NSF/ENG-86035

PB87-188639

JAPANESE PRIVATE SECTOR EARTHQUAKE PROGRAMS AND THEIR APPLICABILITY IN THE UNITED STATES

Volume I:

Earthquake Programs of Companies in the United States

REPORT DOCUMENTATION PAGE	1. REPORT NO. NSF/ENG-86035	2.	3. Recipient's Accession No. PB87 148839/AS
4. Title and Subtitle: Japanese Private Sector Earthquake Programs and Their Applicability in the United States, Volume I: Earthquake*			5. Report Date: November 1986
7. Author(s): R. Reitherman			8. Performing Organization Rept. No. 8503-FR-1
9. Performing Organization Name and Address: Scientific Service, Inc. 35 Arch Street Redwood City, CA 94062			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) (G) ECE8416400
12. Sponsoring Organization Name and Address: Directorate for Engineering (ENG) National Science Foundation 1800 G Street, N.W. Washington, DC 20550			13. Type of Report & Period Covered 14.

15. Supplementary Notes

*Programs of Companies in the United States

16. Abstract (Limit: 200 words)

Approximately 150 California companies with earthquake programs were surveyed. Larger firms were more likely to have active earthquake programs than small firms; firms with essential functions that could be seriously interrupted by an earthquake, such as utilities and banks, also tend to have more vigorous programs. Most firms, through the efforts of both top management and lower level employees with safety-related responsibilities, began their programs around 1980. Elements of earthquake programs included: centralized corporate safety audits, nonstructural survey and retrofit programs, large-scale structural strengthening of buildings, storage of emergency supplies, evacuation plans, and implementation of intra- and inter-company communication networks.

17. Document Analysis a. Descriptors

Earthquakes
Safety engineering
Corporations
Hazards
Surveys

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement: NTIS	19. Security Class (This Report)	21. No. of Pages
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

8503-FR-1 November 1986

JAPANESE PRIVATE SECTOR EARTHQUAKE PROGRAMS AND THEIR APPLICABILITY IN THE UNITED STATES

Volume I:

Earthquake Programs of Companies in the United States

by

Robert Reitherman

This material is based upon work supported by the National Science Foundation under Grant No. ECE-8416400, Dr. William Anderson, NSF Program Manager.

Any opinions, findings, conclusions, or recommendations expressed are those of the author and do not necessarily reflect the views of the National Science Foundation.

Scientific Service, Inc.
35 Arch Street, Redwood City, CA 94062
(415) 368-2931

EXECUTIVE SUMMARY

The study of private sector earthquake programs is of great significance for two basic reasons: most people live and work in private facilities, with the private sector accounting for about two-thirds of the economy; also, there is a large amount of innovative talent in the private sector whose efforts in the earthquake field should be studied to stay abreast of the latest developments in the establishment of earthquake programs for companies.

Comparing U.S. with Japanese private sector earthquake programs is really a question of a comparison between California and Japan, since private sector earthquake programs, with only a few exceptions, do not exist in other states.

Governmental earthquake programs in the United States should always be thought of in the plural, because there is great variety among the federal, state, and local programs that exist. One can speak of "the U.S. space program," but not of "the U.S. earthquake program." In most respects, governmental earthquake programs are concentrated at the local level, although in California there are significant state earthquake programs as well. The federal government's National Earthquake Hazard Reduction Program's expenditures are approximately 75% devoted to research. More direct federal intervention to reduce earthquake risks, such as a nationwide mandatory seismic building code, has never been a feature of the federal government's program.

With few exceptions, governmental laws or policies do not directly affect private sector earthquake programs, and so the rapid rise in California of this phenomenon in the past half dozen years has generally occurred only because of voluntary efforts motivated by a realization that relatively inexpensive efforts can substantially reduce risk. Nonprofit organizations have been very active in promoting private sector earthquake programs. Most companies have learned the most from other companies, often by exchanges of information and ideas at meetings sponsored by the Red Cross, Business and Industry Council for Emergency Planning and Preparedness, Industrial Emergency Council, and professional and trade groups.

A survey of approximately 150 California companies provides some insights into present patterns and trends among companies. The survey conducted used a sample of only the higher visibility firms with earthquake programs--those who attend earthquake conferences. The results are thus representative of firms in California with active earthquake programs--not firms in general.

Larger firms are more likely to have active earthquake programs than small firms; firms with essential functions that could be seriously interrupted by an earthquake, such as utilities and banks, also tend to have more vigorous programs.

Most firms started their earthquake programs around 1980. This does not reflect the influence of any particular earthquake or piece of legislation at about that time, but is rather probably just due to an approximate consensus that began to evolve in the eighties that companies should investigate ways to protect themselves from earthquakes.

Particular programs were begun by the efforts of both top management and lower level employees with safety-related responsibilities. None of the firms responding to the survey reported that a union or employee association was a factor in originating an earthquake program.

Two-thirds of the 21 medical organizations surveyed have exercised their earthquake plans, which is greater than any of the other types of organizations surveyed, such as assembly occupanices (50%), financial (43%), or transportation (43%). This probably reflects both the very essential nature of medical services in an earthquake disaster and the accreditation requirement imposed on hospitals of twice-a-year disaster exercises. The nuclear power industry is the only other common example where disaster exercises are mandated.

Earthquake programs reside in a variety of places in corporate organization charts, with health and safety, facilities, or security being the most likely departments.

California companies provide instructive examples of a variety of elements that may be included in an earthquake program. These include:

- Centralized corporate safety audits, including nationwide criteria indicating which facilities should have plans for which types of natural hazards.
- Nonstructural survey and retrofit programs, protecting laboratories, offices, and other areas within a large facility.
- Large-scale structural strengthening of buildings to ensure good performance in earthquakes (even though, in some cases, the buildings are of recent vintage).
- Training of employees, using classes, brochures, and video tapes.

- Provision for use of an alternative headquarters after an earthquake that might disable the facility where the company is normally headquartered.

- Employee ID cards for essential personnel, including arrangements with local law enforcement to facilitate the recognition of the cards.

- Purchase of radio equipment to allow a company to communicate with other branches of the company or to allow communications between designated employees' houses distributed around a region and the downtown corporate headquarters.

- Emergency supplies are commonly stored in metal lockers, containing water, first aid, limited food supplies, flashlights, and other gear that often resembles camping equipment.

- Evacuation plans have included arrangements with local structural engineering firms to quickly have facilities inspected after an earthquake to determine whether evacuation is called for, and studies of the safest exterior areas for post-earthquake gathering. Evacuation of wheelchair-confined individuals and "roll-taking" methods have been devised.

- Mutual aid among companies in one case includes a 24-hour emergency radio net to facilitate requests for aid among member firms.

- Earthquake insurance is not a major tactic relied upon by firms to reduce their risk.

ACKNOWLEDGEMENTS

Numerous individuals and institutions have been extremely helpful during the course of this study. While it is impossible to list everyone by name, the authors would like to give credit to some of the many people who assisted us greatly on this project.

Dr. Shintaro Yano, Kajima Corporation, Tokyo,
Mr Yujiro Ogawa, Research Director, Urban Safety Research Institute, Tokyo,
Mr. G. Mawatari and Mr. H. Okada, National Land Agency, Tokyo,
Mr. Toshiroh Sugiyama, Director, and Mr. Yasuoki Saito, Chief of Staff, and the staff of the Earthquake Preparedness Division, Shizuoka Prefectural Government,
Mr Tadahi Ashimi, Director of the City Planning Division, City of Osaka, and his staff,
Mr. T.Suzuki and the staff of the Bureau of General Affairs, Miyagi Prefectural Office,
Dr. Yoshio Kumagai, Institute of Socio-Economic Planning, University of Tsukuba,
Dr. Hirokazu Iemura, Earthquake Engineering Lab, Department of Civil Engineering, Kyoto University,
Mr. Kawatani, Water Works Bureau, Osaka City Office.

Many other indiviudals in Japan assisted us greatly in our research. Each of our visits (and in some cases there was a repeat visit on our second research trip) involved one to several days of preparation time on the part of the company or agency who received us, and the amount of information openly provided was indispensable to our research. Assistance in interview visits was provided by the following agencies, companies, and universities:

Ohbayashi Corporation
Laboratory of Urban Safety Planning
Tokyo Gas Company, Ltd
Tohoku Oil Company, Ltd
Tokyo Electric Power Company, Ltd
Sony Corporation
Osaka Gas Company, Ltd
Tokyo Metropolitan Government
Ministry of Construction
Niigata Prefectural Government

Hitachi, Ltd
Fuji Bank, Ltd
Shizuoka Bank, Ltd
Building Research Institute, Tsukuba
Showa Shell Sekiyu Company, Ltd
Tokico, Ltd
Toa Nenryo Kogyo Company, Ltd, Shimizu Oil Refinery
Shizuoka Hospital
Tokyo Water Authority
Soyoukai
Kokubu Company
Toyokeizi
Tokyo National Museum
Takenaka Komuten

Robert W. Hubenette and David J. Smollar, consultants to the project, participated in the first research visit to Japan; consultants David J. Leeds and T.C. Zsutty were involved in comparative studies of seismic risk for California and Japan.

