In all, about two-thirds of the damaged and lost housing had been repaired or replaced, some by private initiatives *(see Figure 3.4.12)*. The temporary prefab settlements have become permanent and the prefabs, provided by the government, were sold to the occupants. Public facilities, including a finance hall, city hall, court room, computer center and mosque, are now under construction in the old city center. Reconstruction is proceeding on schedule and expected to be complete by 1992.

The geologic and seismic studies show the old city center in Seismic Zone II in which geotechnical studies should be undertaken prior to approving development, particularly of high occupancy buildings or critical facilities. Unfortunately, high density housing and public facilities are being built without these studies. Some areas within the center known to have loose soils and a high water table are restricted to small shopping centers and low-occupancy service buildings.

Initially, the decision to delay rebuilding pending completion of the geologic and seismic studies was enforced by the strong presence of the central government which maintained military control over the area until 1981. The area also retained status as a disaster area until 1985, with a visible national involvement in the region. The disaster status allowed suspension of normal bidding and procurement practices and facilitated a flow of central government assistance to the area. Since 1985, when the disaster status was removed, reconstruction has been much slower.

Now the people who were involved with the geologic and seismic studies are no longer in a position to influence rebuilding decisions. The studies have been turned over to local authorities for use, and often they do not understand how to use them.

Figure 3.4.12. New apartment building in El Asnam.

El Asnam Rebuilding Timeline

1 week	*Tent shelters opened*
3 weeks	*Debris removal starts* *Businesses begin reopening* *Public facility repairs begin*
1 month	*Sites for prefab housing chosen* *Telephone service restored* *Cement plant resumes production*
3 months	*Building demolition starts* *Public transportation restored* *Site preparation for prefab housing starts*
6 months	*First prefab houses delivered*
8 months	*Prefab store construction starts* *Prefab housing construction begins*
9 months	*Services permanently restored*
2 years	*Public facilities restored* *Business activity at normal levels* *Population rehoused in prefabs* *Clearance completed*
3 years	*Geologic and seismic studies begin*
5 years	*Geologic and seismic studies completed*
6 years	*Reconstruction plans adopted*
12 years	*Expected completion of rebuilding*

Findings

1. **Multidisciplinary team.** The rebuilding of El Asnam was a multidisciplinary process involving cooperation between geologists and seismologists who evaluated the earthquake hazards and engineers who used information from the seismologists and geologists to develop a new building code. City planners also played a role in translating the hazard and building code information into land use plans and regulatory procedures.

2. **Geologic and seismic studies.** The geologic and seismic studies were worth the cost, providing essential information for rebuilding. However, three years is too long to wait before beginning such studies; they should be started immediately after an earthquake to avoid unnecessary delays of rebuilding. Such studies should cover the entire damaged area.

3. **Relocation.** Although the studies supported the relocation of El Asnam's central district, the attraction of the original site was not overcome and the relocation did not take place.

4. **Mitigation.** The urban plan to rebuild El Asnam included open spaces near housing centers where people can gather in the aftermath of an earthquake, and wide streets to ease rescue operations. High rise buildings, blind alleys and dead ends were avoided.

5. **Construction standards.** The new building code provided for construction standards to vary according to the importance of the building.

6. **Communication with local officials.** Local government officials, who are ultimately responsible for application, need clear and simple explanations of how to use hazards information and land capability analyses.

7. **Early recovery.** It is important to start immediately identifying and permitting reoccupation of safe buildings and allowing repairs and strengthening of salvageable buildings. The long delay in El Asnam resulted in shortages in equipment and supplies and looting of unoccupied buildings.

8. **Damage assessments and building repairs.** Deciding about repairs and strengthening of damaged buildings was complicated for several reasons:

    a. Reasonable standards were difficult to develop and apply.

    b. Skilled manpower, equipment and building supplies were scarce.

    c. Repairs often took longer and cost more than building from scratch.

    d. People were reluctant to move back into earthquake damaged buildings even after strengthening.

    e. Strengthening sometimes resulted in designs which looked strange with local architecture.

9. **Organization.** An interministerial organization within the Algerian national government, formed to oversee rebuilding, allowed quick decisionmaking.

Mexico City, Mexico, 1985, Opportunity to Upgrade Housing

Jorge Gamboa De Buen, architect, was the Financial Director of the emergency rebuilding program called Renovación Habitacional Popular (RHP). In this position, he was responsible for obtaining funds for the program from the World Bank and federal tax funds. He was also in charge of planning and administering the use of the funds for social assistance and building.

Figure 3.5.1. Map of Mexico showing the location of Mexico City.

Mexico City Earthquake Data

Time: September 19, 1985, 7:18 a.m.
Magnitude: 8.1 Intensity: IX
4,500 people killed, 14,000 injured, 50,000 homeless
Lost or seriously damaged:
5,728 buildings
95,000 housing units
Minor damage to infrastructure, industry and business
Heavy damage to schools and hospitals
Estimated total damage: $4 billion – 90% from ground shaking and 10% from liquefaction and fire

Setting and Earthquake

Mexico City, with over 15,000,000 people is the world's second largest city *(see Figure 3.5.1)*. The city is the center of government, commerce and industry for the nation and is growing rapidly by sprawling outward from its center, engulfing valuable agriculture land. Like Nicaragua, Mexico has initiated efforts to decentralize government and economic activities by encouraging development in a ring of smaller cities, such as Cuernavaca, Puebla and Pachuca, around Mexico City.

An 8.1 earthquake struck September 19, 1985, followed by a 7.3 aftershock the next day. The epicenters were about 250 miles away on the Pacific coast of Michoacan. The old parts of Mexico City, located on deep alluvium over an ancient lake bed, experienced amplified ground shaking and much more damage than would normally be expected from an earthquake centered so far away. The long seismic waves particularly affected buildings with 6 to 15 stories. About 90 percent of the damage was caused entirely by ground shaking; liquefaction and fire contributed to the other 10 percent.

Over 4,500 people were killed, 14,000 injured and 4,000 rescued from the rubble. In all 5,728 buildings were damaged, of which 860 collapsed or partially collapsed and another 2,200 suffered structural damage *(see Figure 3.5.2)*. Over 90 percent of the damage was concentrated in three central boroughs of the city located on the site of the ancient lake bed.

The impact of the earthquake fell heavily on housing. The city lost about 95,000 housing units

Figure 3.5.2. Damage in central Mexico City, photographed in February 1986 by William Spangle and Associates.

accommodating nearly one-half million people. Schools and hospitals were also severely hit. Over 700 schools, and 4,000 hospital beds in 41 hospitals – 25 percent of its supply – were lost. Infrastructure damage was also heavy. Water, electric and telephone service was disrupted in many places and some roads, bridges and freeways were damaged. Total damage was estimated at $4.1 billion (1986 dollars).

Early Recovery

Immediately after the earthquake, the Mexico City government coordinated rescue operations, removal of corpses, debris clean up and removal of loose elements from building facades. Following these actions, the streets were reopened to traffic. By the end of October, temporary repairs had restored water, electric, transportation and telephone systems and services to most areas of the city and in mid-November, emergency building regulations were enacted. By March 1986, the government had demolished 92 buildings; another 86 were demolished by their owners in the ensuing months. All together, almost 600,000 cubic yards of debris were trucked from the city *(see Figure 3.5.3)*.

Planning and Rebuilding

Two weeks after the earthquake, Mexico's president formed the National Reconstruction Commission which negotiated credit from the World Bank to start recovery. One week later the Reconstruction

Figure 3.5.3. Earthquake rubble being hauled from city in February 1986; photo by William Spangle and Associates.

Commission of the Metropolitan Area of Mexico City was formed. These two commissions, operating at the highest levels within both the national and city governments, planned the reconstruction. They quickly ruled out major changes in land use in the city, because the damage was scattered with sound buildings remaining in even the most severely damaged neighborhoods. The Commissions approved specific programs for rebuilding each sector, such as housing, hospitals, schools, and telephone services. The most interesting of these programs dealt with housing and schools.

Housing

Most families that lost housing in the earthquake were large, averaging five persons, and most were low-income renters, dependent on jobs located in the central area. The housing program consisted of a series of parallel and phased efforts to rehouse 95,000 displaced families. About half the need was to be met through the following programs:

- Houses, apartments, and credits available through existing public housing organizations were immediately offered to 16,500 displaced families.
- Assistance was granted to 12,000 families with minor damage to repair and upgrade their housing.
- Houses were provided to 7,200 families by the Red Cross, Community Support Foundation, Solidarity Civic Center, UNICEF, and the Ecumenical Council of Mexico.
- Relocation assistance was provided to 10,500 families in the badly damaged Nonoalco-Tlatelolco public housing complex.

These programs were designed to rehouse 46,200 families. The remaining 48,800 families were helped through an innovative program to both replace and improve housing in the heavily damaged historic downtown. This program, called Renovación Habitacional Popular (RHP), was established to renovate or replace 44,437 damaged housing units in 15 months.

The damaged housing units were all located in the three central boroughs and constituted 14 percent of the area's housing stock. Most were in privately owned tenement buildings constructed in the early 1900's; some were protected as historic and architecturally important structures. Many of the buildings were deteriorated with small units and very high occupancies.

Families with an average of 4.6 persons lived in units with an average size of 240 square feet. About a third of the units had controlled rents which contributed to their deterioration *(see Figure 3.5.4)*. A majority of the residents were older people and many had lived in the area for over 30 years. Ninety percent were renters and over a third lived and worked in the same neighborhood.

In response to tenant requests for help, on October 11, 1985, the government issued a decree expropriating plots with 44,437 housing units and small shops *(see Figures 3.5.5 and 3.5.6)*. The decree contained provisions for compensating the owner. The initial objective was to rebuild 42,000 dwellings while

Figure 3.5.5. Sign announcing the expropriation of the property for the housing program.

Figure 3.5.4. Deteriorated and earthquake damaged housing in central Mexico City.

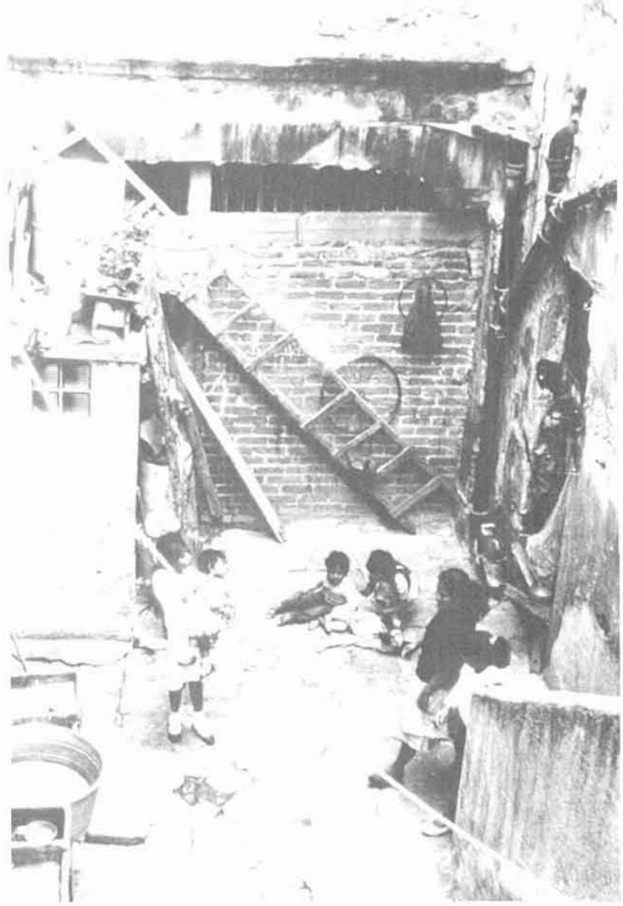


Figure 3.5.6. Post-earthquake living conditions.

private aid agencies rebuilt 2,437 dwellings. The program was later expanded to rebuild a total of 48,800 dwellings.

The program operated within a framework accepted by all parties involved: earthquake victims, government and nongovernment aid agencies, universities, technical support groups, professional associations, and international organizations. On May 13, 1986, 103 organizations signed an agreement establishing the following guidelines for the program to rebuild housing on the expropriated plots:

- Dwellings were to be reconstructed on the same plots for the same tenants.
- Safe and comfortable temporary housing, close to their original homes, was to be provided for the families during rebuilding.
- Economic aid was offered to families who found temporary housing on their own to rent or share.
- New units would have 430 square feet and include a living-dining room, two bedrooms, bathroom, kitchenette and space for washing clothes.
- As in other low-income housing programs, beneficiaries of the program would repay only the direct building costs.
- Historic buildings would be restored, if they were adequate for housing and the cost was within reasonable limits.

The program was organized to implement the social, technical and financial objectives contained in the guidelines. The primary *social task* was to restore the original neighborhood's social and economic networks both during and after renovation and rebuilding. Eligible tenants received "certificates of rights" guaranteeing them units in the same location they lived in before the earthquake. They then were asked to sign a sales agreement approving architectural plans for their units and the loan terms. When the units were completed, tenants received full ownership of the new units with a six month guarantee for all repairs.

