UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

REDUCING LOSSES FROM EARTHQUAKES THROUGH PERSONAL PREPAREDNESS

by

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Open-file Report 84-765

1984

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ABSTRACT

Many ways have been developed for reducing earthquake hazards. Personal preparedness is just one of these ways and includes, among many others: inspecting and strengthening the home, organizing the neighborhood, and securing nonstructural objects. Personal preparedness is a very important phase in what should be an unbroken chain of tasks extending from long-term mitigation before an earthquake, through response during an earthquake, to recovery and reconstruction after an earthquake.

INTRODUCTION

Actions to reduce earthquake hazards can be divided into five phases: two before the event, one during the event, and two after the event. These five phases are: (1) pre-event mitigation techniques which may take 1 to 20 years, (2) preparedness measures which may take 1 to 20 weeks, (3) response during the event, (4) recovery operations following the event which may take 1 to 20 weeks, and (5) post-event reconstruction activities which may take 1 to 20 years. Obviously, those times will vary depending upon the magnitude of the

earthquake and the resources available to the community and metropolitan area.

Preparedness is just one phase of hazard reduction; personal preparedness is just one aspect of that phase. For example, the Council of State Governments (1976) suggests an outline for a comprehensive state emergency preparedness plan and the Western States Seismic Policy Council (1984, Appendix A) reports on the status of states' earthquake preparedness projects. The Southern California Earthquake Preparedness Project (1983), through "planning partner" arrangements with selected public jurisdictions and private entities, has developed prototypical planning guidelines for responding to, and recovering from, an earthquake. The Federal Emergency Management Agency recently funded the Central United States Earthquake Consortium -- the nation's first effort to develop and coordinate earthquake preparedness activities in a region composed of several states. Corporate, utility, and governmental preparedness (as well as mitigation, response, recovery, and reconstruction) can be very complex; discussion of these is beyond the scope of this paper.

A prerequisite to personal preparedness is familiarity with and concern about all hazard-reduction phases. For example, strengthening the structure of the home, storing water, and showing family members how to shut off the electric-, gas-, and water-supply lines are only a part of one phase -- personal preparedness. Equally important are the other phases which might include picking up children from an evacuated school, securing heavy objects at the work place for the safety of a spouse, and retrofitting the commuter-highway overpasses needed to reunite a family. For purposes of this paper, we will introduce all five hazard-reduction phases.

MITIGATION TECHNIQUES

Many techniques for reducing earthquake hazards before the event are available to planners, engineers, and decisionmakers. Some of these techniques are well known to the planning profession, such as public acquisition of hazardous areas; or to the engineering profession, such as designing and constructing earthquake-resistant structures. Others are obvious, such as warning signs and regulations. Still others have been successfully used in solving landslide, flood, and soil problems, but have not heretofore been applied to earthquake hazards.

These and other techniques are listed in Table 1 under the general headings of discouraging new development, removing or converting existing unsafe development, providing financial incentives or disincentives, regulating new development, protecting existing development, and ensuring the construction of earthquake-resistant structures.

These techniques may be used in a variety of combinations to help reduce both existing and potential earthquake hazards. Most of them are long range, taking from 1 to 20 years or more to prepare, adopt, and execute. Many of the techniques have been discussed and illustrated by William Spangle and Associates, and others (1980), Brown and Kockelman (1983), Kockelman (1983), Blair and Spangle (1979), Nichols and Buchanan-Banks (1974), and Jaffee and others (1981).

Table 1. Some mitigation techniques for reducing earthquake hazards

Discouraging new development in hazardous areas by:

Adopting seismic-safety or alternate-land-use plans
Developing public-facility and utility service-area policies
Disclosing the hazards to potential buyers
Enacting Presidential and gubernatorial executive orders
Informing and educating the public
Posting warnings of potential hazards

Removing or converting existing unsafe development through:

Acquiring or exchanging hazardous properties
Clearing and redeveloping blighted areas before an earthquake
Discontinuing nonconforming uses
Reconstructing damaged areas after an earthquake
Removing unsafe structures

Providing financial incentives or disincentives by:

Adopting lending policies that reflect risk of loss
Clarifying the legal liability of real-property owners
Conditioning Federal and state financial assistance
Making public capital improvements in safe areas
Providing tax credits or lower assessments to property owners
Requiring nonsubsidized insurance related to level of hazard

Regulating new development in hazardous areas by:

Creating special hazard-reduction zones and regulations
Enacting subdivision ordinances
Placing moratoriums on rebuilding
Regulating building setbacks from known hazardous areas
Requiring appropriate land-use zoning districts and regulations

Protecting existing development through:

Creating improvement districts that assess costs to beneficiaries
Operating monitoring, warning, and evacuating systems
Securing building contents and nonstructural components
Stabilizing potential earthquake-triggered landslides
Strengthening or retrofitting unreinforced masonry buildings

Ensuring the construction of earthquake-resistant structures by:

Adopting or enforcing modern building codes
Conducting appropriate engineering, geologic, and seismologic studies
Investigating and evaluating risk of a proposed site, structure, or use
Repairing, strengthening, or reconstructing after an earthquake
Testing and strengthening or replacing critical facilities

PREPAREDNESS MEASURES

Preparedness measures are necessary because long-range mitigation techniques can not completely reduce all damage and all threats to life safety. In addition, preparedness is applicable to home, school, and place of work and enhances disaster response. Important personal preparedness measures include:

- Storing emergency supplies for survival, sanitation, safety, and cooking.
- Knowing first-aid and water-purification procedures.
- Developing or being familiar with evacuation routes and deciding on a place for the reunion of the family.
- Learning how to shut off gas-, electric-, and water-supply service lines.
- Securing valuable and nonstructural objects to prevent damage or personal injury.
- Keeping portable extinguishers and garden hoses ready for fighting fires.

Preparedness measures can be taken anywhere from 1 to 20 weeks or more before an event. An excellent booklet by Lafferty (undated) on earthquake preparedness includes: suggested topics for family discussions, family-member assignment check list, community-awareness check list, list of food items for a 2-week emergency supply, suggested replacement periods for stored food, and sample menus for the first 72 hours after an earthquake. Another booklet, by the American Red Cross (1982), includes: extensive lists of home-emergency supplies, procedures for purifying water, first-aid instructions, and an earthquake-survival test. These preparedness measures provide not only for increased safety and reduced damage, but have the additional value of giving people confidence in their ability to cope with a disaster.

Many of us are overwhelmed by the broad range of techniques, measures, operations, and activities available for reducing earthquake hazards; this feeling is completely justified. However, we should make an effort to be personally prepared. There are several reasons **not** to be prepared for an earthquake; those reasons are restated (and refuted) in Figure 1.

Three personal preparedness measures are discussed here: inspecting and strengthening the home; organizing the neighborhood, school, church, or civic group; and securing heavy or valuable objects around the home, school, or workplace.

Inspecting and Strengthening the Home

The 1971 San Fernando earthquake provided lessons in the types of home structures most likely to fail. Potential weaknesses include numerous cracks that penetrate the entire foundation, unbolted sill plates, cripple walls, lack of solid sheeting or shear panels, unreinforced masonry chimneys, poorly attached masonry veneer, lack of diagonal bracing, large window openings, and untied terra cotta or slate roofing tiles.

A special report by Sunset Magazine (1982) on **Getting Ready for a Big Quake** provides general instructions on how to check your home for both structural and nonstructural safety, and how to make it more earthquake resistant. Additional reference material includes **The Home Builders Guide for Earthquake Design** by Shapiro, Okino, Hom, and Associates (1980), **An Earthquake Advisor's Handbook for Wood-Frame Houses** edited by Chusid (1980), and **Peace of Mind in Earthquake Country** by Yanev (1974).

Figure 1. -- **Seven Reasons Not to Get Ready for an Earthquake**

Reason #1 If a bad earthquake hits, we'll all be dead anyway.
Not true. There may be a lot of fatalities, but many more people will be alive -- and your loved ones may be among those who need your help. This is similar to the "why wear your seat belt" response: defeatist.

Reason #2 If I had food, I'd have to defend it with a gun against all the people who wouldn't have food.
Deciding to store emergency supplies is a personal decision. Some people store much more than they will need, in order to be able to give to others. Other people are organizing their entire block or neighborhood so they aren't the only ones with food. Cooperation is a key to survival. Naturally, you will have to make up your own mind. But ask yourself honestly: how would you react if faced with a life or death situation? Would you steal or kill for your family members? Why not prepare, and spare yourself that predicament.