An Advisory Committe met twice during the project to suggest directions for the research effort and to review results. The active members of this committee were:

Pete Ashen, American Red Cross, San Francisco
R.E. Barrett, Safety Engineer, Chevron Oil Field Research Company
Al Doyle, Safety Coordinator, Hewlett-Packard
Michael Eliastam, M.D., Chief of Staff, Stanford University Medical Center
John P. Miller, AT&T Communications
Kent Paxton, Area Coordinator, San Mateo Area Office of Emergency Services
Barabara I. Poland, Emergency Preparedness Coordinator, GTE
Tony Prud'homme, formerly Director of Emergency Planning, ARCO
Adrian Ruddell, Burke Industries
Brian West, Cypress Semiconductor
Benjamin Wong, Kaiser Foundation

Evelyn Kaplan and Larue Wilton of Scientific Service, Inc., performed numerous administrative tasks to keep the project running smoothly, as well as handling the editorial and production aspects of the final reports.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Section 1
INTRODUCTION

The topic of private sector earthquake programs is of great significance, but has been little studied. Approximately one-third of the gross national product of the United States is attributable to government expenditures. while the larger portion of the economy is private. Most of the country's population lives and works in privately owned facilities. The role of federal, state, and local government in ensuring adequate levels of earthquake safety is an important subject, but the emphasis on the activities of governmental agencies has perhaps obscured a basic point: Because the majority of the earthquake risk of the country resides in the private sector, and because a large variety of essential economic activities in the United States is within the province of companies rather than governmental agencies, solving only the government's earthquake problems and improving only governmental earthquake programs will leave the majority of our potential earthquake problems untouched or only indirectly reduced.

Another important reason for looking carefully at the earthquake programs of companies in the United States, especially in the comparative light of programs of companies in Japan, is that a great fund of innovation resides in the private sector, and the increasingly common establishment and refinement of earthquake programs among companies in the past decade provide, in effect, a set of experiments, carried out by a variety of organizations with varying locational and other physical characteristics, from which we can learn. Establishing and managing earthquake programs could perhaps have been studied solely as a topic related to governmental organizations a few years ago, but today it would be a serious oversight to neglect the experience of the private sector, at least in California.

In discussing earthquake programs, we refer to the entire array of types of measures that can be used to reduce earthquake risks, including the following:

- o Structural strengthening of buildings and other structures
- o Nonstructural retrofits to protect equipment, contents, and built-in nonstructural features such as windows or ceilings
- o Emergency planning, including training and education efforts
- o Financial techniques, such as investment and insurance decisionmaking

In some companies, measures under only one of these basic categories pertain, while in other cases activities representing all of these categories will be found.

The term "program" generally refers to a coherent assemblage of individual earthquake countermeasures, activities, or projects, combined into an effort that is directed by an overall strategy, but we also use the word to generally describe the collection of earthquake techniques used by a given company, even where these techniques are decentralized to the point where there is no overall coordination strategy at the level of the corporation or facility.

The topic of earthquake programs in the United States treated here actually consists almost exclusively of the earthquake programs of California companies. The reasons for this California phenomenon in comparison with the underlying more widespread distribution of seismicity in the United States will be examined to try to learn what prerequisites there are for the development of private sector earthquake programs.

Before focusing attention on the programs of companies in the United States, it is necessary to at least briefly summarize the governmental programs that exist. This is accomplished in Section 2. In comparing the experience and successes of United States and Japanese firms in setting up and managing earthquake programs, the role of governmental agencies in mandating or assisting such programs is an important factor, and it is impossible to analyze a company's earthquake or other risk management activities completely apart from the governmental context in which the company functions.

Section 3 summarizes some of the general patterns noted among California companies at present, as well as possible trends underway that point toward the future. Presented are general observations and survey data intended to be representative of California companies with advanced earthquake programs; the section is not an attempt to describe the typical or average company.

Section 4 presents some of the more instructive individual examples of corporate earthquake programs in California.

Section 2
THE PUBLIC CONTEXT OF PRIVATE SECTOR EARTHQUAKE PROGRAMS IN THE UNITED STATES

This section has been written with the foreign (primarily Japanese) reader in mind, as well as the American audience, since the products of this research project are intended to be accessible to the many individuals on both sides of the Pacific who can critically review and apply these findings where appropriate.

The need for this discussion of the public context of private sector earthquake programs was pointed out in the Introduction. The earthquake programs of companies in Japan cannot be discussed without listing many ways in which government regulations, leadership, and encouragement affect these private efforts. This is true to a much lesser extent in the United States, and comparisons between the two cases must take this into account.

Presenting a simple summary of the earthquake programs of governmental agencies and non-profit organizations in the United States is not a simple task. This section may seem like an elementary lesson in civics, but its contents may provide some new insights even for American readers. The process of trying to provide explanations of public sector earthquake programs to Japanese individuals during the research project's two visits to Japan forced the author to look at the subject from a distant perspective.

From a distance, the larger facts are more clearly distinguished from the smaller points. One of the larger facts that, although obvious, is easy to overlook, is that earthquakes are a very small concern when compared with all the other problems with which federal, state, or local governments must contend. Those who attempt to improve governmental earthquake programs must be realistic in facing this fact to avoid trying to make the tail wag the dog.

INTRODUCTION

There is no United States governmental earthquake program - rather, there is a collection of federal, state, and local level earthquake programs. American earthquake programs should always be thought of in the plural, not the singular. If one mistakenly assumes that a single unified program exists, this misconception will make it impossible to understand how earthquake programs in the United States function.

The way in which earthquakes and other natural hazards are treated by government agencies in the United States resembles many other aspects of the American political system. As intended by the Founding Fathers of the 1700's the U.S. political system is a relatively complicated system of checks and balances, shared powers, and joint responsibilities.

There were disagreements at the time the nation was formed in the late 1700's over the extent to which the federal government should prevail over the individual states and citizens. Alexander Hamilton, the first secretary of the treasury, argued that the central government should have a strong role in the economy, establishing a national bank, issuing bonds to pay the Revolutionary War debt, collecting taxes, and so on; Thomas Jefferson, the first secretary of state and later the third president, was reluctant to concentrate so much power in the national branch of government. In the two centuries since then, the debate concerning which level of government (federal, state, or local) and which type of agency (executive, judicial, or legislative) should have which specific responsibilities, and what limits should be placed on their authorities, has continued. Government roles in the field of earthquakes in the United States may seem more defined by a series of exceptions to general rules than by any simple generalizations. This may well be true, and if so, it is merely a reflection of the larger context of American politics.

TOP-DOWN OR BOTTOM-UP?

Figures 1 and 2 illustrate the paradox of government roles in the United States as they relate to earthquakes and other types of disasters. The usual organization chart representing the levels of government in the United States, the top-down chart of Figure 1, shows the federal government on top, then the smaller and less powerful state, and then the even smaller and less powerful local government. In terms of the degree of involvement in responding to disasters such as earthquakes, the bottom-up organization chart of Figure 2 is more applicable. Most hazard reduction activities that would occur in advance of an earthquake - such as enforcement of building codes or requiring strengthening of existing buildings - and most emergency response techniques that would be used during an earthquake disaster - such as fire fighting, search and rescue, evacuation of areas downstream from damaged dams, or medical treatment - are local roles. Only if local resources are overwhelmed does the next higher level, the state, become involved. The federal government then becomes involved when requested by the state. Efforts are now underway to facilitate the immediate involvement of federal agencies when a great earthquake hits a large urban area, but at present, it is generally necessary for disaster losses to be documented before the federal government actively responds.

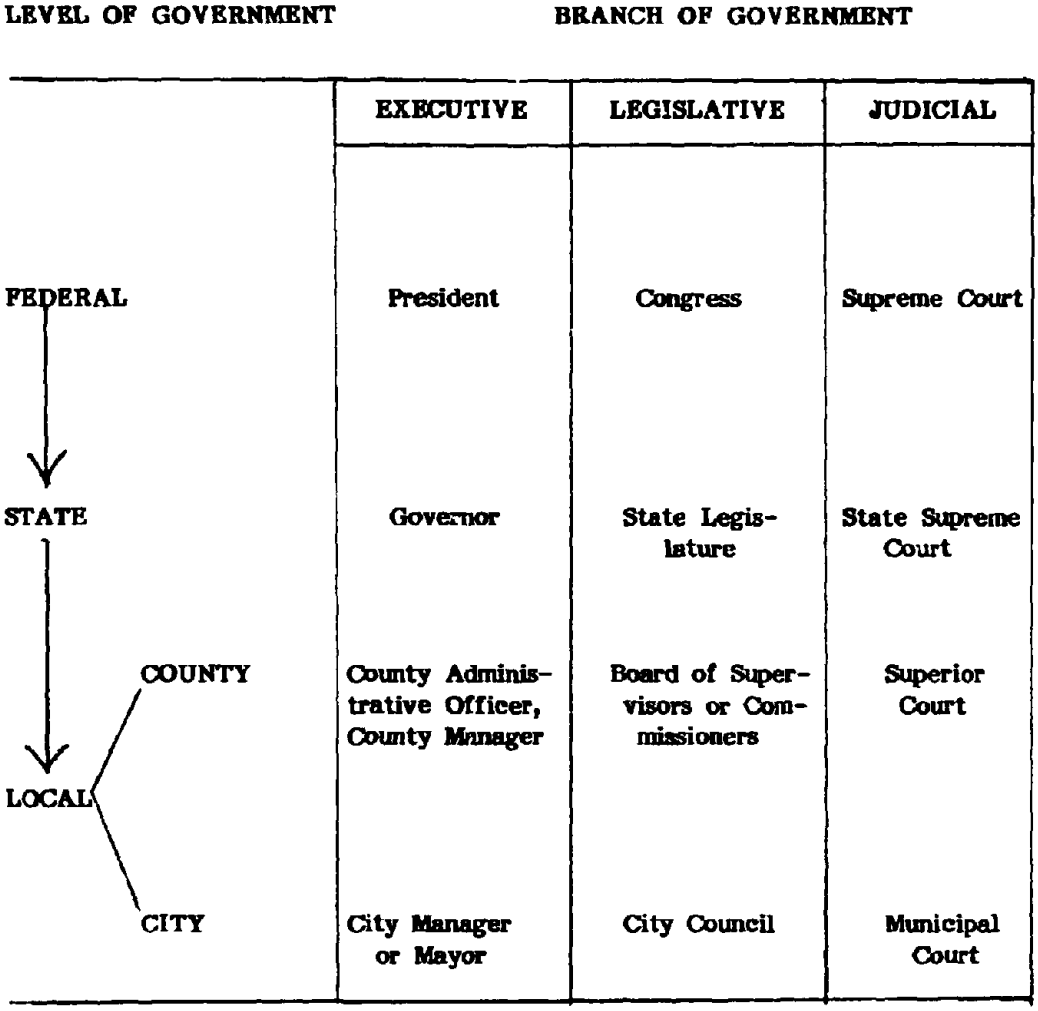


Figure 1. Typical Organization Chart of Levels and Branches of Government in the United Stetes.