While the new units were being built, tenants were housed temporarily in camplike settlements located in street median strips, parks, vacant lots and parking lots in their neighborhood *(see Figure 3.5.7)*. Right after the earthquake, about 4,000 families needed temporary housing. The number grew to over 42,000

Figure 3.5.7. Temporary housing in street median strip.

families receiving temporary housing or rental assistance at the program's peak between August 1986 and September 1987. Units in the camps had less than 200 square feet and were constructed of metal and asbestos sheets. A communal kitchen and bathrooms were provided for each 20 units. Camps were enclosed with metallic mesh fencing and concrete barriers to protect them from cars. Each camp had 24 hour police surveillance and teams of social workers and medical personnel.

Technical tasks included assessing damage, making decisions to demolish or repair and decentralizing administration to manage simultaneous construction work on about 3,000 building sites. An important technical task was to design units that allowed

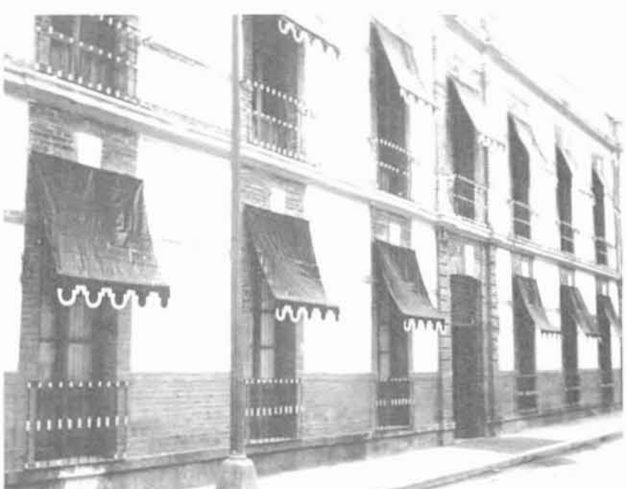


Figure 3.5.8. Facade treatments used to complement historic neighborhoods.

replacing all the units on a lot with larger units. Seven housing prototypes were designed which could be adapted to different lot sizes and densities. All provided 430 square feet units with slab foundations and concrete block walls. For safety, height was limited to three stories, and soils studies were done prior to building design at each site.

The most difficult technical task was preserving historic buildings. Each building had to be dealt with on an individual basis. Strict preservation was abandoned in favor of preserving facades while using modern building materials and methods to insure reasonable earthquake safety. Special care was taken to adapt the facades of the prototype buildings to complement the historic neighborhoods *(see Figure 3.5.8)*. Distinctive entrances and communal spaces were used and, throughout the project, color was an important design element *(see Figures 3.5.9 and 3.5.10)*.

The *financial tasks* included establishing an administrative system to handle the flow of funds which reached a peak of $13 million pesos per day, budgeting and finding the funds to pay for the program. The program budget allocated 40 percent for direct rebuilding costs and 55 percent for indirect costs such as temporary housing, demolitions and rental aid. The remaining five percent paid for program administration. Funds from the World Bank were used to cover the direct costs which will be

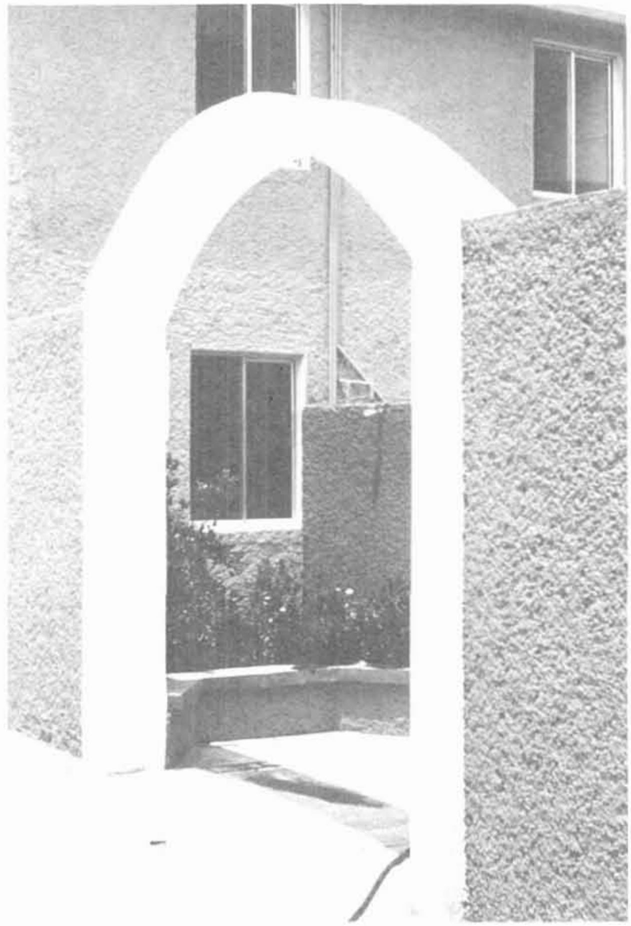


Figure 3.5.9. New housing project with arched entrance.

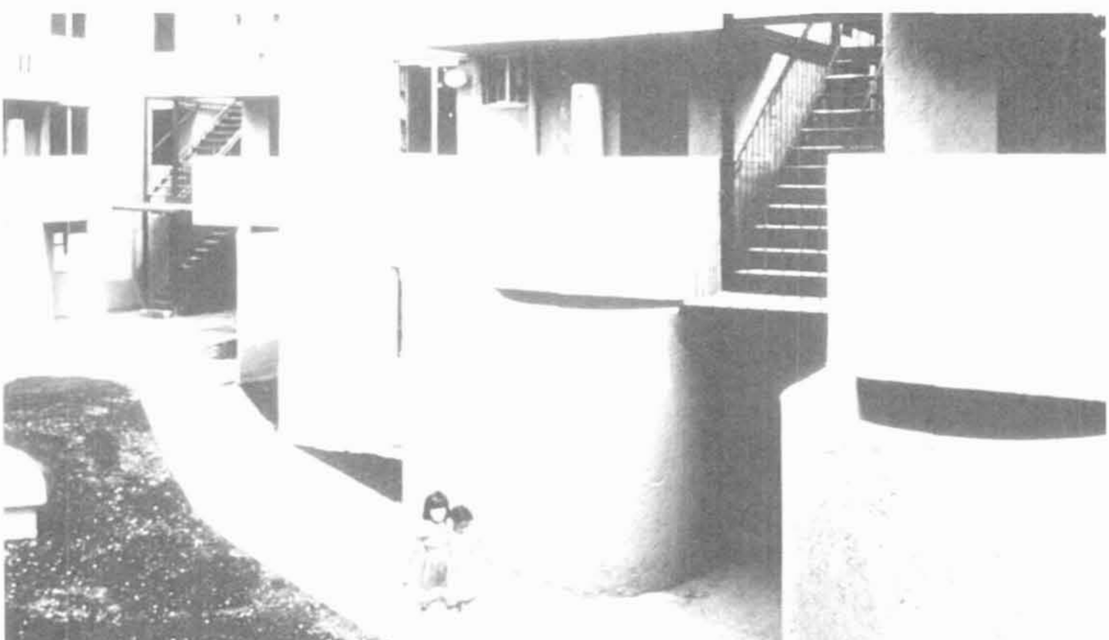


Figure 3.5.10. New housing project.

recovered through the sale of the units. The tenants pay between 20 and 30 percent of their monthly income for the housing and the loans will be fully repaid in 5.5 or 8.5 years depending on the type of loan. The national government's fiscal resources were tapped to cover the indirect costs.

In summary, the Renovación Habitacional Popular program rebuilt 48,800 housing units in 19 months, "preserving the social structure of the community, the urban pattern, and the architecture of the Historic Center. With this, it represents one of the most important experiences in housing reconstruction . . . in the last decades. Since the postwar years in Europe, nothing of this magnitude and speed has been done."

Schools

The earthquakes damaged many schools killing teachers and students and causing psychological trauma among students. About 1,800 schools were damaged in Mexico City, of which 19 were totally destroyed. All schools were closed for three days after the earthquake and then, to avoid a long interruption in studies, elementary school classes were conducted on TV. Almost immediately the Education Ministry in cooperation with parents, school masters and teachers inspected all schools in the city. Temporary classroom space was needed for over 500,000 students. The Ministry converted railroad cars, buses and any available vacant houses or buildings to classrooms. Then, using the new emergency building standards, the schools were reinforced using shear walls, concrete buttresses, X-bracing or cables. By summer 1990, about 700 schools had been strengthened *(see Figure 3.5.11)*.

Other Plans

General plans for the city and land use plans for the 16 boroughs were being revised before the earthquake. After the earthquake, public interest in the plans increased, and it took two years to complete the process. The plans call for lower densities in many parts of the city to reduce earthquake risk, among other objectives. However, this objective conflicts with the desire to prevent sprawl, and it is uncertain how the lower densities can be achieved while still housing a rapidly growing population.

Most of the reconstruction is complete in Mexico City now and the process has been used to achieve significant improvements in the city's housing stock and in the earthquake safety of its school buildings.

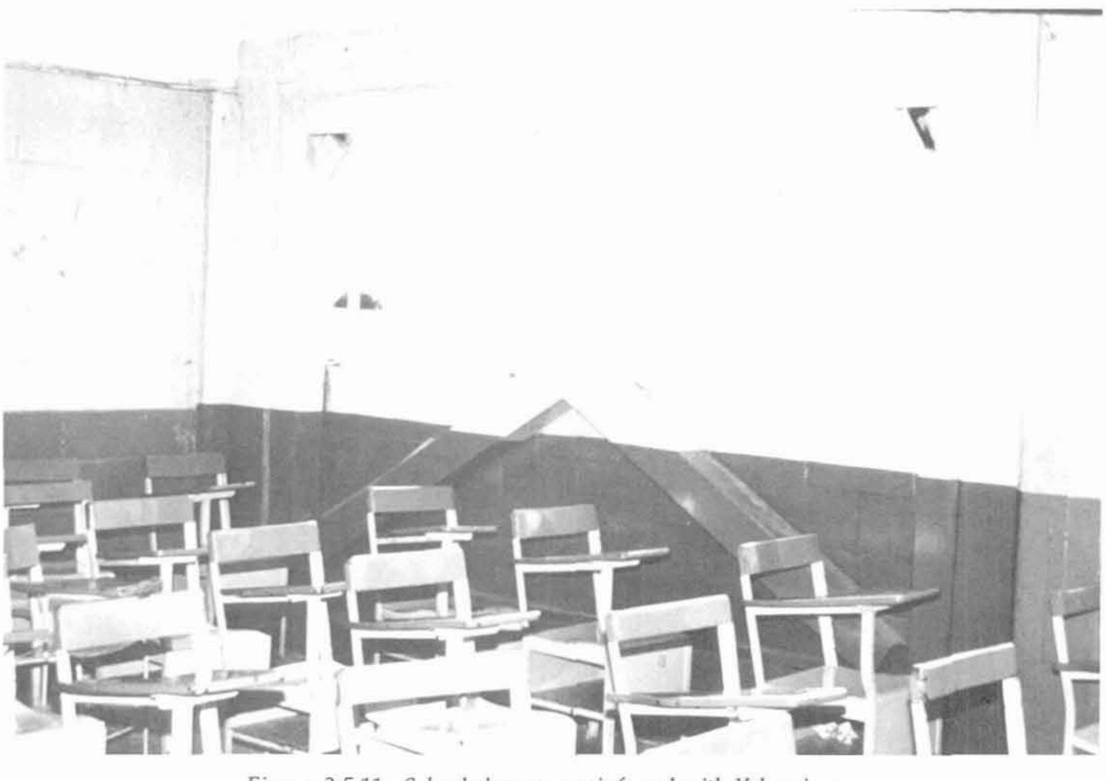


Figure 3.5.11. School classroom reinforced with X-bracing.

Mexico City Rebuilding Timeline

1 week	*Clearance started* *Emergency shelter provided* *Businesses start to reopen* *Infrastructure repairs begin*
2 weeks	*Process for planning established*
1 month	*Expropriation of 3,000 lots*
2 months	*Water service restored*
3 months	*Debris removal nearly complete* *Start repairing public facilities*
6 months	*Reconstruction plan completed* *Infrastructure rebuilt*
7 months	*Demolition with explosives starts* *Temporary shelters built in streets*
2 years	*Business activity restored* *Rehousing completed*
3 years	*Public facilities replaced*
4 years	*Reconstruction completed*

Findings

1. **Downtown revitalization.** Like downtowns in other cities, Mexico City's downtown had old and deteriorating buildings. Families, who could afford to, left for other areas of the city, sometimes abandoning buildings. Although the earthquake initially accelerated the flight from downtown, the Renovación Habitacional Popular has reversed the trend, creating viable neighborhoods again in historic Mexico City.