Reason #3 The rest of the country will come to our aid. Helicopters will be here in no time to drop food and water.
Take a second to think about recent disasters in this country. First of all, none have been on the scale of a good-sized earthquake -- the kind we already know can happen in the Bay Area. Federal or state aid takes days to organize and mobilize; meanwhile, you are on your own. Transportation of emergency supplies will be hampered by destroyed highways, overpasses, train tracks,

Reason #4 I have enough food in my house to last quite a while.
Take another look. In many homes, much of that food is perishable (in your refrigerator or freezer, which may no longer work) or unsuitable (requires cooking or is nutritionally forgettable -- marshmallows, chocolate chips, etc.). Water is even more important. You can live for awhile without food, but it is curtains if you don't have water. If you have a pool in your back yard and a water filter in your emergency kit, you are in A-1 shape. Don't depend on a water heater tank; pipes may rupture and the water may leak out.

Reason #5 I don't have any room to store emergency goods.
Some kits are quite compact and can fit in a linen closet or under a bed. In a small apartment, emergency food and equipment may mean making some changes. But what is more important? 15 pairs of shoes on the closet floor, or food and water that could save your life???

Reason #6 Storing food in your house is useless, because the house will fall down on it. It could be inedible, or impossible to get to.
Possible. If you have a garden shed or a free-standing garage, that might be a safer storage area. But again, wouldn't you rather be trying to figure out how to get to the food after your house falls down, than trying to figure out where to buy, beg, or steal water and food?! If this is a big concern to you, you could have your house inspected to see how likely it is to withstand an earthquake, and what structural changes could improve those chances.

Reason #7 It will never happen to me.
Talk to someone from Coalinga.

Source: Mele Kent (1983) from an interview with Randy Shadoe; reprinted by permission.

Organizing the Neighborhhod

State and Federal assistance takes days to organize and mobilize; see Figure 1, reason nos. 2 and 3. However, immediate help is usually available from your neighbors and friends. According to Popkin, a study by Haas and others (1977, p. xxix) suggests that "families in the United States rely on institutional support for post-disaster assistance, with help from relatives and friends or self-help playing only a small part in their recovery." Neighborhood groups can very often bridge this gap and can influence government decisionmakers in order to expedite recovery operations and reconstruction activities. Sunset Magazine (1982) gives an outline for organizing a neighborhood preparedness group and provides a sample registration form. The Southern California Earthquake Preparedness Project (1983) has developed a neighborhood self-help planning guide which tells how to set up a community program.

Securing Nonstructural Objects

People have been hurt by falling light fixtures, flying glass, overturning shelves, and spilled toxins. The Federal Emergency Management Agency (1981, Table 2) estimates that one-third of the property lost in future earthquakes in California will be attributed to building contents. Such contents are only one part of the nonstructural portion of a building.

Nonstructural damage is caused by object inertia or building distortion. For example, if an office computer or file cabinet is shaken, only friction will restrain it from overturning, falling, or impacting against its user. As the

structure bends or distorts, windows, partitions, and other items set in the structure are stressed, causing them to shatter, crack, or spring out of place. Numerous protective countermeasures are available, including:

- Bolting down pedestal bases of sharp or heavy office machines, equipment, and fixtures.
- Tying fragile artwork to the walls.
- Connecting filing cabinets together at the top and tying them to the wall.
- Zigzagging free-standing, movable partitions.
- Using smaller, operable, and wood-frame windows to accommodate structural drift.
- Installing locks on cupboards.
- Boxing classroom carboys that contain hazardous liquids.
- Strapping hot-water heaters to wall studs with plumber's tape.

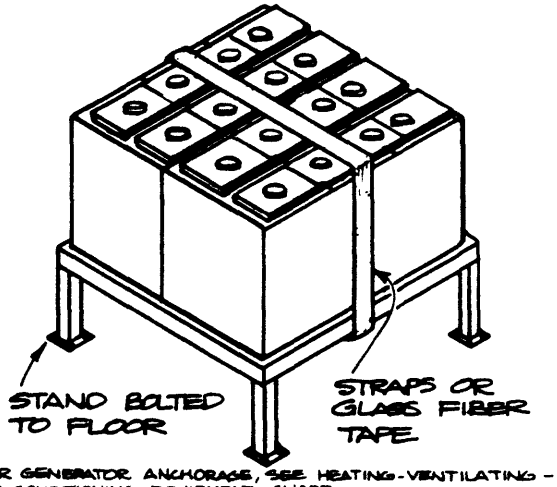
An excellent book on reducing the risk of nonstructural earthquake damage was prepared for The Southern California Earthquake Preparedness Project (Reitherman, 1983). It describes typical conditions found in office, retail, and government buildings. Measures are suggested for restraining over 20 nonstructural building components, such as office machines, electrical equipment, file cabinets, built-in partitions, suspended ceilings, exterior ornamentation, elevators, piping, stairways, and parapets. Each component is rated for existing and upgraded vulnerability for life-safety hazards, percent of replacement-value damaged, and post-earthquake outages for three levels of shaking intensity (Figure 2).