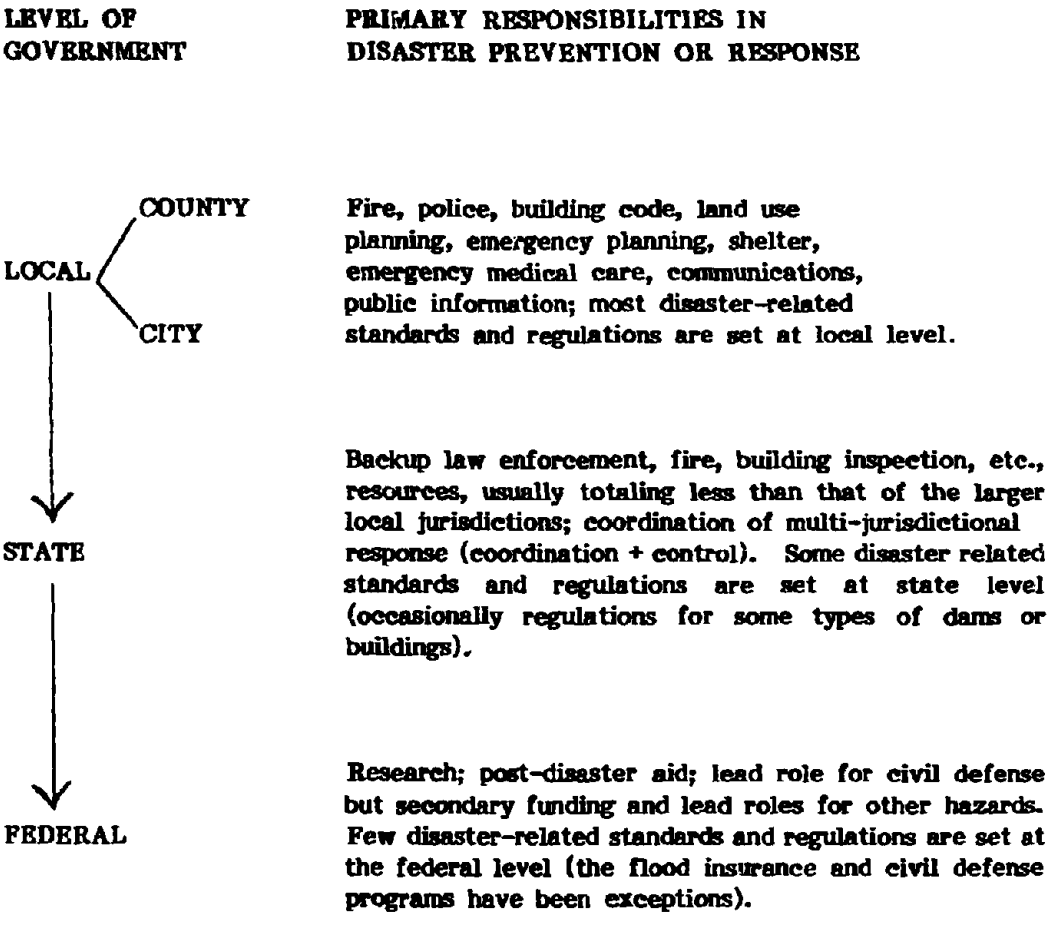


Figure 2. Typical Organization Chart of Levels of Government and Their Disaster-Related Responsibilities.

The relationship between government agencies must be explained by more than merely a recitation of statistics. For example, the federal government spends about $70 million per year on earthquakes, a small amount compared to the amount spent annually in Japan, but a large amount in the United States when compared with what state or local governments spend for earthquakes. For most states, there is no separate budget figure for earthquake expenditures. In most cities, even in the areas of highest seismicity in the United States, no one is assigned full-time to the earthquake hazard. Thus, if we look only at budget figures, it seems the federal programs are dominant, but in fact the bottom-up pattern is a better portrayal. Local governments, even if they do not specifically allocate money for earthquake programs, are responsible for most earthquake hazard reduction or emergency response tasks before and during earthquake disasters. The federal expenditure for earthquakes mostly consists of research projects, not action-oriented programs. In Japan there is no debate concerning the national scope of earthquake hazards, while in the United States this subject involves some degree of political disagreement.

LOCAL GOVERNMENT

"Local government" could mean either a city or a county, or in some cases a special purpose local district such as a regional transportation system. A county's jurisdiction for purposes of regulating construction, providing fire or police services, or similar activities is essentially the entire area of the county minus the areas of incorporated cities. Rural land will thus usually fall within the jurisdiction of a county. Some counties are also responsible for urbanized areas after incorporated cities are deducted. A small city may also contract with the county in which it is located for the provision of fire or other services.

This is somewhat of an oversimplification since some activities, such as the recording of property deeds and numerous other legal transactions, will be handled by the county even when the event occurs within an incorporated city. There are about 2,000 counties in the United States (see Figure 3). In the state of California, there are 58 counties and 441 incorporated cities. In some parts of the United States, notably New England, counties are not as important a part of the political system as elsewhere. It may come as a surprise to people from other countries, and perhaps also to some Americans, that the U.S. Constitution does not specifically define the powers and authorities of cities and counties, while the Constitution has many provisions concerning the relationship between the federal government and a state. Many typical powers and programs conducted by local governments have evolved over time, just as the Constitution does not anywhere refer to political parties, even though they are a major part of the American political system today.

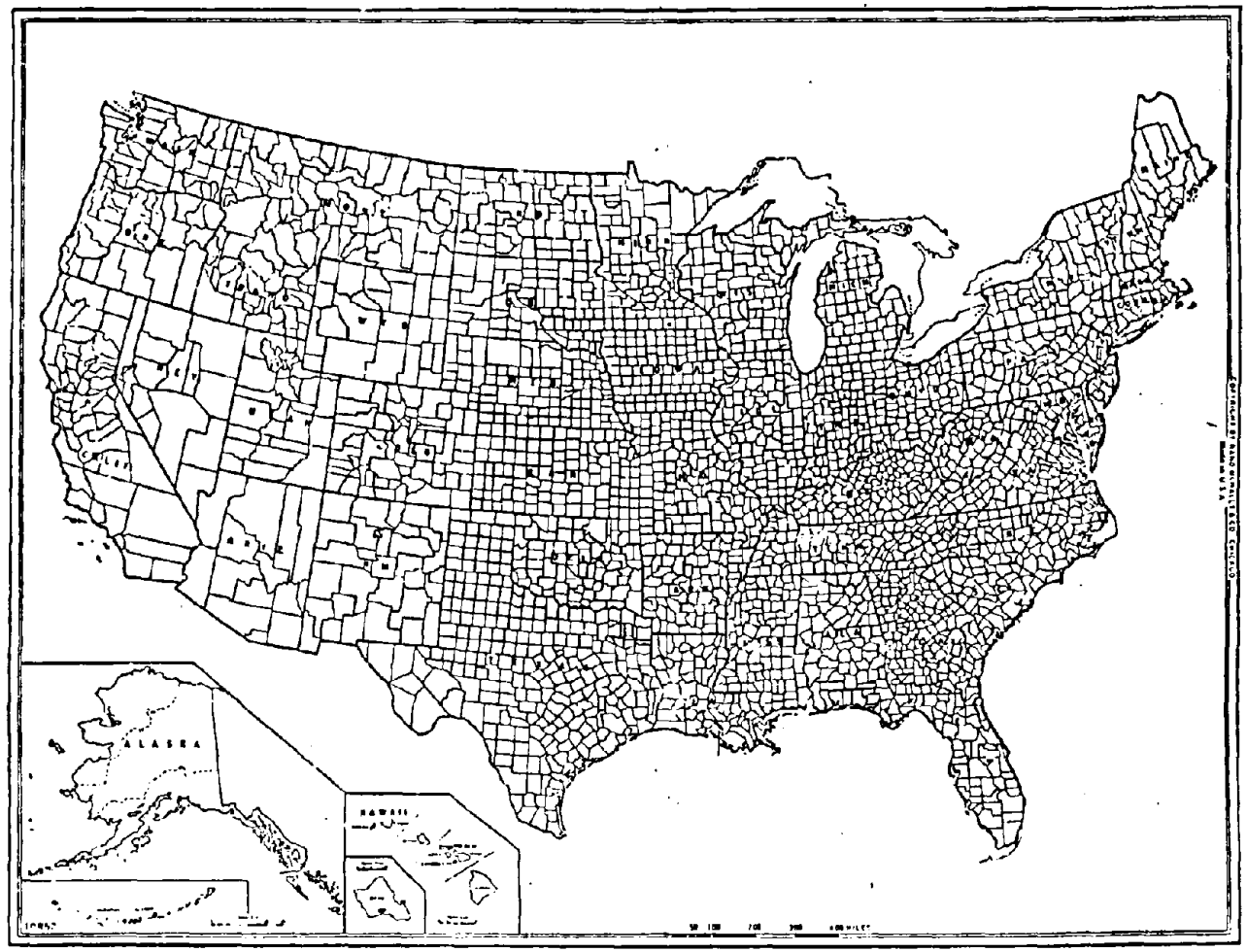


Figure 3. Counties of the United States.