2. **Housing reconstruction program.** The Renovación Habitacional Popular rebuilt or repaired 48,800 housing units in 19 months. All the new units have at least 430 square feet and plumbing – a significant improvement over pre-earthquake conditions. Improvements in housing conditions were needed before the earthquake, but the earthquake permitted the use of "solutions that, although necessary, were considered impossible before." The RHP program served as a demonstration, showing other central city neighborhoods how to improve their housing.

3. **Historic district.** The reuse of urban space in the city's historic area proved to be less costly than providing similar quality housing and the associated services and infrastructure for low and middle income families on the city's outskirts. In addition, planners estimate that between 100,000 and 150,000 extra trips per day to the city center would have resulted from relocating the displaced families to the outskirts.

4. **Social and cultural fabric.** The rebuilding program retained the longstanding social network among residents of the old neighborhoods and preserved fragile networks sustaining many small shops and home businesses producing goods such as shoes, clothing, toys, furniture and home appliances.

5. **Public participation.** The rapid rebuilding of housing was made possible through a democratic agreement, formed with the participation of all involved parties, which set clear and accepted rules for the process.

6. **Schools.** About 700 schools were reinforced with shear walls, concrete buttresses, X-bracing and/or cables and were back in operation – much safer than before the earthquake.

7. **Construction standards.** A new building code based on the emergency code was developed which increases the seismic coefficients for design and applies different standards to different parts of the city based on soil conditions. A structural engineer is now required to approve the design of important buildings.

8. **Financial administration.** To process the 10,000 checks a week at the peak of rebuilding, a new financial structure was created to expedite the flow of money.

Armenia, Soviet Union, 1988, Rapid Planning – Stalled Rebuilding

Aleksander Krivov, Deputy Chairman of Goscomarchitecture, is the person in Moscow who shouldered the responsibility for reconstruction after the Armenian Earthquake. He did this initially as part of the communist regime in the Kremlin and continued as the communist government entered a turbulent period and the relationship between the central government and Armenia and between Armenia and neighboring Azerbaijan erupted into violent confrontations. He accepted the responsibility as an opportunity to change urban design in the USSR, particularly returning to smaller residential buildings and a neighborhood focus.

Figure 3.6.1. Map of Armenia.

Armenia Earthquake Data

Time: December 7, 1988, 11:41 a.m.
Magnitude: 7.0 Intensity: VIII-IX
25,000 people killed, 19,000 injured, 570,000 homeless
Lost or seriously damaged in Leninakan:
39% of housing; 90% of factories
87% of medical facilities; 88% of schools
Estimated damage: $1- 1.5 billion (10-12 billion rubles) caused by ground shaking

Setting and Earthquake

Armenia is a republic in the Caucasus Mountains in southwestern Soviet Union bordering Turkey and Iran *(see Figures 3.6.1 and 3.6.2)*. Armenia has a distinctive ethnic identity and little liking for the government in Moscow *(see Figure 3.6.3)*. It is also engaged in a civil war with its neighboring republic, Azerbaijan. Reconstruction has been hampered by the conflict and changes in the communist system less than two years after the earthquake.

About 40 percent (2,000 square miles) of Armenia was heavily damaged. This area contains about 1,000,000 people living in 27 towns and 358 settlements. The largest cities are Leninakan (now renamed Kumairi) with a population of 233,000, and Kirovakan with a population of 173,000. These are industrial cities with economies based on machine production, textiles, construction and food processing.

Prior to the earthquake, little attention had been given to planning for earthquake safety. Construction designs and quality were inadequate to withstand the shaking that occurred. The seismic code used for building understated the actual seismic risk. In addition, the cities had few standby resources for search and rescue, debris removal and early recovery, let alone reconstruction of the damaged areas. No planning for rebuilding had been done.

The earthquake was a moderate 6.3 magnitude according to U.S. scientists and 7.0 according to Russian scientists. It consisted of three shocks seconds apart and was followed by a 6+ aftershock within five minutes. Whatever the magnitude, it struck on December 7, 1988 with devastating effects, leaving more than 25,000 people dead, 19,000 injured, and 570,000 homeless, plus 300,000 Armenian refugees from Azerbaijan.

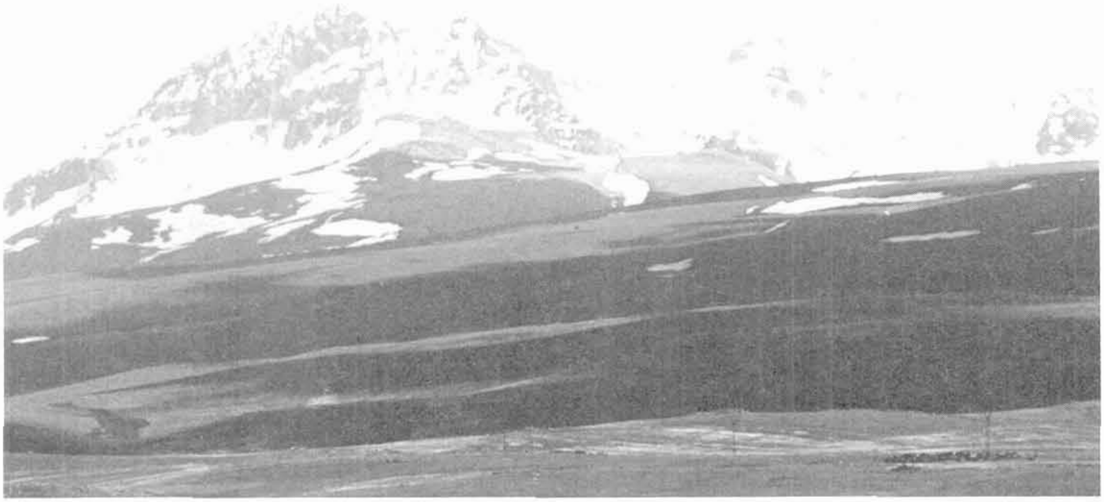


Figure 3.6.2. The Caucasus Mountains near Leninakan.

Figure 3.6.3. Distinctive Armenian church illustrating typical construction.

The heaviest damage occurred in Leninakan, the cultural and educational heart of Armenia, and in Spitak, the town closest to the epicenter *(see Figures 3.6.4 and 3.6.5)*. Leninakan lost 39 percent of its housing, 90 percent of its industry, 87 percent medical facilities and 88 percent of its schools. Housing in the town of Spitak was listed by Armenia's Council of Ministers as "completely destroyed." The total loss in the earthquake exceeded $1 billion (1989 dollars), and almost all is attributed to poor construction.

Figure 3.6.4 Destroyed masonry building in Leninakan. Photo courtesy of the Earthquake Engineering Research Institute.

Figure 3.6.5. Searching a furniture factory in Leninakan. Photo courtesy of the Earthquake Engineering Research Institute.

Early Recovery and Planning

As soon as word of the earthquake reached him, President Mikhail Gorbachev, who was attending a United Nations meeting in New York, flew home and committed to rebuild the devastated area in two years. He indicated from the beginning, that time, not money, was the priority.

The Vice Prime Minister, very high in the Politboro, organized a Commission to coordinate reconstruction. The commission established seven committees in three days. Aleksander Krivov was chosen to head three of them: 1) a committee to assess building damage and determine which buildings could be saved, 2) a committee for planning and design including land use and what to do with the rubble, and 3) a committee to develop building standards.

For the first seven months after the earthquake, this Commission coordinated recovery. After that, the central staff of the Armenian Council of Ministers coordinated the effort which was directed by regional staffs in the damaged cities of Leninakan, Kirovakan, Stepanavan and Spitak. A separate commission of specialists was formed to assess the design and construction of buildings damaged in the earthquake.

The initial task of planners in the damaged area was to assist in estimating damage. Only direct losses were estimated; "we still do not know the long term economic and agricultural losses or the indirect costs, such as the cost of interrupting normal shipping to bring construction materials to the area." The most controversial aspect of this work was determining which buildings could be saved and which had to be demolished. A five-point scale was used to rate building damage, and the most difficult questions arose in the middle range, particularly determining whether 2nd and 3rd grade buildings could be repaired. Some buildings which could have been restored were probably demolished, and some buildings rated repairable are still unrepaired and empty.

Another early planning task was to find sites for temporary housing. It was recognized that the sites would probably be occupied for at least two to five years during which time additional large earthquakes were a possibility, so earthquake vulnerability was a major factor in site selection.

Planning for Rebuilding

In the Soviet Union, planning and building construction are very standardized. The government provides high-density housing in small cities surrounded by large collective farms. The Soviet model calls for no more than 150 people per acre housed in 16-story apartment buildings. Similarly, schools are large, designed for either 1,000 or 2,000 pupils on about 25 acres. These patterns, leading to high occupancy of buildings, resulted in heavy casualties in this earthquake.

The earthquake changed the Soviet Union's entire approach to planning. Not only did the approach lead to unnecessary loss of life in the earthquake, but the cities in Armenia had over 2,000 years of cultural tradition which was not respected by Russian-style planning. For example, the Soviet model called for housing suitable only for a nuclear family, while in Armenia extended families are important and often share housing. After the earthquake, "we could not come in and override this cultural fact by imposing the typical Soviet standards." In this emergency situation, planners were given more than the usual latitude in making decisions.

At the time of the earthquake, Armenia had very few planners. About 1,000 planners from 30 "design institutes" in the country worked on plans to rebuild the damaged cities and small rural towns. Knowing the importance of good seismic and geological information, the expert committee of the Commission formed by the Council of Ministers produced 23 seismic zonation maps of the damaged areas within two months. These were used to plan land uses and determine building standards for rebuilding. In 1989, the commission published the results of the engineering, geological, hydrological and seismological studies of area. Seismic studies continued. On some occasions, it has been necessary to make minor changes in land use plans in Leninakan and Kirovakan as a result of new information.

For the first time in the Soviet Union information was available to make a quantitative comparison of the relationship of geologic factors to losses. It was clear that concentrated building damage occurred in areas of ground failure. Planners used this information to designate such areas for landscaping, light sports buildings, and parking. Plans for rebuilding the cities and towns were reviewed and generally supported by the International Academy of Architecture and the UN Centre for Human Settlement. Restoration projects were not started until the plans were completed. Only minor revisions in the plans have so far been necessary, usually because new information about building damage changed early decisions about restoration versus demolition.

Planning for rebuilding and restoration was completed in five months. "I had no superior and no higher approval from the central government was required. All plans were approved by me for the central government and by the Armenian government."

Leninakan

Leninakan is an old city laid out like ancient Greek cities *(see Figure 3.6.6)*. A new plan for Leninakan had been completed in 1987 before the earthquake. It was a traditional socialist scheme, linking city and

Figure 3.6.6. Scene of central Leninakan.

regional planning in a "design for a better life." The plan called for Leninakan to remain the urban center of the region with new development directed to three new satellite towns five to six miles away. Each satellite was planned to hold 50,000 to 100,000 people. This plan was rejected after the earthquake, because the proposed town sites, in the Ahuruan River valley with especially high ground water, were clearly unsafe.

Much of the earthquake damage occurred to new, high-density apartment buildings constructed on the outskirts of the city. A team of specialists in geology and engineering convened in mid-December to determine what to do. Some Armenian architects favored building replacement housing about five miles southeast of Leninakan. This proposal was rejected by the Republic government, because of "a number of unwelcome functional, environmental and social consequences," including the desire of people to return to their original home sites, inefficient separation of work and living places, lack of infrastructure including water supply, and earthquake safety.

Instead, a new plan evolved to rebuild the damaged areas and permit growth through expansion of the existing urban area to the northwest *(see Figures 3.6.7 and 3.6.8)*. This area, cropland adjacent to destroyed

Figure 3.6.7. Plan diagram for Leninakan region. The proposed urban expansion area is shown in the light "blocks" to the northwest of the city.

Figure 3.6.8. Detailed plan for part of Leninakan's urban expansion area.

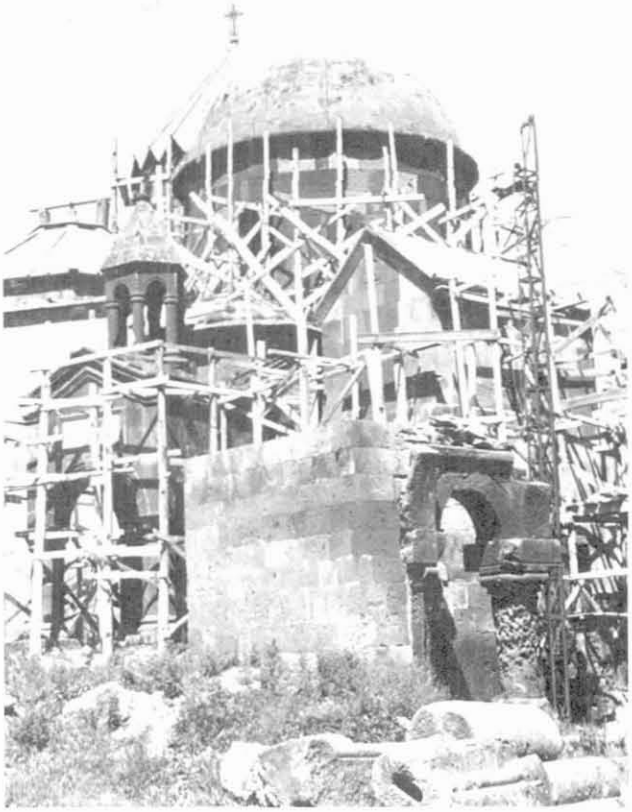


Figure 3.6.9. Restoration project in historic Leninakan.

parts of the city, has favorable topography and geologic conditions. It is large enough to accommodate the first round of building to replace destroyed housing and eventually a population of about 100,000. The plan preserves the cohesion of the old city and prevents building in the seismically unsafe Ahuruan River valley. The plan was accepted in April 1989 by the Armenian ministers.