EMERGENCY POWER GENERATORS

DAMAGE EXAMPLE

earthquake: 1971 San Fernando
credit: John F. Meehan

PROTECTIVE COUNTERMEASURE



APPROXIMATE COST: $10 per rack for strapping
$50 for bolting

EXISTING VULNERABILITY

SHAKING INTENSITY	EFFECTS	✚	$	▦
LIGHT	slight chance of piping connection break	low	0–5%	mod
MODERATE	slight shifting of equipment; batteries slide	low	5–20%	high
SEVERE	lurching of generator off supports; batteries fall	mod	20–50%	high

UPGRADED VULNERABILITY

SHAKING INTENSITY	EFFECTS	✚	$	▦
LIGHT	no damage	low	0%	low
MODERATE	no damage	low	0%	low
SEVERE	damage to rest of electrical system more likely than generator damage	low	0–5%	low

✚ LIFE SAFETY HAZARD $ % OF REPLACEMENT VALUE DAMAGED ▦ POST-EARTHQUAKE OUTAGE

Figure 2. Excerpt from Reitherman (1983, p. 39) showing how to reduce risk from earthquake damage for one type of nonstructural building component.

RESPONSE DURING THE EVENT

According to Blair and Spangle (1979) "individuals are virtually helpless during the course of an earthquake. They must 'ride it out' wherever they happen to be at the time the earthquake strikes..... Helplessness is confined to those seconds when the ground is shaking; man has the knowledge and ability to avert many of the damaging effects of earthquakes." An enlightened response can occur during and immediately following the event. It includes short-term emergency assistance, and should be geared to reduce secondary damage and speed recovery operations. During and immediately after an earthquake, appropriate responses could include:

- Ducking under a desk, table, or bed; or standing in a doorway.
- Remaining calm and reassuring children and pets.
- Avoiding window openings, high buildings, power poles, heavy tile roofs, and overhanging structures.
- Fighting fires, escaping, or evacuating.
- Drawing and conserving water.
- Shutting off gas-, water-, and electric-supply lines.
- Checking for injuries.
- Listening to radio and television for emergency bulletins.
- Checking for damage to building, sewers, and drains.
- Cleaning up broken glass and spilled toxins.
- Assisting in neighborhood or workplace search-and-rescue operations.

Brochures such as **When an Earthquake Strikes** by the Santa Clara County Girl Scout Council (undated), **Safety Tips for Washington Earthquakes** by the Washington State Department of Emergency Services (undated), and **Earthquakes -- How to Protect Your Life and Property** by Gere and Shah (1980) contain

excellent advice.

Lafferty (undated) provides a check list of responses for when an earthquake strikes, safety rules to be followed during an earthquake, and a form for authorizing medical treatment of minors. The American Red Cross (1982) also provides advice on coping with childrens' reactions to earthquakes and instructions for turning off gas-, electric-, and water-supply lines.

RECOVERY OPERATIONS

Recovery operations take from 1 to 20 weeks and may continue until all public facilities, institutions, and utilities return to normal. Repair of critical facilities* usually has first priority in a community or metropolitan area. Personal-recovery activities include:

- Ensuring safe ingress and egress to-and-from the home and its rooms.
- Repairing power and telephone lines.
- Repairing water-, gas-, and sewer-service lines.
- Inspecting structures and posting warning signs if found unsafe for habitation.
- Assisting neighborhood or community work parties that are assigned burial, temporary-shelter, vaccination, and transport tasks.

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*The term "critical facilities" is used here to include:

(a) Lifelines such as major communication, utility, and transportation facilities, and their connection to emergency facilities;
(b) Unique or large structures whose failure might be catastrophic, such as dams or buildings where explosive, toxic, and radioactive materials are stored or handled;
(c) High-occupancy buildings, such as schools, churches, hotels, offices, auditoriums, and stadiums; and
(d) Emergency facilities such as police and fire stations, hospitals, communications centers, and disaster-response centers.