Most of the key earthquake-related functions that can make a life or death difference in an emergency are local responsibilities, even though there may be state or federal minimum standards imposed or funding provided. Building code enforcement, land use planning, emergency response planning, fire and police services, and emergency medical care are all primarily local responsibilities.

Most local jurisdictions, for the purpose of responding to large emergencies, have formed mutual aid agreements. These are very commonly used to coordinate response between adjacent fire departments, for example, and firefighting resources from one city are dispatched to a neighboring city rather routinely. More rare is the concept of the operational area, which groups together many cities so that there can be a single point of contact for communications between the local and state levels of government in an emergency.

Building Codes

In most cases, cities or counties do not write their own building codes, but they do process building permits and enforce the regulations. The areas of the western United States that enforce earthquake regulations - and earthquake regulations are enforced in only a small portion of the United States - generally use either the Uniform Building Code (UBC) or a local version closely related to it. The earthquake regulations of the UBC are in turn written by the Structural Engineers Association of California, a non-governmental professional association. Figure 4 illustrates the areas of the United States where, in general, earthquake regulations have been enforced because of a combination of two factors: a code such as the UBC has been adopted, and the seismic zone is high enough to require significant earthquake-resistant practices. Figure 5 portrays the risk of experiencing severe ground motion in the United States. While the very highest risk areas of the United States, such as along the West Coast and in Alaska, do use seismic codes, only very rarely will a seismic code be enforced in any of the moderate risk areas of the eastern half of the country.

Where over three-fourths of California's population resides, a large earthquake capable of causing a regional disaster will probably occur every century (and earthquakes causing localized disasters occur on average every few decades). At any given point east of the Rockies, the recurrence interval for large disasters is at least several centuries if not a thousand years or more. This difference in seismicity appears to be a telling factor. Another significant and related reason for the low level of concern outside the West is that the last eastern earthquake disaster, the 1886 Charleston, South Carolina earthquake, occurred one hundred years ago.

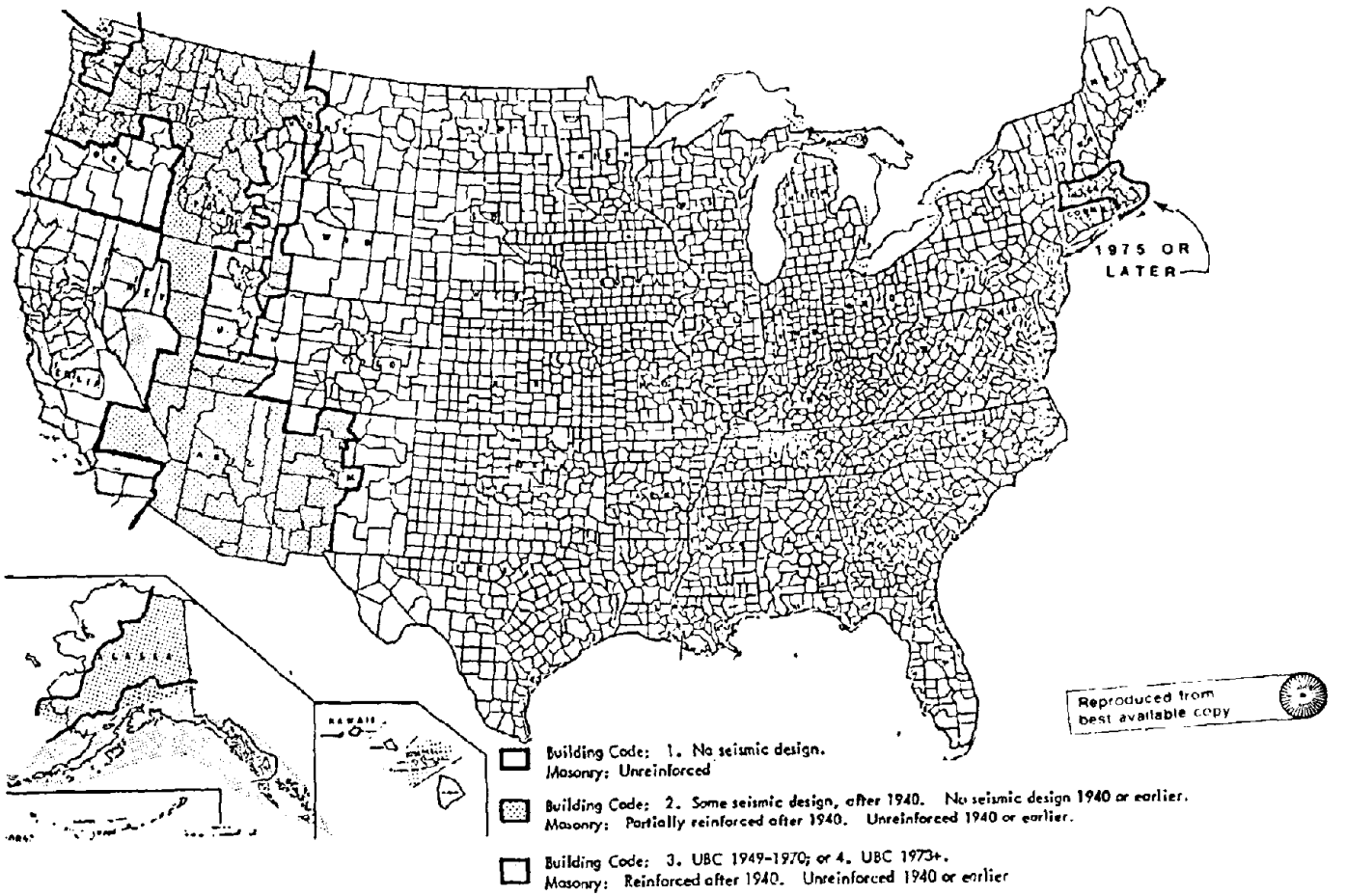
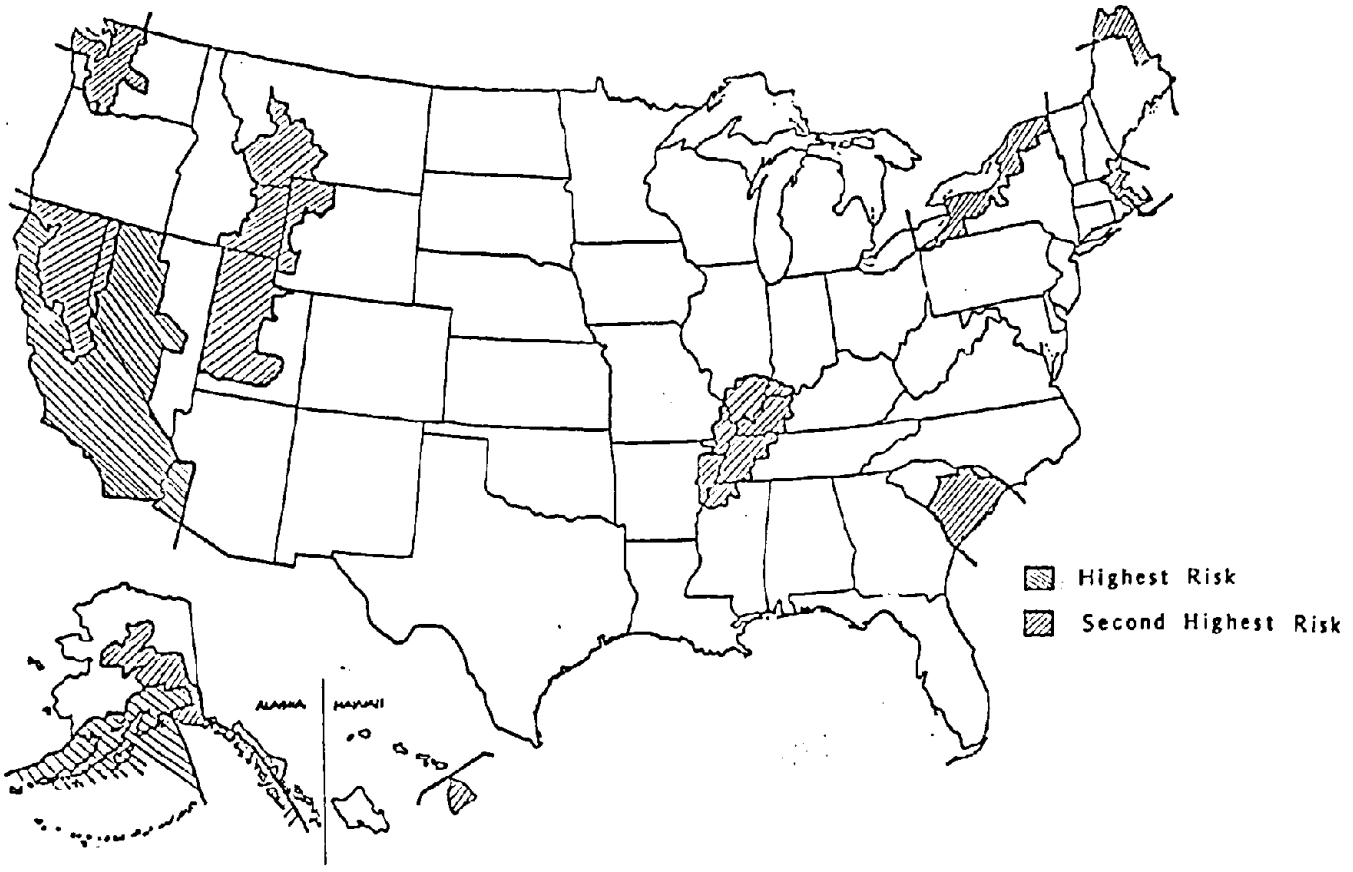


Figure 4. Areas of the United States Where Earthquake Regulations are Typically Enforced.
Source: FEMA TR-84



Source: National Survey Instructions (TR-84), Federal Emergency Management Agency.