The general plan for rebuilding distinguishes between new construction and restoration projects. The historic sectors of the city are included in a "zone of special restoration" in which every house and historic public facility will be rebuilt according to its original plan *(see Figure 3.6.9)*. Because Leninakan is located in an area with high ground water, these restoration projects require special engineering. Rebuilding according to the plan is expected to take ten years.

Rebuilding

As of now little actual rebuilding has taken place and it appears that the initial schedules will not be met. During 1989, construction plans were partially completed, geologic and seismic studies undertaken and construction sites cleared *(see Figure 3.6.10)*. In the first seven months of 1990, about 600,000 square

Figure 3.6.10. Construction site with cranes.

Figure 3.6.11. New housing under construction near Leninakan.

feet of housing were built out of a total of over 4 million square feet planned for the year.

In Leninakan, the first area to be rebuilt consisted of three- and four-story apartment buildings *(see Figure 3.6.11)*. A central square is being designed for the new expansion area of Leninakan and areas of single family houses are designated. Building designs must be approved by Armenian architects.

In the summer of 1989, about 50,000 workers from the other republics were assigned to clean and rebuild Leninakan. After an initial spurt of activity, rebuilding was halted when Azerbaijan blocked the railroad service to Armenia preventing passage of workers and supplies.

Other problems in implementing the plans include:

- absence of efficient ways to organize construction,
- lack of materials and technical background in construction techniques,
- delay in converting agricultural lands for urban expansion,
- Lack of public facilities and slow restoration of public facilities,
- delays in obtaining engineering for construction sites,
- poor construction quality and difficulty controlling quality of repairs,
- unauthorized construction of temporary housing in locations planned for reconstruction projects,
- plan changes necessitated by more specific geologic or seismic data, and
- failure to construct planned bypass road around Leninakan so that traffic continues to pass through the city.

Armenia Rebuilding Timeline

1 week	*Heavy equipment brought to site Commission for planning set up*
2 weeks	*Roads, electricity, water service restored; Debris removal underway*
3 weeks	*Begin repairs of minor damages Mobile housing brought in*
1 month	*Clearance completed*
2 months	*USSR approves master plan Set up temporary schools*
3 months	*Life-supporting business, agriculture, and industry in operation*
5 months	*Armenia approves master plan*
6 months	*Public building repair continues*
7 months	*600,000 square feet of housing built*
2 years	*Reconstruction not completed*

Findings

1. **Seismic studies.** Seismic studies, particularly evaluations of ground failure potential, pre-earthquake building condition, and the possibility of industrial catastrophes provided essential data for reconstruction planning. The studies helped determine where urban development would take place in the damaged region.

2. **Planning process.** A high-level organization with clear authority to make decisions was able to complete reconstruction planning for the region and the damaged cities and towns in five months. This would have been virtually impossible with broader citizen participation.

3. **Temporary housing.** To lessen hardship, temporary repair of damaged buildings should be permitted. Temporary housing should be kept out of areas planned for new construction projects.

4. **Information.** Loss estimation data identifying how individual hazards contributed to the total loss are needed to prepare reconstruction plans. Now there is no numerical model to compare the impacts of alternative plans. Armenia also lacked instrumental data on the damaged buildings to help determine standards for rebuilding.

5. **Seismic zonation.** Seismic zonation done for Armenia delineated two or three zones of seismic intensity. Given the complexity of the seismic setting, this should be increased to seven or eight zones.

6. **Pre-earthquake studies.** Predicting earthquake impacts is like, but not the same as seismic zoning. Because of building and other environmental conditions, areas in the same seismic zone may experience very different effects. Impact predictions are useful in locating and designing safer buildings and neighborhoods and in preparing for reconstruction before an earthquake strikes.

7. **Construction standards.** The Armenian earthquake demonstrates the importance of good quality construction. Most catastrophic building failures happened because of poor construction. A great need exists for trained building inspectors.

Chapter 4

Rebuilding after California Earthquakes

Part of the symposium was devoted to exploring rebuilding after recent California earthquakes. This was done to help place the experiences of rebuilding after the foreign earthquakes into the legal, governmental and economic context of disaster recovery in the United States.

Information about rebuilding after the Coalinga and Whittier earthquakes was presented at a lunchtime panel moderated by Paul Flores, Director of the Southern California Earthquake Preparedness Project. The planning directors from both cities described and commented on the rebuilding experiences of their cities.

The symposium's opening reception featured a slide presentation by Richard Eisner, Director of the Bay Area Regional Earthquake Preparedness Project on the Loma Prieta earthquake and the first day of the symposium was spent touring damaged areas in Santa Cruz County. Geologists working in the epicentral region and local officials from Santa Cruz County, the City of Santa Cruz and the City of Watsonville shared their experiences with us.

This chapter summaries the main points from the luncheon panel and the field trip. The Coalinga and Whittier accounts are summarized from tape recordings of the panel talks. The Loma Prieta story is drawn from notes made during the field trip supplemented by our continuing efforts to monitor rebuilding efforts in Santa Cruz County. All of the Whittier photographs are from slides used in the presentation. The other photographs in this chapter are by William Spangle and Associates except where otherwise credited in the captions.

All the California earthquakes were moderate in size and caused much less damage than the least damaging of the foreign earthquakes. Yet all posed difficult problems for planners and other government officials during rebuilding. It is important to learn from these experiences and then imagine how much more difficult the processes would be with damage approaching the scale of the foreign examples.

As pointed out by Paul Flores, moderator of the luncheon panel on the Coalinga and Whittier earthquakes, most cities in California can expect to have similar earthquakes periodically. From a regional perspective these are not the "big ones" bringing destruction to many jurisdictions and the critical networks that tie a region together. However, the damage locally from these moderate earthquakes may be as severe as these communities will ever experience.

Figure 4.0. Map of California showing location of recent damaging earthquakes.

Coalinga, 1983, The Limits of Public Power

*This is a summary of a presentation by **David Bugher**, Planning Director of the City of Coalinga. Dave was not in Coalinga at the time of the earthquake, but since March 1989 has been presiding over the process of bringing economic recovery to Coalinga's downtown, still not rebuilt eight years after the earthquake. He expects that it will take another five to ten years.*

> **Coalinga Earthquake Data**
>
> *Time: May 2, 1983, 4:43 p.m.*
> *Magnitude: 6.7 Intensity: VIII*
> *205 people injured, 32 seriously; 520 families homeless*
> *Lost or seriously damaged:*
> *46 of 51 downtown buildings*
> *1,000 housing units – 40% of total*
> *Estimated total damage: $31 million – all from ground shaking*

Setting and Earthquake

Coalinga is a town of about 8,000 people on the western margin of California's central valley about 65 miles southwest of Fresno, the nearest city (see Figure 4.0). Coalinga is an agricultural and oil town located too far from the state's employment centers for ready commuting. Its economy has been in a state of decline for many years.

The earthquake, measuring 6.7 on the Richter scale, struck in the late afternoon on May 2, 1983. Miraculously, no one was killed; 205 people were injured, but only 32 of them seriously. However, damage was extensive. The downtown lost 46 of 51 buildings, most of them unreinforced masonry constructed before the turn of the century *(see Figure 4.1.1)*. In all, 87 commercial buildings holding 141 businesses were eventually demolished.

Almost 2,000 housing units were damaged including about 1,000 units destroyed or with major damage. The destroyed and seriously damaged units amounted to almost 40 percent of the city's housing stock. Most of the losses were to single family homes which fell off their foundations *(see Figure 4.1.2)*. Damages totaled over $31 million (1983 dollars).

Figure 4.1.1. Destroyed unreinforced masonry buildings in downtown Coalinga.

Figure 4.1.2. Damaged single family house.

Early Planning

The first task was to provide housing for about 520 families. Two trailer parks were immediately authorized with space for 187 mobile homes *(see Figure 4.1.3)*. In addition, FEMA placed 93 trailers on private parcels and Starcrafter Trailers donated 60 tent trailers. Through these and other efforts about 65 percent of the need for temporary housing was met; other families camped in their front yards or moved in with friends or relatives *(see Figure 4.1.4)*. By the end of the first month, only 132 families still needed temporary housing.

The second task was to find space for businesses to reopen *(see Figure 4.1.5)*. Nine businesses reopened in the community college gymnasium and others in mobile units installed downtown by the Chamber of Commerce. Some businesses relocated to a new shopping center on the edge of town or in home garages.

The third task was to clear the rubble and find places to dump it. The city used rubble to line a creek, providing some protection against flash floods. But people began to dump debris into the creek and it became an "ugly mess." Coalinga now has $180,000 in federal funds from the Stream Stabilization and Restoration program to clean up the creek and cover the rubble, creating a strip park along the creek.

Planning and Rebuilding

Soon after the earthquake, the council adopted standards and procedures for abating imminently dangerous buildings and the most recent edition of the Uniform Building Code to govern rebuilding. The building department worked 12- to 14-hour days to process building permit applications, initially waiving fees for permits for repairs and rebuilding.

Prior to the earthquake, Coalinga had not adopted procedures for making decisions in a disaster. In the first month after the earthquake, the city council granted the city manager extraordinary power. Among other authorities, he was given the discretion, within general guidelines, to override the general plan and zoning regulations. The California Environmental Quality Act, Army Corps of Engineers and Department of Fish and Game requirements were essentially ignored.

Figure 4.1.3. Trailer park established after the earthquake.

Figure 4.1.4. Family camping in front yard.

Figure 4.1.5. Business operating on sidewalk after the earthquake.

During the first year, the need to rebuild took precedence over the general plan. Nonconforming uses destroyed in the earthquake were not allowed to be reestablished. However, in some areas, owners were permitted to create new nonconforming uses, such as apartments in a heavy commercial zone. No variance applications were processed, but the city was very lenient on repair and rebuilding of nonconforming structures. Such land use conflicts were dismissed to be dealt with later, but the "later" did not come and the city is still left with inconsistencies created by rebuilding decisions.

One of the most important early decisions was to expand the existing downtown redevelopment area to include the entire city. The state legislature agreed to reassess property values as of the immediate time after the earthquake for purposes of calculating the tax increment accruing to the redevelopment agency. Thus, the agency has benefited from the post-earthquake recovery in property values throughout the community. It has a budget of over $5 million per year and can invest directly in rebuilding. The agency is now engaged in a campaign to market downtown land and, if necessary, it plans to develop the lots and then sell them.

At the time of the earthquake, Coalinga had no professional planner on staff and an out-of-date general plan that was no help in guiding reconstruction. The county or consultants had done what planning had been carried out, and development regulations were administered by the city manager's office and the public works department.

The city retained consultants to prepare a redevelopment plan and design guidelines for downtown reconstruction. Then, services of a part-time "circuit riding planner" were used until 1986 when the city hired its first planning director. At that time, almost the entire city staff was replaced, because the city council was dissatisfied with progress in rebuilding and decided it needed new direction. The post-earthquake period proved politically treacherous for incumbent public officials, both elected and appointed.

The rebuilding effort highlighted "glaring land use issues" in the community and, as a result, Coalinga now has a professional planning department with a planning director, assistant planner and support staff. It is still using planning consultants to keep up with the work load. Coalinga contracts for legal services and has one attorney working almost full-time on land use issues.

After the earthquake, a downtown merchant association was formed and the city asked the

Figure 4.1.6. EDA building in downtown Coalinga, May 1990.

group if it wanted rapid rebuilding above all else, or was willing to accept slower rebuilding with better design and aesthetics. The association opted for design and aesthetics, leading to design guidelines for downtown and a city-wide redevelopment effort.

The city also applied for and received a grant from the Economic Development Administration (EDA) for three 15,000 square foot commercial buildings. "We now have these beautiful buildings, but most of the space is vacant, because of the lease terms imposed by EDA" *(see Figure 4.1.6)*. The city is currently lobbying Washington for a change in terms so that it can sell the buildings, perhaps by the square foot as commercial condominiums. It is also trying to market still vacant land in downtown *(see Figure 4.1.7)*.

FEMA eventually removed its trailers from Coalinga, but the lands that had been requisitioned for the trailer parks, now enhanced with infrastructure, remain in use as trailer parks. They are in the logical corridor for commercial expansion and are now considered a land use problem.