Personal recovery is difficult to separate from the recovery of the community or metropolitan area. For example, Rubin (1978) has written a helpful booklet on **Natural Disaster Recovery Planning for Local Public Officials** which includes: a discussion of the impact of a disaster on a community, warning signs that indicate insufficient community preparedness, and examples of successful community recovery. The Pan-American Health Organization (1981) has provided easy-to-read comprehensive procedures for emergency relief including: management of mass casualties; disease control; management of relief supplies; and the planning, layout, and management of temporary settlements and refugee camps. Examples of continuing response and recovery activities for a volcanic eruption were given in a series of **Technical Information Network** bulletins released by the Federal Coordinating Office (1980).

RECONSTRUCTION ACTIVITIES

The reconstruction phase usually involves strengthening weakened or damaged structures, razing irreparable or obsolete buildings, or commencing a neighborhood or community redevelopment program. This phase, taking from 1 to 20 years or more, provides a unique opportunity to reduce future damage and loss of life from similar events by:

- Relocating structures to less hazardous areas; for example, out of a fault-rupture zone or landslide area.
- Constructing earthquake-resistant structures, particularly critical facilities.
- Reducing population densities in hazardous areas.
- Realigning infrastructures, such as pipelines, power lines, and transportation routes, thereby minimizing the transversing of hazardous areas.

- Introducing redundancy into critical facilities; for example, alternate transportation and pipeline routes across fault-rupture zones.

The post-event reconstruction phase can also be considered a mitigation technique (see Table 1). Other techniques which may be used in conjunction with this one are moratoriums on rebuilding, regulations concerning land-use, location of capital improvements, and financial incentives and disincentives.

William Spangle and Associates, and others (1980) describe reconstruction plans and actions taken after the following earthquake disasters: 1971 San Fernando Valley, California; 1964 Alaska; 1969 Santa Rosa, California; 1963 Skopje, Yugoslavia; and 1972 Managua, Nicaragua. In addition, their discussion of the San Fernando and Alaska earthquakes includes issues, options, and opportunities seized or missed. Popkin in **Reconstruction Following A Disaster** (Haas and others, editors, 1979, p. xxix) notes:

> Most policy issues involving reconstruction arise because some element of the community wants to avoid a similar future disaster. This usually happens shortly after the disaster and may cause conflict with the widely-held desire to return to normal as quickly as possible. The strongest pressure of all for prompt return to normalcy comes from the existence of displaced families and businesses. Such pressures do not necessarily make for orderly, well-planned reconstruction processes.

CONCLUSION

Many ways to reduce earthquake hazards are available, including: long-term mitigation techniques, preparedness measures, responses, recovery operations, and reconstruction activities. However, a prerequisite to their effective use

is public awareness. Turner and others (1980) make the following recommendations for improving public awareness:

- Carefully prepared and selected advice concerning earthquake preparedness for individuals and households should be given widespread and repeated public distribution through the media as well as other channels.
- This preparedness advice should come from some authoritative government agency and should be endorsed by well-known local government officials and public personages.
- Each recommended preparedness measure should be presented in conjunction with a brief but credible explanation justifying that recommendation and suggesting how it can be implemented.
- Some responsible state agency should develop a program to promote earthquake safety in the household making use of local government, private agencies, and citizen groups. An especially useful program of this type would be one that conducted household safety inspections.

Successful programs promoting public awareness include this conference; SEISMOS '83, a City of Los Angeles simulated seismic event and metropolitan response (Manning, 1983); the 12th Annual Japanese National Earthquake Preparedness Week and Drill (Bernson, 1983); the 1983 National Seismic Policy Conference (Western States Seismic Policy Council, 1984); the South Carolina Seismic Safety Consortium conferences (Bagwell, 1983); and the Governor's Conference on Geologic Hazards (Utah Geological and Mineral Survey, 1983).

ACKNOWLEDGEMENTS

Joyce Bagwell, Baptist College at Charleston, Pamela Johnston, U.S. Virgin Islands Disaster Programs Office, Cheryl Tateishi, The Southern California Earthquake Preparedness Project, and Jane Bullock, Federal Emergency Management Agency, kindly reviewed this paper and provided valuable suggestions. Special thanks are owed Catherine Campbell for editing and Cynthia Ramseyer for word processing.

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