Figure 3. Higher Risk Earthquake Zones of the United States.

In some areas of the country there are very great differences between the building code regulations used in adjacent communities. This is because building codes are usually a prerogative of local government and there are political differences between local communities; this variation is not based on drastic differences in seismicity or types of construction from one neighboring local government to another. For example, in Charleston, South Carolina, which is usually considered to be in one of the highest risk earthquake zones on the East Coast, the City of Charleston enforces earthquake regulations for new construction and is even considering a retroactive ordinance requiring some strengthening of older buildings. The neighboring City of North Charleston, located just across the river from Charleston, does not have any earthquake regulations, and half of the counties of South Carolina have not adopted a building code of any kind, let alone a code with earthquake regulations.

In California, some of the larger cities and counties have well-qualified structural engineers on the staffs of their building departments. (In California, and in some other states, a structural engineer is a civil engineer who has passed additional requirements. In California, earthquake engineering is emphasized on the strict structural licensing examination. The states, rather than the federal or local government, license most occupations.)

The places in the United States that have retroactive ordinances requiring the strengthening of existing buildings for earthquakes enjoy this protection as a result of local, not state or federal action. For example, Long Beach, Los Angeles, Santa Ana, and Santa Rosa, and a few other cities in the state of California, or Ogden in the state of Utah, enacted their programs requiring the strengthening of old unreinforced masonry buildings without any state or federal requirement to do so, and the costs of their programs are paid for at the local level.

Hospitals and Ambulances

The local government may not necessarily own its own hospital or ambulance service, but it is usually the level of government most involved in the medical field in ways that are relevant to the earthquake problem. The federal government may provide more funding of health care, but disaster exercises, emergency response plans, communications, committees that work on emergency medical care procedures for disasters, and other earthquake-related tasks are usually local activities. Many counties also own and operate their own hospitals. Some cities and counties run their own ambulance services with government employees, while others contract with private firms for this service. (Only in a very few places in the entire United States are fire department services handled under a contract with a private firm.)

Emergency Services Offices

Counties and most large-sized cities usually have a small office devoted to emergency services, aside from the larger police and fire departments. The emergency services office would not directly provide fire services, for example, but would be involved in a city-wide disaster plan that included the fire department. In a hurricane-prone area, the local emergency services office would probably be responsible for receiving up-to-date information on storms, maintaining evacuation plans, and communicating warnings. In an earthquake, the emergency services office would be involved in such activities as verifying damage and requesting state aid.

Fire departments do not usually vary greatly from one city to another. They are usually called the same thing, "fire department", their priorities and activities are quite similar, the training and backgrounds of their personnel are similar, etc. Local emergency services offices, however, can vary greatly from one local government to another. This office may be called the office of emergency services, disaster services office, or office of civil defense. In one city or county, this office may be concerned primarily with nuclear attack. In another area, the federally-funded civil defense activities will be minimized, and hurricanes, floods, earthquakes, or other natural hazards will be emphasized. The titles of agencies are not necessarily accurate indications of their roles. In one community, the office may be part of the police or fire department, while in another it will report directly to the administrator of the city or county.

An example of an unusually active partnership between local government and industry is the radio network coordinated by the City of Santa Clara emergency services office in the San Francisco Bay Area. Participating companies maintain radios at their sites that are linked to the city's central station. In an emergency, mutual aid can be coordinated among companies.

A typical local government jurisdiction with a population of about one million people might have an emergency services office of about half a dozen people. The fire department for this urbanized area would perhaps have a staff of 500. While the emergency services office may be the "coordinator" of emergency services, this coordination does not include the authority to tell the fire department how to run its own affairs. The word "coordination" is one of the more slippery terms in the field of emergency preparedness in the United States, and also one of the most often used.

Fire and Police Services

Local government provides almost all fire and police services, and these two functions typically represent a large portion of a local government's budget. County police departments are called sheriff's departments.

Summary of Local Roles

When one adds up the emergency services that are local roles, it is obvious that as a practical matter, disasters in the United States are essentially treated as a problem of local government. Fire, police, ambulance, and hospital services, enforcement of building codes and city planning laws are predominantly handled by cities and counties, and these activities are the essence of earthquake hazard reduction and emergency response. This is not surprising because many other important functions are also handled locally, such as public education from kindergarten through high school, administration of elections, construction and maintenance of roads other than highways, water and sewage systems, and distribution of welfare payments to the poor. As with these other non-earthquake topics, there are a few state or federal guidelines that must be met, and state or federal money may be contributed to these programs based on formulas related to population and other factors, but by and large local governments can exercise a great deal of discretion in how they provide these services.

STATE GOVERNMENT

A state may also provide some earthquake-related services, but in the great majority of the 50 states, there are no full-time staff devoted to the earthquake hazard. While it is often stated that about 3/4 of the 50 states have at least a moderate level of seismic risk, it is difficult to find strong programs conducted by state agencies with the exception of California, so the reader should keep in mind that the following comments concerning California do not apply to the other states.

Building Codes

In California, the state is responsible for building code enforcement for schools and hospitals, through the Office of the State Architect. The Field Act, which created the state earthquake regulations for schools, was a very direct result of the 1933 Long Beach, California earthquake, which severely damaged dozens of schools. The state earthquake regulations cover public schools from kindergarten up through high school and the two-year community, or junior, college system. Private schools, and the entire state college and university system were exempted from these requirements. Consequently, there are no public school buildings still used as schools that have not been designed to the state's strict standards, or, if built prior to that time, that have not been subsequently analyzed and strengthened where necessary. The retroactive strengthening occurred in many school districts in the 1960's and 1970's, with a combination of state and local funding to pay for the often extensive rebuilding required.

These thousands of public elementary, junior, and high schools, or junior colleges, would be rated as low earthquake hazards. By contrast, because the university system's buildings are not covered by this law, university buildings are not as safe. The state's university system consists of nine campuses. According to a recent study (McClure, 1984) 21% of the major University of California buildings were rated in the worst of four categories. There were 3,514 "very poor" buildings and another 5,839 "poor" structures.

Why would California high schools be above average in their seismic safety, whereas a University of California building might be much more unsafe? The answer sometimes given is that the student must attend the lower grade levels whereas university education is voluntary, and a place can be much more hazardous if one voluntarily assumes the risk of going there. This argument is not true, however: Students are not forced to attend community college after graduation from high school, but these buildings are covered by the state law, and since the list of high hazard University of California buildings has not been publicized, it would come as a complete surprise to a student that he or she was "voluntarily" living in a high hazard dormitory or attending classes in a building that the structural study said could collapse in an earthquake.

This is a good example of an end result that is illogical, but is politically difficult to change.

The Hospital Act of 1972 was a result of the 1971 San Fernando, California earthquake. Hospital damage was prominent in this earthquake. The regulations for hospitals are different from those for public schools in their details, but are similar in that they are administered by the state and the quality control during construction is more stringently regulated than for ordinary construction. While this results in greater safety, some private engineers have complained that, on some hospital projects, the fee obtained by the private engineers to design the building and produce all of the construction documents is about the same as the fee charged by the state to oversee the design and construction. Such questions concerning whether the government should be involved in regulating private activities, and the cost of this intervention, come up repeatedly in many fields, and so this debate is not restricted to earthquake issues.

Land Use Control

The California Division of Mines and Geology is responsible for the production of fault zone maps, which are required by the Alquist-Priolo Act (another direct result of the political momentum caused by the 1971 San Fernando earthquake). This state law forces local governments to regulate construction within active fault

zones, which they had previously been reluctant to do. Keep in mind that unless there is a special state or federal law such as this one, which is rare, all land use policies are local government decisions. Another state law requires local governments to add seismic safety chapters to their general plans or city planning master plans, which most local governments had also neglected to do. These are examples of leadership being assumed by the state, because local government had failed to act.

To indicate the variation in earthquake safety regulations between states, consider the case of the state of Alaska, whose southern coastal region is even more seismic than the coast of California. Even though Alaska experienced a great earthquake with dramatic soils failures as well as severe ground motion as recently as 1964, there are no land use policies in Alaska similar to the California examples discussed above. A very large landslide area in 1964, Turnagain Heights in Anchorage, where houses moved hundreds of feet and tumbled like boxes down toward the sea, is now being redeveloped with more houses.

As mentioned before, there are many exceptions to any generalization about government roles in the United States. There are numerous overlaps between the levels of government. Some cities or counties in California produce their own geologic hazards and fault maps, for example, though the regulation of development in fault zones must be at least as strict as called for in state standards.

Professional Background of Staff Personnel

By professional background, a few state-level agencies in California are unusual in having geologists, engineers, or administrators with high quality earthquake expertise. The Division of Mines and Geology or the Office of the State Architect have enough ongoing earthquake tasks to be able to provide long term careers to well qualified professionals, but this is not typical of other states where the volume of work (which is related to the amount of regulation) and the required expertise do not justify having earthquake experts on the government payroll.

Emergency planners at the state, or at the local or federal level, do not as yet enjoy the professional status of engineers, architects, geologists, or city planners. There is no particular educational curriculum for them to study in college, no standard examinations, and little agreement on the definition of their field. A public works department of a government agency would obviously hire an engineer to fill a high level position in the agency, but an emergency services agency might hire people with a variety of backgrounds to fill a position as an emergency planner. It is generally difficult to be promoted up through the governmental bureaucracy, if one specializes in emergency planning, as compared to many other occupations.

Government salaries for qualified professionals are often lower than in the private sector. An engineer or geologist with excellent talents and a good reputation will probably make more money working for a company than for the state university system or a state agency, although in the private sector, there is less certainty that the job will exist through good economic times and bad.