In all, Coalinga received more than $50 million in federal and state aid to cover about $31 million in damages. This large public investment has not been enough to bring about the revival of the downtown commercial center. The city has had little success attracting private investment, because the name "Coalinga" has become synonymous with earthquakes and investors have been scared away. The redevelopment agency is working to overcome this obstacle to full recovery.

Figure 4.1.7. Parcel for sale, downtown Coalinga, May 1990.

Coalinga Rebuilding Timeline

1 week	*Debris removal begins* *Emergency shelters opened* *Damage assessment begins* *Highways repaired*
2 weeks	*Oil fields resume operations* *First mobile home park opened*
1 month	*Second mobile home park opened* *Downtown demolitions begin*
2 months	*Downtown clearance completed* *Most businesses in temporary space*
5 months	*Redevelopment plan completed*
6 months	*Most damaged houses repaired*
18 months	*EDA commercial buildings completed*
7 years	*Downtown still not rebuilt*

Findings

1. **Rebuilding opportunities.** In general the earthquake opened up unanticipated opportunities to change land uses in Coalinga and challenged city officials to be creative.

2. **Temporary housing.** The location of temporary mobile home parks created land use problems as the use became permanent. A pre-earthquake plan establishing guidelines for selecting temporary housing sites might have been helpful.

3. **Downtown reconstruction.** The main problem facing Coalinga in rebuilding downtown is the lack of market support to justify significant private investment in downtown. The earthquake brought this longstanding problem to the forefront. Rents were very low in the old buildings – insufficient to support the cost of financing and constructing new buildings. A new shopping center which opened up on the periphery of the town just before the earthquake, reduced the demand for downtown retail space. Large public investments have not yet induced the needed private investments.

4. **Debris removal.** Rubble disposal ended up providing the city with a tangible benefit, but planning in advance would have made the process much easier.

5. **General plan.** Rebuilding applications were approved which were inconsistent with the general plan. Cities need a simple, flexible general plan to help guide rebuilding. Under current California law, general plans are too specific.

6. **Emergency ordinances.** Coalinga hastily adopted emergency ordinances granting more power than perhaps necessary to the city manager. Such ordinances should be prepared in advance when the contents can be carefully considered.

7. **Staff.** Coalinga also needed to have mutual aid agreements with other jurisdictions and a plan to give staff people enough time off to handle problems at home.

Whittier, 1987, Rebuilding When Damage is Scattered

*This is a summary of a presentation by **Elvin Porter**, Planning Director, City of Whittier for 26 years. Elvin was planning director at the time of the earthquake and played an increasingly important role in rebuilding as the action shifted more and more from the city manager's office to the planning department.*

Setting and Earthquake

Whittier is a city of about 72,000 people located 15 miles due east of Los Angeles at the base of the Puenta Hills, home of the Whittier Fault *(see Figure 4.0)*. Some development is on and near the fault, but, as required by the state Alquist-Priolo Special Studies Zones Act, geologic studies are required before approving any new development in the fault zone.

The 5.9 magnitude earthquake struck on October 1, 1987 damaging 5,000 buildings and displacing 80 businesses and 1,800 residents. Most of the damage was in "Uptown," Whittier's central commercial district, with many renovated, but not strengthened, unreinforced masonry buildings *(see Figure 4.2.1)*. In addition, many older houses in north Whittier fell off their foundations *(see Figure 4.2.2)*. Yet, even in the most heavily damaged areas, infrastructure and many buildings remained intact.

Figure 4.2.1. Damaged unreinforced masonry building in Uptown commercial area.

Whittier Earthquake Data

Time: October 1, 1987, 7:42 a.m.
Magnitude: 5.9 Intensity: VIII
No deaths or serious injuries in Whittier
18,000 homeless; 150 jobless
Lost or seriously damaged:
5,000 buildings, about 15% of all buildings
80 businesses and about 120 houses destroyed
Estimated damage in southern California: $358 million (1987 dollars) – all from ground shaking

Planning and Rebuilding

The city had recently conducted an emergency response exercise and was able to handle the initial response to the earthquake effectively. Debris was cleared quickly, and then "we had to do it again following damaging aftershocks." Demolitions in Uptown started within a few days. The Chamber of Commerce and Whittier Uptown Association brought in trailers which were installed in Uptown parking lots to house businesses temporarily *(see Figure 4.2.3)*.

Immediately after the earthquake, the planning department was assigned to help keep track of events and provide information about the city, land uses, and building occupancy. The planning staff also provided information to help estimate the value of damage. But, for the first 8 to 10 months after the earthquake, the planning department was not unusually busy. Temporary housing was not an issue, because most of those left homeless found accommodations with family or friends. "Then rebuilding plans started coming in and we've been very busy ever since."

Figure 4.2.2. Damaged single family house in north Whittier.

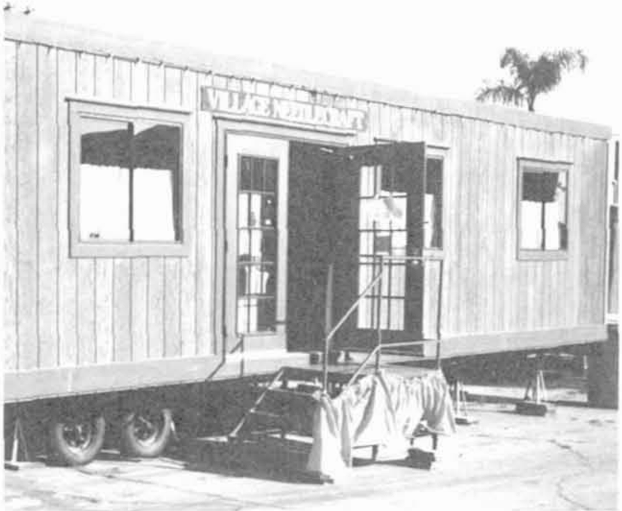


Figure 4.2.3. Trailer housing an Uptown business, photographed by William Spangle and Associates.

Figure 4.2.4. Pile of used bricks for use in rebuilding.

Before the earthquake, Whittier had two redevelopment areas, but most of the damage was not in either. The state enacted special legislation to permit Whittier to designate quickly a new redevelopment area, including most of Uptown and begin collecting the tax increment. A citizens advisory committee was formed to help implement the plan and develop design guidelines. The committee decided to maintain the "pedestrian scale" of Uptown, to allow only retail uses on ground floors in the area, and to seek viable use of upper floor space which was underused before the earthquake.

The city also decided to retain the architectural style of the brick buildings as much as possible. Bricks were saved from demolished buildings to be reused in rebuilding *(see Figure 4.2.4)*. The decision to favor real brick facades has been a difficult one for the design review board, which faces complaints from developers that brick is too expensive. In at least one case, the board has compromised by allowing a stucco building with brick trim *(see Figure 4.2.5)*.

Figure 4.2.5. Sketch of a planned stucco building with brick trim – a proposed compromise.

Figure 4.2.6. House jacked up for foundation repairs.

Rebuilding damaged houses in northern Whittier posed difficult planning problems. The area was planned for and developed in single family homes, but zoned R-4 permitting apartments. The zoning was not consistent with the general plan as required by California planning law. After the earthquake, some owners jacked up their houses to repair the foundations and usually added space at the same time *(see Figure 4.2.6)*. Other owners decided to replace damaged single family homes with duplexes which the zoning permitted. Neighbors complained and the city faced pressure for a moratorium on repairs and rebuilding until the zoning question was resolved.

As a compromise solution, the city council adopted an urgency ordinance requiring a conditional use permit for any residential development of more than two units in north Whittier and Uptown. This allowed repairs and rebuilding to proceed while replanning was taking place. At the same time, the permit requirement provided a chance for neighbors and the city to review and comment on rebuilding projects. The city eventually downzoned much of the area from multi-family to single-family residential *(see Figure 4.2.7)*.

When rebuilt, Whittier will not have a totally new look. Most buildings in the city were undamaged or repairable. The new buildings will be designed to fit into the existing urban environment. In Uptown, where damage was most concentrated, new buildings will be safer, but significant changes in land use have not occurred *(see Figure 4.2.8)*.

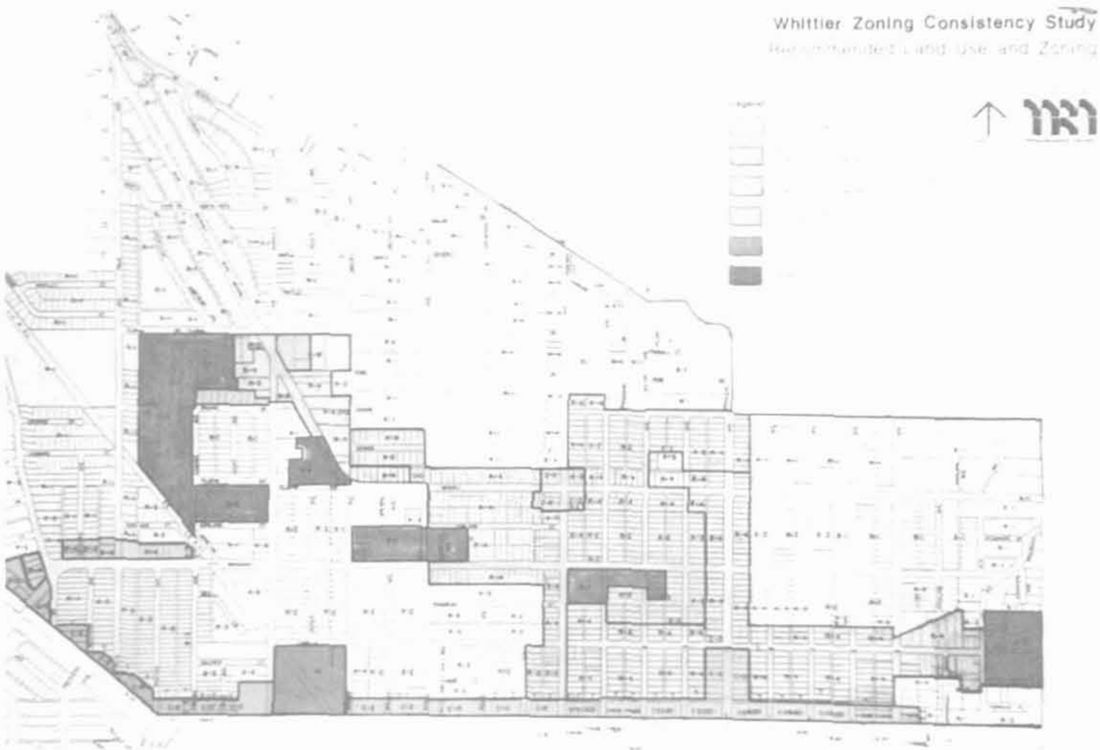


Figure 4.2.7. Diagram of zoning consistency study done to resolve rebuilding issues in north Whittier residential areas.

Figure 4.2.8. Theisen building, the first to be reconstructed in Uptown Whittier.

Whittier Rebuilding Timeline

1 week	*Debris removal begins* *Trailers allowed on residential lots* *Infrastructure restored*
2 weeks	*Redevelopment plan started*
3 weeks	*Temporary housing provided*
1 month	*Demolition completed* *Business trailers installed Uptown* *Businesses reopen in safe buildings*
2 months	*Citizens Advisory Committee formed*
21 months	*Long range specific plan adopted*
2 years	*Most businesses in permanent space*
3 years	*Business trailers removed* *Reconstruction not completed*

Findings

1. **Planning opportunities.** Large scale relocation and redesign did not occur in Whittier because so much of the urban structure was still intact after this relatively moderate earthquake.

2. **General planning.** Whittier experienced problems as rebuilding progressed with inconsistencies between its general plan and zoning. Decisions about repairs and rebuilding would have been less controversial if the city's plan and regulations had been current and consistent before the earthquake. Good routine planning pays off.

3. **Planning tasks.** The time after the earthquake when the planning department was not very busy should have been spent reviewing and revising plans and ordinances to alleviate the inconsistencies which caused so many problems later.

4. **Redevelopment.** Redevelopment with tax increment financing is a key method of funding public investments in the area to rebuilt. The process also provides an opportunity to strengthen unsafe buildings.

Loma Prieta, 1989, A Warning of Events to Come

This account of rebuilding after the Loma Prieta Earthquake stems from a slide presentation by Richard Eisner, Director of the Bay Area Regional Preparedness Project, at the opening session of the symposium and from the field trip to damaged sites in Santa Cruz County the following day. Local planners and other officials met with us at each stop and the stories of the individual jurisdictions in the area are theirs.

Setting and Earthquake

Loma Prieta is the first California earthquake since San Fernando in 1971 to have regional impacts. Richard Eisner, Director of the Bay Area Regional Earthquake Preparedness Project, opened the symposium with an overview of some of these impacts. He noted that losses were high in the epicentral area and in widely dispersed locations in the Bay Area a long distance from the epicenter. In addition, the regional transportation system was disrupted with the temporary closure of the Bay Bridge and the loss of the Cypress structure, other elevated freeways and freeway bridges. The earthquake singled out areas with poor ground conditions or unsafe buildings for especially heavy blows. These areas include the San Francisco Marina district, downtown Oakland, Hollister, Los Gatos, Santa Cruz and Watsonville *(see Figure 4.3.1)*.

In his talk, Eisner showed that the damage pattern in the Loma Prieta earthquake was similar to the damage pattern in the 1906 San Francisco earthquake. This supports the notion that hazardous areas can be predicted based on past experience and planned for accordingly.

Although damage occurred throughout the region, the process of rebuilding is local, involving decisions by local planning commissions, city councils and boards of supervisors in a context of aid and requirements established by state and federal agencies. Local rebuilding is also influenced by regional conditions including a severe shortage of affordable housing, lean fiscal times for local governments and strong growth pressures. Thus, although the authority to plan and approve rebuilding rests with local government, it is strongly affected by regional factors beyond local government's control.

Loma Prieta Earthquake Data

Time: October 17, 1989, 5:04 p.m.
Magnitude: 7.1 Intensity: IX
62 people killed, 3,000 injured, 12,000 displaced
18,300 houses and 2,575 business damaged
Damage to bridges and freeways
Estimated total damage: $6 billion (1989 dollars) – ground shaking, ground failure and fire

The sections which follow are based on information gathered during the field trip to Santa Cruz County on the first day of the symposium. They describe how three jurisdictions – Santa Cruz County, the City of Santa Cruz and Watsonville – are dealing with particular rebuilding problems.

Figure 4.3.1. Collapse of the Cypress freeway accounted for most of the earthquake deaths. This photo shows the structure being demolished.

Santa Cruz County
Rebuilding in Areas of Failed Ground

The Santa Cruz Mountains, home of the San Andreas Fault, divide the populous Bay side of the San Francisco peninsula from the more rural Pacific coast. Earthquake damage was heavy to homes in the sparsely populated region of the Santa Cruz Mountains near the earthquake's epicenter. Here ground shaking was particularly violent and disturbance of the ground surface indicates that fault rupture or landsliding contributed to the damage (*see Figure 4.3.2*). The future safety of homesites in the mountains is uncertain, complicating decisions about rebuilding. With funds from FEMA, the Army Corps of Engineers is in charge of detailed geologic studies of the region to determine safe locations and conditions for rebuilding.

The first stop on the field trip was a homesite where ground cracking destroyed a house built 40 to 50 years ago before the county required any geologic investigations. William Cotton and Associates, a geotechnical firm, had dug a trench across the crack to explore its origin and potential for additional movement. The trenching was also designed to assess if the property contained a safer site for a new house (*see Figure 4.3.3*). Bill Cole and Burt Hardin, engineering geologists with the firm and Paia Levine, a geologist with Santa Cruz County met us at the site. Dianne Guzman, Santa Cruz County Planning Director, was present as a symposium participant.

Figure 4.3.2. Landslide in Santa Cruz Mountains on Highway 17. Photo courtesy of William Cotton & Associates.

Soon after the earthquake, the county began issuing permits in the field for minor repairs. "Then," as Ms. Guzman noted, "we began to learn from the geologists that we were dealing with a very complex situation." Within a week of the earthquake a preliminary map of cracks and fissures was completed based on aerial photographs and field observations. This map became the basis for delineating the "red zone" consisting of a broad band between the Zayante and San Andreas faults where the ground disturbance was greatest. Later, areas with particularly hazardous conditions, called "areas of critical concern" were mapped within the red zone (*see Figure 4.3.4*).

Soon after the map was done, the county imposed a moratorium on building permits on vacant lots pending completion of the federally-funded seismic and geologic studies started in November 1989. The county also prohibited repair and rebuilding of any building located in the "areas of critical concern" which was damaged more than 50 percent of its value. Buildings with less damage could be repaired if geologic review showed the site was not hazardous.

Figure 4.3.3. Symposium participants Yvonne Fortenberry, Miriam Greenbaum, Diane Guzman, Bob Stacey and Bob Olson observing ground cracks on the Wool property in the Santa Cruz Mountains.

Figure 4.3.4. Early map showing the Red Zone in the cross hatch pattern and the "areas of critical concern" in the solid dark pattern.

Figure 4.3.5. "Areas of critical concern" as refined by geologic studies.

But private geologists have been reluctant to conclude that sites are safe for rebuilding before completion of the regional studies. In some cases, they claim they cannot assess the stability of a site until after significant rains, but the region is in its fifth year of drought with no end in sight.

Based on geologic studies, the "areas of critical concern", were redrawn including less land *(see Figure 4.3.5)*. The areas still contain about 350 property owners. Most have opposed the restrictions on rebuilding, and the county has liberalized its initial requirements several times. Planning Director Guzman explained, "we now allow people to repair and rebuild if the only way to resolve geologic questions is to wait for a rainy winter." Then, the owner must sign a hold harmless waiver and a declaration waiving claims for losses if abatement of hazards is subsequently required by the county. Owners object to signing these waivers, because they find that financial institutions are generally unwilling to loan money for rebuilding if waivers are required.

Planning for rebuilding in this mountain region has been the most difficult technical and political problem facing the county. It is much easier to deny permits for building new houses than permits to repair or replace existing houses. Few people have the means to walk away from their homes and start over elsewhere. Disaster assistance is not much help in this situation.

Not unreasonably, residents cling fiercely to the emotional and economic investments in their homes.

Yet, the county faces a real ethical dilemma in permitting people to reoccupy sites which may fail catastrophically with heavy rains or future earthquakes. The geologic studies are still inconclusive. Some of the large landslides seem to be slow-moving endangering property, but not lives. The county may decide to allow people to move back if they understand the risks. The Board of Supervisors is currently split on the subject.

Santa Cruz County Rebuilding Timeline

1 week	*Preliminary map of ground cracks* *County began issuing repair permits*
2 weeks	*Moratorium adopted on new building* *Controls on rebuilding enacted*
1 month	*Rebuilding restrictions liberalized* *Corps of Engineers study begins*
2 months	*Technical Advisory Group (TAG) formed*
3 months	*Rebuilding restrictions further liberalized*
18 months	*TAG report released* *Decisions on rebuilding still pending*

City of Santa Cruz
Involving Citizens in Rebuilding

Santa Cruz is an old city of about 40,000 people with lovely beaches, many older people and a major university. In the 1960's, the City of Santa Cruz undertook a large redevelopment project to turn its aging and deteriorating downtown into a pedestrian-oriented, specialty shopping area called Pacific Garden Mall. Here, as in Whittier, many old unreinforced masonry buildings were refurbished without reinforcement to create a historic city center. The mall was almost totally destroyed in the earthquake. In Santa Cruz, Charles Eadie, Project Manager with the city redevelopment agency, told us about planning for rebuilding downtown Santa Cruz and the unexpected roles planners assumed after the earthquake. Then, Building Official, Dick Stubendorff led us on a tour of the Pacific Garden Mall *(see Figure 4.3.6)*.

Immediately after the earthquake, priorities were clear. Rescue crews searched for survivors in the rubble, and the Police Department cordoned off downtown to prevent further loss of life. After 5 or 6 days, a second more difficult phase began. At that time, Charles Eadie was brought in, because of his background working with downtown business people on plans for the area, to develop procedures to allow people back into unsafe buildings to retrieve stock *(see Figure 4.3.7)*. This became very controversial when business owners were given almost no warning and very little time to recover inventories from damaged buildings. It proved very difficult to balance concern for public safety with peoples' reasonable desires to save their belongings.

The city found it very difficult to absorb volunteers. City staff was too overworked to provide direction and more wanted to help than the city was prepared to use. Charles Eadie observed, ". . . there were three kinds of people: 1) the ones you hear nothing from; 2) the ones who freak out and ask 'What about me? What about me?' and 3) the ones who just roll up their sleeves and pitch in. We needed a way to use the third group to handle the second group." State and federal workers also required local direction.

To qualify for disaster assistance, it is important to quickly assess the damage. Sixty volunteer engineers showed up at the Watsonville airport, and one person was assigned the job of getting them rooms, cars,

Figure 4.3.6. Symposium participants on tour of Pacific Garden Mall. Building being repaired in background.

Figure 4.3.7. Merchants retrieving stock.

food, and maps. They were divided into teams, and using ATC 20, inspected the entire town in two days. Then during the next two weeks or so, they helped evaluate the safety of damaged buildings throughout town, determining which had to be demolished.

Property owners and historic preservationists were sharply split over the need to tear down buildings. The historic Cooper House had to be demolished soon after the earthquake – a terrible blow to the city's architectural heritage. Questions about the future of the historic St. George Hotel ended up in court only to be resolved when a fire in one end of the building did enough additional damage to render the decision moot *(see Figure 4.3.8)*. The building came down, leaving one demolition decision still pending 15 months after the earthquake.

The city lost 25 of 45 unreinforced masonry buildings on the mall. Before the earthquake, the council had refused to override property owner opposition and pass an ordinance mandating strengthening of these buildings. Now the city quickly adopted the previously rejected ordinance to establish standards for repairs and rebuilding. Downtown is located on deep alluvial soil which amplifies ground shaking. Innovative engineering is often required for building foundations here.

Before the earthquake, the mall was suffering economic problems and merchants were complaining that growing numbers of homeless and loiterers were driving shoppers away. Still land values were high and owners were talking about replacing two- and three-story buildings with four- and five-story buildings. The future character of downtown became the subject of intense community debate with strong differences of opinion among the various interest groups.

To try and forge a consensus, the city council formed a 36-member task force, called Vision Santa Cruz, to guide the planning for a new downtown. Vision Santa Cruz was a public-private partnership including people who were not used to talking to each other. This was a new concept in Santa Cruz, accepted because of the pressing needs for decisive action. So far the group has presided over a preliminary economic analysis and accepted an urban design framework. It is now working with consultants on a specific plan for Pacific Garden Mall. The city expects to rebuild the streetscape and infrastructure during 1991 *(see Figure 4.3.9)*.

The planning for rebuilding the mall has been difficult, because the city is trying to allow rebuilding while at the same time completing a complex planning process. Public participation is essential to

Figure 4.3.8. St. George Hotel shortly before it was demolished.

Figure 4.3.9. Planning a new downtown as seen in headlines from the Santa Cruz Sentinel.

City of Santa Cruz Rebuilding Timeline

1 week	*Debris removal begins* *Water and electric services restored*
2 weeks	*Historic Cooper House demolished*
1 month	*Tent pavilions open for businesses*
2 months	*Vision Santa Cruz formed*
3 months	*First FEMA trailer arrives*
4 months	*HUD temporary housing vouchers come*
5 months	*Bridges repaired* *First new building approved for mall*
7 months	*Council adopts rebuilding "principles"*
8 months	*Group formed to do a specific plan* *First business opens in repaired building*
15 months	*St. George Hotel demolished*
16 months	*Draft specific plan completed*

build the support for the plan, but it takes time, and some property owners are anxious to move ahead with rebuilding. Public expectations are high and may be unrealistic. The city anticipates that rents will be 20 to 30 percent higher in new buildings, meaning that the area must generate more business than before the earthquake. The economic facts may make it difficult to provide amenities, like a performing arts center, desired by many Santa Cruzans.

City of Watsonville
Rehousing and Redevelopment

Watsonville is an agricultural service town in the heart of artichoke country. A majority of its 30,000 people are Hispanic. The earthquake inflicted heavy damage on Watsonville's downtown and nearby neighborhoods of single family residences. Planning Director, Maureen Owens, described how the planning department responded to the earthquake in Watsonville and led us on a tour of the damaged downtown and adjacent residential streets *(see Figure 4.3.10).*

The first task after the earthquake was to assess the damage. Watsonville has a geo-based data system which gives the parcel number, address, zoning, general plan designation and size of every parcel in town. The city immediately acquired a new program

Figure 4.3.10. Maureen Owens explaining Watsonville's plans to Jim McKenzie, Bob Sturdivant, Elvin Porter, and Michael Devers.

Figure 4.3.11 Single family home being repaired.

to add damage information to the data base. State fire inspectors were sent in to help with the damage inspections. Each was given a map and asked to color each parcel inspected the same color as the tag the building received – red, yellow or green. This provided a clear picture of the damage pattern.

Some 650 single family homes near downtown were tagged red or yellow, and thus, were uninhabitable after the earthquake. Most of the red-tagged houses fell off their foundations and some had to be demolished; however, most of the owners are deciding to repair their homes by jacking them up and building new foundations underneath *(see Figure 4.3.11)*. Some of the yellow tags where issued because of gas leaks which were fixed soon after the earthquake. The loss of housing added to an already severe shortage of affordable housing, overcrowding and poor housing conditions in the community.

Emergency shelters were opened right after the earthquake, followed by temporary mobile homes for displaced families. The city quickly prepared sites for FEMA trailers on public or quasi-public land – the fairgrounds and the St. Francis School. Planning Director Owens said, "the city really needed the trailers, but finding suitable sites posed problems. The mobile home parks are ugly. Residents in adjacent single family neighborhoods have accepted them as necessary under the circumstances, but do not want them as permanent uses." By spring 1991, all but a few trailers at one site had been removed by FEMA.