In a large earthquake where the city and county building departments will be overwhelmed in their task of quickly conducting post-earthquake safety inspections of buildings, the Structural Engineers Association of California and the American Society of Civil Engineers provide volunteers who are treated as state employees for purposes of avoiding liability and who are organized by the state Office of Emergency Services, rather than by local government. These volunteer engineers are organized by their own professional associations, but the state Office of Emergency Services handles issues concerning the liability of volunteer engineers, provides an identification card, and is the central source for receiving requests for aid and dispatching volunteers. This state-coordinated service is a superior example of what "coordination" can specifically mean in the field of earthquake preparedness.

Seismic Safety Commission

California is the only state that has a Seismic Safety Commission, a council of part-time volunteers who suggest state legislation and who are responsible for seeing that important seismic problems do not fall through the gaps between agencies. This commission is supported by a staff of about half-a-dozen people.

One other state, Utah, had for a few years a seismic safety council, and one state in the eastern half of the United States, Massachusetts, enacted in 1975 a statewide building code that requires cities and counties to enforce earthquake regulations.

National Guard

Reserve military units, called the National Guard, are organized by states and can be authorized by the governor of the state to respond to a natural disaster. This is a large source of personnel and equipment, especially air and ground transportation units, at the state level. As with all of the relationships between government agencies described here, there are numerous legal requirements involved for addressing communications to the proper agency, filling out the proper forms, etc. This can be more than a trivial matter, as was shown in the 1983 Coalinga, California earthquake. Trucks, personnel, and food serving equipment of the California National Guard were sent to Coalinga. Because a conversation between a member of the Red Cross--a non-governmental, nonprofit organization--and a state official was construed as an official request by the Red Cross to have the National Guard sent in,

the bill for their services was subsequently sent to the Red Cross. If an official of the city of Coalinga had sent the request up through the proper bureaucratic channels to the state level, the state would have paid the bill, which amounted to tens of thousands of dollars.

State Fire Department Resources

Most states have very little firefighting equipment or personnel to use in an earthquake. In California, where much of the state is mountainous and forested, there are a number of fire stations operated by the state for fighting forest fires, as can be clearly seen from the name of the agency that runs these fire departments - the California Department of Forestry. These state fire stations are located in areas remote from the urban areas where the greatest post-earthquake fire and rescue needs would arise, however, so again it is basically a matter of the local governments providing the first line of resistance to the attack by the earthquake disaster. In many states, there would be no significant supply of state firefighting equipment.

FEDERAL GOVERNMENT

The primary function of the federal government in the field of earthquakes up to now is research and post-disaster aid payments, not emergency response or hazard reduction, but for purposes of responding to a large disaster, federal resources can be mobilized once certain criteria are met. A key step is the declaration of a disaster by the governor and a request by the governor to the president to issue a federal disaster declaration. These declarations are important for opening up the door to federal resources. While the fact that a state rather than a city or county requests this federal aid may seem a minor detail, the charge has been made by some members of Congress that federal aid to their states was delayed after disasters because the party in power at the state level was not the same as the party in national power. The Federal Emergency Management Agency, which administers this aid, is now proposing uniform eligibility criteria. A disaster causing $1 per capita loss in a state might be used as a criterion that local and state resources could not handle the loss, and thus federal aid would be justified.

Military Resources

As with the states' National Guard resources, the largest clearly defined federal personnel and equipment resource is the military. Military aircraft have been used to fly resources to communities isolated by floods or snowstorms, for example. U.S. Army aircraft of the Sixth Army headquartered in San Francisco will be used for rapid aerial reconnaissance of key installations, such as dams or

hospitals, after a major San Francisco Bay Area earthquake. There is no significant supply of fire equipment owned by the federal government, however, and most of the resources that could be quickly used in a disaster are things that serve an everyday non-disaster role.

The U.S. Army Corps of Engineers frequently provides disaster response aid in floods, and has also been involved with earthquake response. The actual resources deployed--for example, the large cranes used at two collapsed Veterans Administration hospital buildings in the 1971 San Fernando hospital--are in many cases owned by private construction contractors who are under contract to the Corps.

Post-Disaster Financial Aid

Post-disaster grants and loans have been federal activities for many years, although at present the federal government is trying to minimize its responsibility for making these kinds of payments. After the 1964 Alaska earthquake, for example, the federal government distributed disaster aid within Alaska that totaled slightly more than the total cost of damage in the earthquake. At the coastal town of Valdez, where the Alaskan oil pipeline ends, the entire town was rebuilt at a new site at federal government expense. Disaster-caused damage to public facilities is more often reimbursed than in the case of private property, which must qualify under different programs. In terms of paying for disasters after they occur, the bottom-up pattern is reversed, and the federal government is clearly the major level of government involved.

Insurance

The National Flood Insurance Program is administered by the Federal Emergency Management Agency (FEMA) and has provided subsidized flood insurance rates to homeowners and businesses, but it is not involved in earthquake insurance.

Private insurance companies do not provide flood insurance directly to customers in the United States, while all forms of wind damage, whether caused by tornadoes, hurricanes, or wind storms, are covered by the usual property insurance policies issued by insurance companies. The standard property insurance policy specifically excludes coverage for earthquake damage. This was made very explicit in California by a law (AB 2865) passed by the legislature in 1984, to clear up any doubt about this issue. Only if a homeowner or business buys a separate earthquake insurance policy, which can cost about as much as the basic fire insurance policy, will there be coverage for earthquake losses. In California, about 10% to 15% of the houses have this earthquake coverage. Earthquakes are the one major hazard that is seldom covered by insurance.

Research

The $70 million National Earthquake Hazard Reduction Program (NEHRP) is essentially a research program, although its name does not reflect this fact. See Table 1. For example, strengthening a collapse-prone building would be an obvious example of what is usually meant by "hazard reduction," and another example that people would think of when they hear the words "hazard reduction" would be regulation of construction on active faults, but neither of these activities is required or funded by NEHRP, although some of the research paid for through this program is eventually applied to such practical problems. A state such as California occasionally funds small research projects, while cities and counties virtually never pay for earthquake engineering research.

The Trickle-Down Approach

Economists have a term called "trickle-down" to describe economic policy that attempts to help the poorer portions of the population by stimulating the growth of larger businesses or encouraging wealthy individuals to place money in profitable investments. The theory is that the benefits generated by these wealthier strata of the economy will eventually trickle down to the poorer classes.

The federally funded earthquake research program is based on a kind of trickle-down theory. This has been clearly stated by the body commissioned to review and direct this program, the Committee on Earthquake Engineering Research of the National Research Council. This prestigious group of prominent scientists and engineers described the policy as follows:

> "The results of basic earthquake engineering research ultimately find use in practical applications, though considerable time may elapse before the results are used fully. The way in which this research usually leads to practical application is as follows: the owners, planners, and designers of special facilities, such as nuclear power plants, major dams, offshore drilling platforms, and high-rise buildings of fifty stories or more, usually recognize the advantages to be gained by making use of research results . . . . After critical facilities and high-technology projects have used these results, the state of the art works its way down to the design of ordinary engineered structures and facilities that are governed by building codes, industrial codes, and other standards. Finally, nonengineered structures, such as single-family dwellings, are affected through highly simplified requirements in building codes . . . .
>
> "The lag time for research results to be used in critical facilities is, typically, about one to three years. For research to be reflected in

Table 1
NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM
EXPENDITURES BY TYPE OF PROGRAM ELEMENT

NATIONAL BUREAU OF STANDARDS		
Research	499,000	
Non-research	-0-	
Subtotal	499,000	
FEDERAL EMERGENCY MANAGEMENT AGENCY		
Research	2,650,000	
Non-research	3,055,000	
Subtotal	5,705,000	
NATIONAL SCIENCE FOUNDATION		
Research	26,900,000	
Non-research	860,000	
Subtotal	27,760,000	
U.S. GEOLOGICAL SURVEY		
Research	22,073,000	
Non-research	14,481,000	
Subtotal	36,554,000	
TOTALS		
Research	**52,122,000**	**(74%)**
Non-research	**18,396,000**	**(26%)**
Total	**70,518,000**	

Source: FEMA, 1985 (Note: Research and non-research subtotals are approximate figures derived from the government budget data.)

building codes and other codes usually takes on the order of five to ten years or longer. For nonengineered structures the lag time may be much longer." (Committee on Earthquake Engineering Research, 1982)

There is a great distinction in the United States between the production and use of knowledge. In terms of accomplishments in the production of new knowledge, as measured by the numerous Nobel Prizes won by American scientists for example, the United States is very adept. In the application of this knowledge to the solution of practical problems, however, there are some obvious inefficiencies. The United States is pre-eminent in the field of high-technology medical techniques such as heart transplants, and it also has a very high rate of heart disease, because some relatively simple habits related to diet, smoking, and exercise have not been implemented throughout the population. The United States has produced some very sophisticated engineering analysis methods, such as the finite element method, but in this same nation it is still possible to build unreinforced masonry buildings in all but a few states, and by far the majority of all gas-fired water heaters even in a high seismic state such as California are not restrained to prevent their falling over in an earthquake.

First the Disaster, Then the Legislation

The National Earthquake Hazards Reduction Program was enacted by the National Earthquake Hazards Reduction Act of 1977. Again, it is no accident that the act was enacted after the 1971 San Fernando earthquake, and after the 1964 Alaska earthquake, which resulted in large federal disaster aid payments. The Alquist-Priolo Fault Zones Act and Hospital Act were passed by California as a result of the San Fernando earthquake, and the efforts of the City of Los Angeles to retroactively mandate earthquake regulations on unreinforced masonry buildings, which culminated in 1981, began ten years earlier also.