Downtown Watsonville lost most of its unreinforced masonry buildings in the earthquake *(see Figure 4.3.12)*. Most had not been brought up to building code standards for fire protection and were vacant above the first floor. At the time of the earthquake, the city was in the process of redeveloping downtown. One downtown block had been cleared of unreinforced masonry buildings to make way for a post office and another commercial project before the earthquake and the city expects those projects to move forward.

Figure 4.3.12. Downtown buildings damaged in earthquake.

The owners of downtown property seem anxious to rebuild and the city is paving the way for rapid rebuilding by approving projects expeditiously, granting variances if needed, and working cooperatively with the business community. In the meantime, Watsonville had commercial vacancies and a new shopping center just coming on line at the time of the earthquake. Displaced downtown retailers were able to move into available space and little business has been lost.

As a result of the earthquake, the city is redoing both its general plan and the redevelopment plan for downtown. Both will call for a mix of retail, commercial and housing uses in downtown and additional housing construction to meet the need for affordable housing. Watsonville also will be reviewing and improving building standards, increasing inspections of facilities storing hazardous materials, reviewing ways to reduce nonstructural damage in industrial buildings, and separating gas and electric lines to mobile home parks. It is also seeking better ways to regulate building on manmade fill, peat and shrink-swell soils and better standards for repair, particularly of foundations.

City of Watsonville Rebuilding Timeline

1 week	*Debris cleared*
2 months	*1st downtown rebuilding plan approved*
3 months	*FEMA trailers arrive* *Last Red Cross shelter closed*
4 months	*Downtown rebuilding committee formed* *Plans for one block submitted* *Ford's Department Store reopens in temporary quarters downtown*
6 months	*Urban Land Institute downtown plan released*
18 months	*Rebuilding underway*

Findings – Loma Prieta Earthquake

1. **Geologic information.** Responsible decisions about rebuilding in areas of ground failure in the Santa Cruz Mountains require geologic and seismic information. These areas were delineated quickly on a preliminary basis so that repairs and rebuilding could proceed without delay in less hazardous areas of the county.

2. **Subdivisions.** Decisions to subdivide land are particularly important. Once land is divided and lots sold, it is very difficult to prevent building on a lot no matter how unsafe it may prove to be. Waivers have limited value, in part because the person originally agreeing to accept the risk is often not the person exposed when disaster strikes.

3. **Pre-earthquake planning.** Santa Cruz County found it easier to regulate new development to prevent unsafe location of buildings than to prevent the repair or replacement of existing buildings. A good planning job before an earthquake can avert the most difficult problems afterwards.

4. **Public participation.** Public participation in planning takes time which inevitably delays rebuilding. Yet, failure to provide for public participation, in the long term, can lead to serious delays if opposition to rebuilding projects arises.

5. **Timing.** Santa Cruz has tried to balance the need to plan and the need to rebuild quickly by starting with general guidelines for rebuilding which are being refined as the process goes on. Rebuilding projects consistent with the early guidelines are being approved without waiting for completion of the specific plan.

6. **Hazardous building ordinances.** The City of Santa Cruz could have averted much damage by implementing a hazardous building ordinance before the earthquake. Such an ordinance, even if not implemented in time, is helpful after the earthquake to provide standards for repair and rebuilding.

7. **Redevelopment.** Redevelopment plans and procedures are being used in both Santa Cruz and Watsonville to plan and finance public improvements in support of downtown rebuilding.

8. **Housing.** In both Santa Cruz and Watsonville, pre-earthquake housing problems became much worse post-earthquake housing problems. Rehousing might have been easier if there had had been more support for housing programs before the earthquake.

Chapter 5

Timeline for Rebuilding

A timeline was created during the symposium and served as an organizing device for the presentations. We asked each presenter to provide the beginning dates, milestones and completion dates for seven rebuilding activities: clearance, rehousing, restoration of infrastructure, business recovery, replacement of public facilities, and planning. The presenters were also asked to designate when rebuilding after the earthquake was completed. Participants added entries to the timeline using colored paper markers - a different color for each activity. Also for each activity, initial steps were indicated by circles, milestones by triangles, and completion by hexagons. As shown in *Figure 5.1*, the timeline is like a work of art begging for interpretation. The following sections present general observations drawn from review of the timeline, followed by more specific comments on the timing of each of the seven rebuilding activities.

General Observations

A glance at the timeline tells us that rebuilding is a long-term process. Only the presenters of the Friuli, Italy and Mexico City experiences considered reconstruction complete. They estimated that it took nine years and four years, respectively. In El Asnam, reconstruction is expected to be finished in 1992, twelve years after the earthquake. Central districts are not fully rebuilt in Skopje after 28 years or in Managua after 19 years. Given economic and political complications and the high level of destruction, rebuilding in Armenia is likely to also take at least a decade.

In the cases of the California earthquakes, which were less damaging than the foreign ones, rebuilding also takes a long time. Coalinga is still struggling to rebuild its downtown eight years after the earthquake. In Whittier the first new buildings are now opening in the damaged Uptown Area after three years. Actual rebuilding is just beginning in the second year after the Loma Prieta earthquake and every indication is that it will take at least a decade.

Stepping back and looking at the rebuilding timeline reveals some tendencies regarding the sequence of activities and how long they take. *Figure 5.2* synthesizes the timeline entries for the individual earthquakes by activity. It shows clusters of activity in the first week, and at one month, six months and

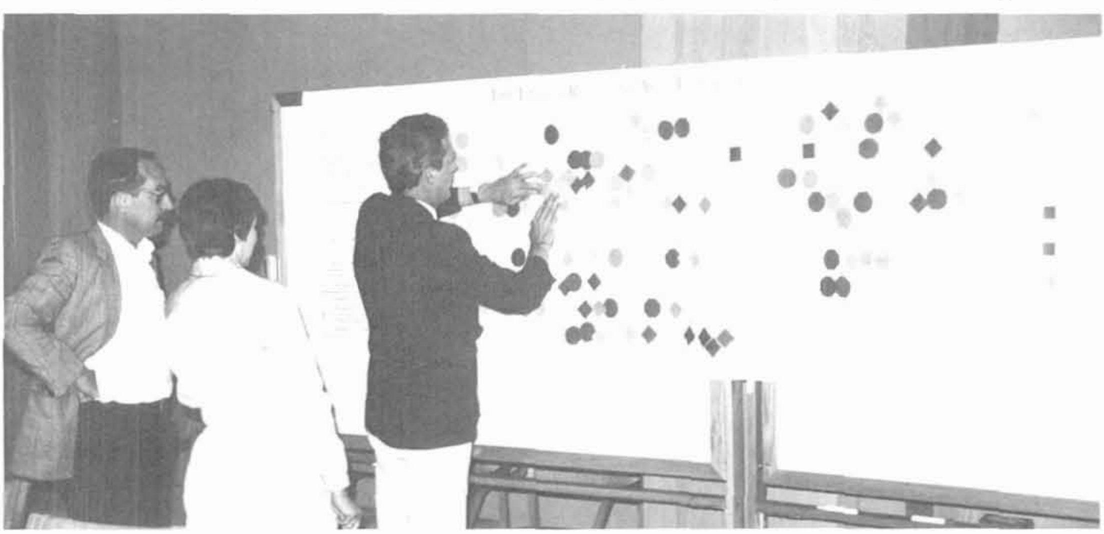


Figure 5.1. Foreign presenter Roberto Pirzio Biroli pastes symbols onto the timeline as Martha Blair Tyler and Farouk Tebbal look on.

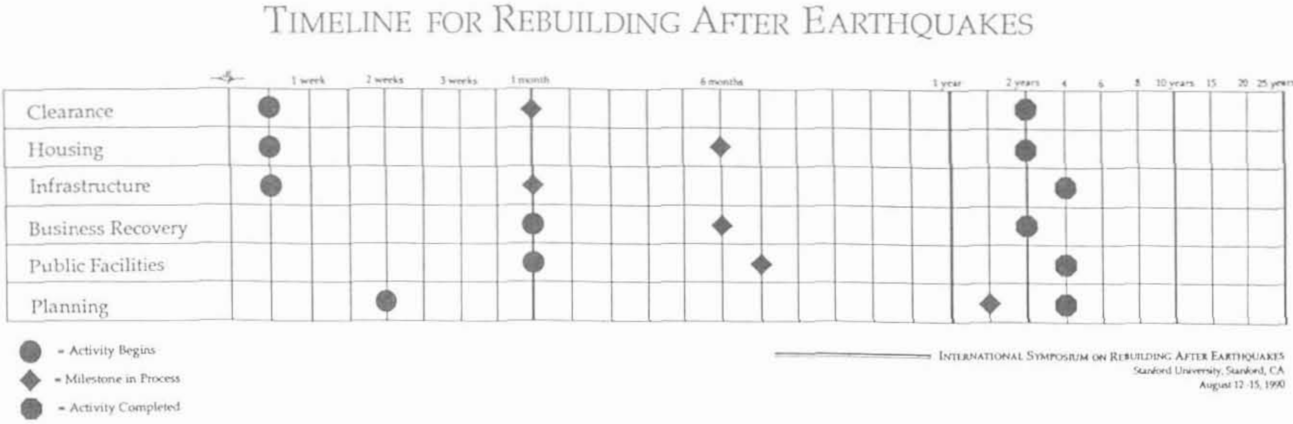


Figure 5.2. Summary of rebuilding timeline.

two years after the earthquakes. By the end of a month all the activities are usually initiated. This first month is devoted to clearance, providing emergency shelter and very temporary housing and patching up utility service and infrastructure. The basic needs of people are met and community functions are restored at least on an interim basis.

The rest of the first year after an earthquake is typically spent preparing for rebuilding. During this phase, demolition and debris removal are completed, temporary housing is provided, temporary business locations are established, and buildings and facilities with minor damage are repaired. Permanent repairs of infrastructure and some public facilities may be started. Planning for rebuilding the most heavily damaged areas is an ongoing activity during this time. At the end of the first year, permanent repairs and rebuilding of damaged facilities and buildings starts.

By two years, significant rebuilding has usually occurred, with or without plans, and the rebuilding which remains usually includes city centers or areas with specific geologic problems or public controversy. Completing reconstruction of these more problematic areas usually takes a decade or more. The actual length of time depends on many factors including the extent of damage, the vigor of local and national economies, the pace of public and private decisionmaking, and the availability of funding.

The sequence of rebuilding activities gives planners some idea of what to expect and when planning intervention might be most appropriate. It appears that many of the parameters of the rebuilt city are determined within one month and that planners need to act quickly during this period to identify and prevent the loss of significant planning opportunities.

Clearance

Clearance includes both debris removal and demolition. These activities are well-defined and the presenters seem to have provided comparable information. Debris removal started within a week of the earthquake in all cases but El Asnam, and was usually completed within the first month. The process is complicated by aftershocks which may necessitate starting over again. Also, deciding which buildings are too damaged to be safely repaired can raise difficult technical and value questions, particularly if historic or symbolically important buildings are involved. If public participation is a part of the process, considerable time can be spent making decisions about demolition.

The timeline shows that clearance took between one month in Armenia where damage was near total leaving few decisions about demolition, to over one year in Managua and El Asnam. The process was completed after the other foreign earthquakes at about six months. With the exception of the City of Santa Cruz, clearance after the California earthquakes was completed within two months. Santa Cruz faced a controversial decision about demolishing an historic hotel which was finally made 15 months after the earthquake.

Housing

The process of rehousing people after earthquakes tends to be done in three stages. First, emergency housing, usually consisting of shelters in undamaged public buildings and tents, is rapidly provided – typically within the first week or two. It is used primarily by those who cannot find immediate shelter with family or friends. It is intended as short-term housing and usually used for less than a month.

If other housing options are available, most displaced people will find suitable housing by the end of a month. However, when housing is in short supply and temporary housing is needed to bridge the gap to permanent rehousing, emergency shelters can stay in operation much longer. In Friuli, tents arrived a month after the earthquake; prefabs were not in place for another year and a half. In Watsonville, Red Cross shelters stayed open for three months because of problems finding affordable housing for victims.

Second, temporary housing consisting of trailers, prefab housing or vouchers allowing victims to rent existing vacant units might be provided. Temporary housing is usually in place a month after the earthquake. For trailers and prefab housing, sites must be selected and provided with infrastructure and the units installed. The time needed to accomplish this varies greatly. In Skopje, 14,000 prefab units were built in five months. El Asnam had temporary housing under construction in eight months and in Friuli, it took 18 months.

In the California earthquakes, temporary housing was provided either by vouchers or trailers. Trailers were installed in Coalinga less than a month after the earthquake, but it took more than three months in Santa Cruz County and Watsonville. Housing vouchers were authorized for Santa Cruz County four months after the earthquake and are still in use more than a year later.

The third stage in rehousing is providing permanent housing either through repair of damaged dwellings or construction of new units. In Skopje, Friuli, El Asnam and Mexico City, this was accomplished in two years, in some cases by recognizing prefab housing as permanent. Housing construction still lags in Managua and Armenia.