It was also no accident that the first earthquake codes in the United States were enacted in 1933 as a direct political result of the Long Beach earthquake of that year. This historic 1933 legislation was passed exactly one month after the earthquake. This success story was due to the government's being ready to move quickly. The engineering standards had already been developed in approximate form in California through the late 1920's and early 1930's, in many ways as an import from the design examples of Japanese earthquake experts such as Naito or Suyehiro. The rationale for the state's involvement was provided by the state's dam safety law, passed in 1929. (This dam safety act, the first in the United States, was enacted as a direct result of the failure of the Saint Francis Dam and the resulting deaths of about 500 people in southern California.)

It is interesting to note that the most devastating earthquake in U.S. history, the 1906 San Francisco earthquake in northern California, had no positive political impact whatsoever. Seismic regulations were not adopted into the San Francisco building code until 1947, for example. The special soils hazards associated with the deep unconsolidated alluvial deposits on the edge of the Bay, including the filled ground area where approximately half of the most densely developed area of downtown San Francisco is located, were not given any special attention in regulations until the 1960's. In 1968, the Bay Conservation and Development Commission, an agency established by the state, appointed a Board of Consultants to Review the Safety of Proposed Fills, which eventually resulted in special regulations for waterfront areas.

GOVERNMENTAL LAWS OR PROGRAMS THAT AFFECT COMPANIES

This topic is relatively easy to summarize, since there are very few ways in which local, state, or federal government affects a company's earthquake program. With very few exceptions (such as nuclear power plants) there are no earthquake regulations, other than building code requirements as previously discussed.

Health and safety laws at the state and federal level do not specifically deal with earthquakes, and most local governments that require safety programs limit this to the hazards of fire and hazardous materials.

Aid to companies is also generally lacking, whether it be technical expertise in engineering or emergency planning or low-interest loans. Exceptions are some types of financial assistance, such as those offered in the City of Los Angeles where 8,000 unreinforced masonry buildings are under retroactive building code requirements, or some local emergency services agencies that actively respond (beyond mailing out simplified brochures on what-to-do-in-case-of-earthquake) to information requests from companies.

NONPROFIT ORGANIZATIONS

Indirect fostering of companies' efforts is more often the case than direct aid, and when government agencies provide this indirect assistance, frequently non-governmental, nonprofit organizations are involved. In California, some prominent examples of such organizations are the Golden Gate (San Francisco) Chapter of the Red Cross and its Business, Government, and Red Cross Disaster Meetings, the Los Angeles and Orange County Red Cross chapters, the Industrial Emergency Council

(San Mateo and Santa Clara Counties) and the Business and Industry Council for Emergency Planning and Preparedness (BICEPP), and the California Emergency Services Association. In addition, the two regional programs jointly funded by the state and federal governments, SCEPP (Southern California Earthquake Preparedness Project) and BAREPP (Bay Area Regional Earthquake Preparedness Project) are beginning to hold workshops and distribute information to companies.

One of the most valuable roles served by these organizations is to facilitate communication between companies at conferences. The Golden Gate Red Cross disaster meetings typically involve several seminars on topics such as protection of computer centers from earthquakes, storage of essential emergency supplies, or communications in disasters.

It is also striking that all of the earthquake regulations in the United States are based on the work of the Structural Engineers Association of California, a non-profit organization whose members have performed this service free of charge and independently of any agency.

Section 3
PATTERNS AND TRENDS OF PRIVATE SECTOR EARTHQUAKE PROGRAMS

PATTERNS

The following patterns are discussed more specifically with reference to the survey conducted during this project.

Size of Company

It is commonly observed that only the bigger companies in California are more likely to have earthquake programs. Small businesses are not extensively represented at conferences devoted to earthquakes, which provide practical information to companies. While emergency planning becomes more essential as the number of employees and the scale of operations grow, hazard reduction related to structural and nonstructural vulnerabilities relates to both large and small companies. For example, probably the great majority of commercial tenants of unreinforced masonry buildings are small, rather than large, businesses; yet this class of construction is especially hazardous in earthquakes.

Most large businesses have multiple sites. Most small businesses, by contrast, have all their eggs in one basket because they are located at a single site, often in a single building. Large firms have much greater flexibility in arranging financing to recover from a setback. (The loans available to small businesses after disasters through the Small Business Administration do not greatly change this picture. Only firms that can demonstrate that banks will not lend them money can qualify for significantly subsidized interest rates.) It may not seem rational for the smaller firms most susceptible to earthquake-caused business failure to be least prepared, but this is quite understandable. Small businesses typically have no position dedicated to safety, facilities engineering, or risk management.

While there are some data to support the above conclusions concerning the smaller versus the larger company, the following generalization is speculative, but is at least corroborated by several examples within the author's experience, while there have been no exceptions. New companies, even the large, very successful, high-growth firms, rarely concern themselves with earthquakes until the organization matures. This is true of several of the large, but new, high-tech firms whose names are familiar to us in the daily news. The driving force behind these firms is the goal of acquiring larger market shares, hiring more employees, developing new products.

Preserving what has been acquired is a thought that only seems relevant after a few years have passed.

Only after passage of a few years do preservation and protection of what has been developed seem important. Consequently, a young firm of a given size and facing a certain level of physical vulnerability is more likely to be at greater risk from earthquakes than the more mature firm. Again, this may not seem rational in economic terms, but it is quite understandable from the standpoint of organizational structure.

Essential Functions

Businesses with more essential functions or that are less able to tolerate outages and interruptions, are more likely to be actively involved in developing earthquake programs. In California, the banking industry has been prominent in this respect, because service interruptions of only a few hours or a day can cause a crisis. The larger, older banks, who are clearinghouse members (responsible for most of the check clearing operations) are the active companies while the small banks with only a few branches are less involved, which also relates to the points made above.

Other examples of companies that are especially interested in earthquake risk reduction techniques because of their concern over post-earthquake disruption of service include privately owned hospitals, telecommunications firms, non-banking financial companies, utilities, electronics manufacturing companies.

Corporations whose headquarters are located in major cities where the earthquake risk is well-known, such as San Francisco or Los Angeles, are more likely to have strong earthquake programs. Partly this is due to the special emergency planning situation of central city sites. It may also be partly due to the earthquake reputation of these cities. To a seismologist, however, many of the more suburban areas are just as likely to be affected by strong earthquakes as the big cities.

TRENDS

Growth

The most prominent trend is the growth of earthquake programs in the private sector. The government's expenditures for earthquake programs has remained relatively constant over the past several years or slightly declined, while companies appear to be investing more and more in this area. The number of governmental agencies and personnel involved in the earthquake area has not grown significantly

for several years, but the number of companies and private sector employees whose jobs now include earthquake-related duties has grown significantly, especially since about 1980.

Industry Standard

Companies appear to be formulating an approximate "industry standard" for adequate earthquake protection. A few years ago it might have seemed adequate to have no earthquake program, but today the question is how much is adequate, and there is little debate over the basic need for this type of hazard protection. While there is not yet a consensus concerning the need for structural analysis and strengthening of buildings, or for nonstructural retrofits, or emergency plans, companies are sharing information on their earthquake programs extensively at numerous meetings and conferences, and peer pressure and a desire to "do what is right" are exerting powerful influences on corporate policy. Most large companies either train their employees in earthquake procedures or at least distribute printed materials on the subject, whereas it used to be common for only a few employees to know of the company's earthquake plan, and these few more often than not had no detailed acquaintance with what the written document meant. This evolution of at least a vague standard of practice has proceeded gradually, unmarked by any single event, and the amount of change that has occurred is larger than people realize.

As the survey data discussed later indicates, union pressure to protect workers from earthquake hazards has up to now been virtually non-existent. Since state or federal OSHA regulations concerning earthquakes also do not exist, this means that peer pressure and the competitive desire to avoid disproportionately large losses after the next earthquake as compared with other firms, are the motives working in lieu of governmental or union pressure.

Liability

To slightly oversimply the past decade or more of liability legislation and litigation as it may apply to future earthquake losses, the principle seems to be established today that "God didn't build the building, so it isn't an act of God if it falls down in an earthquake." The idea of an act of God and its presumed liability protection is becoming an obsolete doctrine. Earthquake damage is largely foreseeable and preventable. Indeed, many firms have foreseen potential problems and have already worked toward preventing their occurrence. While increased knowledge of hazards increases liability, it is also becoming more and more true that ignorance is becoming a less sound strategy from the legal standpoint, and of course no one ever defended ignorance on any other grounds. While legal trends have been moving away from the idea of acts of God and toward holding people more responsible for natural hazards losses, a company must also guess as to the way in

which courts will decide liability issues after the next large earthquake, and it is perhaps likely that the current liability trends will only accelerate as judges and juries decide these issues in the context of the aftermath of a disaster that has killed thousands of people and destroyed billions of dollars of property.

SURVEY DATA

A survey of California companies with more active earthquake programs was conducted in this research project, and although the sample is representative only of the more active companies rather than companies in general, this provides a valid portrayal of this more advanced portion of the private sector. Table 2 shows the questionnaire from which the following survey data were obtained.

Size of Company

Size of samples:

fewer than 50 employees:	30 companies
50-100 employees:	15
100-1000 employees:	52
over 1000 employees:	60
Total:	157

Earthquake plan has been exercised:

fewer than 50 employees:	10%
50-100 employees:	13%
100-1000 employees:	36%
over 1000 employees:	43%

Water heater strapped:

fewer than 50 employees:	6%
50-100 employees:	26%
100-1000 employees:	25%
over 1000 employees:	26%

The above two key indicators of the extent to which a company has an active earthquake program show an increasing level of effort with size of company. (Keep in mind that if all companies, rather than just the more active companies, were surveyed, by using general sampling rather than only the very stratified sample based on lists of companies who attend earthquake conferences, the small companies would be found to diverge much more from the larger companies, since most very small companies have no earthquake program.)