The California earthquakes caused less damage to housing than the foreign ones, leading to a faster process of rehousing through repair rather than rebuilding. In Coalinga, most houses were repaired in six months and Watsonville anticipates completing housing repairs in 18 months.

Infrastructure

Transportation and communications networks and utilities are critical to community recovery and the process of rebuilding. In the worst of circumstances, the infrastructure is usually back in operation within days or weeks and permanently restored within six to nine months. In the California earthquakes, infrastructure repairs were all completed within a week or two. However, the Loma Prieta earthquake destroyed or damaged freeway structures in Oakland and San Francisco which are not yet repaired or replaced 18 months after the earthquake. Specific infrastructure failures, because of engineering or geologic problems, funding constraints, or public policy implications can take much longer than average to repair or replace.

Business Recovery

In the broadest sense, this activity refers to restoration of the economy – all industry and commerce. The timeline provides incomplete information on this activity, but seems to indicate that industrial recovery occurs quite rapidly without much direct governmental involvement. The biggest problems appear to be reestablishing retail and other business operations typically found in downtowns. Most of the earthquakes described during the symposium substantially damaged central districts containing a city's major commercial and public buildings. Thus, restoration of lost commercial space may be linked to reconstruction of the city center – often the last reconstruction task to be completed.

Yet, pre-earthquake levels of business activity are usually reached before the damaged commercial structures are repaired or rebuilt. Often businesses relocate in other parts of a community or in a new community. Such relocation, sometimes initially viewed as temporary, often becomes permanent and can undermine the support for business recovery in the damaged commercial area.

In Skopje, businesses started to reopen a month after the earthquake and industry and commerce were back on line in seven months. At two months, a temporary business center opened in Managua, but full recovery of the central business district has not yet been achieved 19 years later. Factories and offices were reopened two months after the Friuli earthquake and shops reopened in temporary space. By four months the shops were in permanent space. In Mexico City and El Asnam, businesses began reopening in the first month and by two years, business activity was at normal levels. Agriculture, industry and commerce were operating in Armenia three months after the earthquake. Although individual businesses may fail or permanently relocate, business activity seems to reach pre-earthquake levels in one to two years.

In California, business recovery often occurs in two stages – temporary relocation and reopening at permanent locations. In Coalinga, Whittier, and the City of Santa Cruz, action was taken immediately after the earthquakes to find temporary space for displaced downtown businesses. Coalinga used a community college gymnasium on an emergency basis followed by trailers. Whittier used trailers, and Santa Cruz used tent pavilions – all installed about a month after the earthquake. By two years, most businesses were in permanent space in Whittier and surviving businesses were rehoused in Coalinga. Santa Cruz and Watsonville, 17 months after the earthquake, are seeing the beginnings of downtown rebuilding, but because of relocation, business activity is at near normal levels. As with the foreign earthquakes, business recovery appears to be about a two-year process.

Public Facilities

The distinction between public and private is not the same in all the countries represented at the symposium and the timeline data on this activity are difficult to interpret. For example, in Armenia, all the buildings are public. In general, however, repair and rebuilding of high-priority public facilities, such as hospitals and schools usually begins immediately. In Friuli, prefab schools were set up two weeks after the earthquake even before tent shelters were provided. In Mexico City, schools were reopened in temporary structures, including buses, within weeks of the earthquake. On the other hand, rebuilding other public facilities such as city halls, libraries and museums tends to be delayed while more pressing needs are met. City centers, containing complexes of public buildings, are still not finished in Skopje, Managua, and El Asnam many years after the earthquakes.

In the California earthquakes, downtown rebuilding, often including public buildings, seems to be the last reconstruction task to be completed. It may be that the reconstruction of all public buildings signals the completion of rebuilding after earthquakes.

Planning

Planning is a function throughout the rebuilding, but is inconsistently related to actual rebuilding. It sometimes leads and sometimes trails rebuilding. Of all the activities, it is the least well-defined in terms of both content and timing. Most repairs and much building replacement occur according to existing plans and planning regulations, requiring little new effort. However, where damage is extensive or caused by ground failures, new plans and regulations may be needed.

In the foreign earthquakes, formal reconstruction planning started one week to three years after the earthquake and was completed five months to nine years after the earthquake. Managua took the longest to plan, looking at the rebuilding of Managua in a broad regional context and relating it to national policy on population distribution. Here the planning, and the rebuilding, is not yet finished. On the other hand, rebuilding plans for Armenia were completed in five months, but rebuilding is moving ahead slowly. In El Asnam, both planning and rebuilding were deferred pending the completion of seismic zonation studies delineating potentially hazardous areas.

In most of the California cases, reconstruction plans were prepared for damaged downtowns as redevelopment plans. All the cities had redevelopment projects prior to the earthquakes and were able to prepare or revise plans within the first year. In addition, Whittier adopted a specific plan for its business district about two years after the earthquake and Santa Cruz adopted a specific plan for its downtown 18 months after the earthquake. Somewhat like El Asnam, Santa Cruz County is engaged in geologic and seismic studies prior to making decisions about rebuilding. It appears that this process will take one and a half to two years.

International Symposium on Rebuilding After Earthquakes

Stanford University, Stanford, California
August 12-15, 1990

Sunday, August 12, 1990

3:00 - 5:00 PM	SYMPOSIUM REGISTRATION Schiff House, Governor's Corner, Stanford University.
6:30 PM	OPENING RECEPTION, STANFORD FACULTY CLUB Welcoming by Tom Tobin, Executive Director, California Seismic Safety Commission; Presentation on Loma Prieta Earthquake (1989) by Rich Eisner, Director, Bay Area Regional Earthquake Preparedness Project (BAREPP).

Monday, August 13, 1990

9:00 AM - 6:00 PM	FIELD TRIP TO VIEW EFFECTS OF LOMA PRIETA EARTHQUAKE OF OCTOBER 17, 1989 STOP 1: SANTA CRUZ MOUNTAINS NEAR EPICENTER, SANTA CRUZ COUNTY Presentations by William Cole and Burt Hardin, Senior Engineering Geologists, William Cotton and Associates, Inc. and Paia Levine, County Geologist, County of Santa Cruz. STOP 2: CITY OF SANTA CRUZ Presentation by Charles Eadie, Project Manager, City of Santa Cruz Redevelopment Agency; Lunch; Walking tour of damaged Pacific Garden Mall led by City Building Official, Dick Stubendorff. STOP 3: CITY OF WATSONVILLE Presentation by Maureen Owens, Planning Director, City of Watsonville; Walking tour of damaged downtown area. STOP 4: VIEW OF SAN ANDREAS FAULT Stop along Interstate 280 in Santa Cruz Mountains.
7:00 PM	INFORMAL DINNER Gatehouse Restaurant, 227 Lytton Avenue, Downtown Palo Alto.

TUESDAY, AUGUST 14, 1990

Sessions on Tuesday and Wednesday structured similarly with approximately 50-minute presentations followed by 25 minutes for questions and answers and group discussions. All sessions located in the Hartley Conference Center of the Mitchell Building.

9:00 - 10:15 AM	REBUILDING AFTER SKOPJE, YUGOSLAVIA EARTHQUAKE (1963) Presentation by Marjorie Greene, Project Planner, Bay Area Earthquake Preparedness Project (BAREPP), Oakland, CA.
10:30 - 11:45 AM	REBUILDING AFTER MANAGUA, NICARAGUA EARTHQUAKE (1972) Presentation by Luis Ramirez Velarde, Planning Advisor, Nicaraguan Institute for Territorial Studies (INETER), Managua, Nicaragua.
12:00 - 2:00 PM	LUNCHEON - PANEL DISCUSSION OF WHITTIER, CA (1987) AND COALINGA, CA (1983) EARTHQUAKES, STANFORD FACULTY CLUB Moderator: Paul Flores, Director, Southern California Earthquake Preparedness Project (SCEPP); Presentations by Elvin Porter, Planning Director, City of Whittier and Dave Bugher, Planning Director, City of Coalinga.
2:00 - 3:15 PM	REBUILDING AFTER FRIULI, ITALY EARTHQUAKE (1976) Presentation by Roberto Pirzio Biroli, Architect, Udine, Italy.
3:30 - 4:45 PM	REBUILDING AFTER EL ASNAM, ALGERIA EARTHQUAKE (1980) Presentation by Farouk Tebbal, Head of Staff, Ministry of Equipment, Algeria.
6:30 PM	DINNER AT MADER RESIDENCE, MENLO PARK.

WEDNESDAY, AUGUST 15, 1990

9:00 - 10:15 AM	REBUILDING AFTER MEXICO CITY, MEXICO EARTHQUAKE (1985) Presentation by Jorge Gamboa de Buen, Coordinator General of Urban Reconstruction and Ecological Protection, Mexico City, Mexico.
10:30 - 11:45 AM	REBUILDING AFTER ARMENIA, USSR EARTHQUAKE (1988) Presentation by Aleksander Krivov, Deputy Chairman of Goscomarchitecture, Moscow, USSR.
12:00 - 1:00 PM	LUNCHEON - PRESENTATION ON LOS ANGELES RECOVERY PLANNING PROCESS Presentation by Ken Topping, Planning Director, City of Los Angeles.
1:00 - 3:45 PM	PANEL DISCUSSIONS ON KEY REBUILDING ISSUES Moderator: Tom Tobin, Executive Director, California Seismic Safety Commission; Panel Discussants: Paula Schulz, Deputy Director, BAREPP; Ludo van Essche, United Nations Disaster Relief Organization; Bob Olson, VSP Associates, Inc.; Henry Lagorio, National Science Foundation; Martha Blair Tyler, Prinicipal Planner, William Spangle and Associates, Inc. (WSA); and, George G. Mader, President, WSA.
4:00 PM	SYMPOSIUM CLOSING

INTERNATIONAL SYMPOSIUM ON REBUILDING AFTER EARTHQUAKES
Stanford University, Stanford, CA
August 12 -15, 1990

PRESENTERS

Jorge Gamboa de Buen	Coordinator General of Urban Reconstruction and Ecological Protection, Mexico City, Mexico
Marjorie Greene	Project Planner, Bay Area Regional Earthquake Preparedness Project, Oakland, California
Aleksander Krivov	Deputy Chairman of Goscomarchitecture, Moscow, USSR
Roberto Pirzio Biroli	Architect, Udine, Italy
Luis Ramirez Velarde	Planning Advisor, Nicaraguan Institute for Territorial Studies, Managua, Nicaragua
Farouk Tebbal	Head of Staff, Minstry of Equipment, Algeria

U.S. PLANNING DIRECTORS

Don Alspach	Deputy Planning Director, City of Anchorage, Alaska
Jerold Barnes	Planning Division Director, Salt Lake County, Utah
Dave Bugher	Planning Director, City of Coalinga, California
Ron Fong	Planning Director, St. Louis Community Planning Agency, City of St. Louis, Missouri
Yvonne Fortenberry	Planning Director, City of Charleston, South Carolina
Miriam Greenbaum	Manager, King County Planning & Resource Department, Seattle, Washington
Dianne Guzman	Planning Director, County of Santa Cruz, California
Alvin James	Planning Director, City of Oakland, California
Jim Lawson	Planning Director, City of Little Rock, Arkansas
Elvin Porter	Planning Director, City of Whittier, California
Dave Ralston	Manager of Planning, City of Memphis, Tennessee
Gary Schoennauer	Planning Director, City of San Jose, California
Robert Stacey	Acting Planning Director, City of Portland, Oregon
Robert Sturdivant	Chief Planning Officer, County Advanced Planning, Santa Clara County, California
Kenneth Topping	Planning Director, City of Los Angeles, California

PANELISTS AND RESOURCE PERSONS

Michael Devers	Chief of Administrative Officer, Manager, Earthquake Recovery Unit, County of Santa Cruz, California
Richard Eisner	Director, Bay Area Regional Earthquake Preparedness Project, Oakland, California
Paul Flores	Director, Southern California Earthquake Preparedness Project, Los Angeles, California
Henry Lagorio	Earthquake Hazard Mitigation Liaison, National Science Foundation, Washington D.C.
Jim McKenzie	Executive Director, Metroplan, Council of Governments for Little Rock & North Little Rock Metropolitan Areas, Little Rock, Arkansas
Robert Olson	President, VSP Associates, Inc., Sacramento, California
Daniel Ruiz Fernandez	Secretary General of Public Works, Mexico City, Mexico
Paula Schulz	Deputy Director, Bay Area Regional Earthquake Preparedness Project, Oakland, California
L. Thomas Tobin	Executive Director, California Seismic Safety Commission
Ludovic van Essche	United Nations Disaster Relief Organization, Geneva, Switzerland

George G. Mader	President, William Spangle & Associates, Inc.
Thomas C. Vlasic	Vice-President, William Spangle & Associates, Inc.
Martha Blair Tyler	Principal Planner, William Spangle & Associates, Inc.
Laurie A. Johnson	Associate Planner, William Spangle & Associates, Inc.