Table 2
SURVEY QUESTIONNAIRE

May 1985

Questionnaire: Private Sector Earthquake Programs in the United States

(Use multiple check marks if there is more than one appropriate answer for any of the following questions.)

1. EARTHQUAKE PREPAREDNESS MEASURES

Check the earthquake preparedness measures undertaken by your company:

A. Emergency Planning

1.___ Brochures distributed to employees
2.___ Written plan produced, containing procedures specific to earthquakes
3.___ Exercise of earthquake plan conducted
4.___ Radio equipment on hand capable of communicating without utility-provided electricity
5.___ Earthquake insurance purchased
6.___ Medical supplies stored
7.___ Water and/or food stored
8.___ Audio-visual training/education program(s)
9.___ Other: _____
10.___ None

B. Structural Protection

1.___ Engineering consultant hired to evaluate structural safety of building
2.___ In-house engineers used to evaluate structural safety of building
3.___ Building structurally strengthened
4.___ None

C. Nonstructural Protection

1.___ Engineering consultant hired to evaluate nonstructural hazards
2.___ In-house personnel used to evaluate nonstructural hazards
3.___ Nonstructural items retrofitted to increase earthquake resistance:
   a.___ Overhead light fixtures braced or safety chained
   b.___ Water heater strapped
   c.___ Generator or other electrical equipment bolted down
   d.___ Safety film applied to large panes of glass to prevent falling shards
   e.___ Exterior ornamentation anchored
   f.___ Tall shelving or storage racks braced
   g.___ Tall file cabinets restrained
   h.___ Computers or computer floor braced
   i.___ Air conditioning equipment or ducts, heater/boiler, pipes, water tanks braced
   j.___ Other: _____
4.___ None

Table 2 (contd)

2. PLACE OF EARTHQUAKE PREPAREDNESS WITHIN ORGANIZATION

A. Where does the responsibility for earthquake preparedness reside in your company? (Attach overall organization chart if you wish.) If one earthquake function, such as training, is handled by one department, while another, such as nonstructural retrofitting, is handled by another, please use multiple check marks and note which department does what.

Department	Function (if earthquake tasks are divided between more than one dept.)
1.___ Safety, health & safety	_____
2.___ Security	_____
3.___ Facilities, engineering physical plant, maintenance	_____
4.___ Personnel	_____
5.___ Executive, administrative	_____
6.___ Functional manager of each particular manufacturing or service area	_____
7.___ Interdepartmental committee	_____
8.___ Other: _____	_____

3. ORIGINATION OF EARTHQUAKE PROGRAM

A. Where did earthquake awareness program originate?

1.___ Senior executive
2.___ Safety manager
3.___ Union
4.___ Non-union employee group
5.___ Engineer, facilities manager
6.___ Security manager
7.___ Personnel manager
8.___ Risk manager
9.___ Insurance inspector or broker
10.___ Earthquake consultant
11.___ Building official
12.___ Government workplace safety inspector
13.___ Government or public organization information campaign
14.___ Legal counsel
15.___ Other: _____

B. When did the program originate? _____

C. Is your earthquake program an outgrowth of a pre-existing safety program?

___ No
___ Yes (Fire)
___ Yes (Hazardous materials)
___ Yes (Other hazard _____)

Table 2 (contd)

D. Was your company's involvement in earthquake preparedness activities aided or motivated by a government agency or other public organization?

1.___ No aid
2.___ Helpful ready-to-use information
3.___ Helpful referrals to products, services, other information sources
4.___ Technical expertise: engineering
5.___ Technical expertise: emergency planning
6.___ Financial aid
7.___ Mandatory regulations
8.___ Source of aid:
   a.___ Local government
   b.___ State government
   c.___ Federal government
   d.___ Other: _____

4. LEVEL OF EFFORT

A. Emergency preparedness and safety functions are handled by:

1.___ A department with several full-time staff dedicated to this task
2.___ One person, full-time
3.___ One person, part-time
4.___ No one in particular

B. Indicate approximately how much time per year employees are trained:

All Employees	Small Number of Employees with special emergency tasks	
1._____	_____ (days/yr)	Earthquake
2._____	_____	Fire
3._____	_____	Hazardous materials
4._____	_____	Bomb threat, security
5._____	_____	Utilities outage
6._____	_____	Medical emergency
7._____	_____	Flooding

5. HAZARD RANKING

A. Rank the following hazards in order of concern and level of effort expended in your organization to deal with them, with number 1 being the hazard of greatest importance.

a.___ Earthquakes
b.___ Fire
c.___ Hazardous materials
d.___ Medical emergency
e.___ Bomb threats, terrorism
f.___ Flooding
g.___ Utilities outage
h.___ Other: _____

6. SIZE OF ORGANIZATION

A. How many employees?

On your site	Total, if multiple sites	
1._____	_____	fewer than 50 employees
2._____	_____	50 to 100 employees
3._____	_____	100 to 1000 employees
4._____	_____	over 1000 employees

Table 2 (contd)

B. Size of building (use multiple check marks if there is more than one building).
1. ___ One or two stories
2. ___ Two to seven stories
3. ___ Over seven stories

7. OCCUPANCY, USE

____Offices	____Medical
____Retail	____Assembly (theater, etc.)
____Manufacturing	____Utility
____Electronics	____News media
____Labs	____Financial
____Transportation	____Other _____

8. IDENTIFICATION

A. (optional) If you would prefer to fill out the questionnaire anonymously, feel free to do so. In that case, write a separate letter if you would like to be included on a mailing list to be kept informed of the availability of the project reports.

Name: _____
Title: _____
Company: _____
Address: _____
_____

B. Would you be interested in participating in a follow-up personal interview? If so, please give your telephone number:

Telephone number: _____

C. Do you have any particular questions you would like answered concerning the techniques or programs used by Japanese companies to prepare for earthquakes?

When did earthquake program originate?

fewer than 50 employees:	1980
50-100 employees:	1981
100-1000 employees:	1980
over 1000 employees:	1979

This indicates that most of the companies with active programs began their effort about 1980. This does not coincide with a particular earthquake or law, but probably reflects a gradually increasing earthquake awareness and a common business perception that a well-run company in California should have an earthquake program.

Type of Business

Size of samples:

Electronics:	22	companies
Medical:	21	
Assembly (theater etc.):	8	
Office:	126	
Financial:	23	
Utility:	13	
Transportation:	16	
Laboratories:	37	
Manufacturing:	22	
Retail:	16	

(Because of multiple occupancies within one firm, these figures exceed the total number of firms.)

Earthquake plan has been exercised:

(1) Utility:	69%
(2) Medical:	66%
(3) Assembly:	50%
(4) Financial:	43%
(4) Transportation:	43%
(5) Laboratories:	37%
(6) Manufacturing:	31%
(6) Electronics:	31%
(7) Office:	27%
(8) Retail:	12%

Water heater has been strapped:

(1) Medical:	52%
(2) Electronics:	50%
(2) Assembly:	50%
(3) Transportation:	43%
(4) Financial:	39%
(5) Utility:	38%
(6) Laboratories:	37%
(6) Retail:	37%
(7) Manufacturing:	36%
(8) Office:	21%

From the above two key indicators, it appears that retail and manufacturing businesses are less likely to have active earthquake programs, whereas medical, assembly, and financial firms are more likely to be above average in the extent to

which practical measures such as exercises and nonstructural retrofits are carried out. This pattern is not a strong one, however.

Place of Program Within Organization

Considering only the larger firms (more than 100 employees) who have a more extensive organizational structure, health and safety or facilities are the two departments most likely to be in charge of the earthquake program. The security or administrative departments are the next most likely to be centrally involved in the earthquake program. In most companies, some earthquake functions reside in one department while other functions are the responsibility of one or more other departments. Indeed, one of the first issues to arise in a company beginning an earthquake program is where to place this responsibility in the organization chart.

Typically, the health and safety department is involved in workplace safety procedures related to non-earthquake hazards. Facilities or physical plant departments are often involved because the physical nature of earthquake hazard reduction involves strengthening buildings or retrofitting nonstructural items. Security is often a department involved in emergency response and may be in charge of radio communications; it is often the only one of these basic departments staffed 24 hours a day. (Because earthquakes occur randomly with respect to time of day, there is about a one in four chance that one will occur during the 40-hour work week, and a three-fourths chance it will occur outside of business hours.) The administrative or executive department is also often involved in the earthquake program, in the same manner that the executive branch of a government would be involved. Administrative decisions must be made as to budgets and policies in advance of the earthquake, and decisons must be made as to overall priorities for response after the earthquake.

Origination of the Earthquake Program

The two most common sources for the companies' earthquake programs were a senior executive or the safety manager. This is perhaps obvious, but somewhat surprising is the fact that none of the companies reported that either a union or non-union employee group helped bring the program into existence, and in only one instance was legal counsel a cause of the origination.

A generalization based on consulting experience rather than the survey data concerns the role of individual initiative. In many firms, only because of the hard work of one individual does a strong earthquake program exist. In some cases, this person was not even directly assigned the job of developing an earthquake program, but rather took the initiative to see that this was an essential part of the health and safety or risk management function. Only in the past couple of years has it become

more common for a person to come into a job and inherit an ongoing program, rather than have to start one.

This situation increases the amount of innovation and experimentation occurring in this field, but it also increases the chance of discontinuity. As mentioned above, earthquake programs in most firms have yet to find a permanent home in the organization chart and are not yet fully institutionalized. An extreme example is the case of ARCO, which until 1985 had one of the more highly visible earthquake programs of any company in California. When bad economic times necessitated a cut in corporate expenditures of $500 million, the manager who headed the program along with the two-person staff were given early retirement, and the program was eliminated.

This also relates to the relatively short-range planning used by U.S. firms as compared to Japanese counterparts. Once the earthquake protection effort is considered essential by a Japanese firm, it is there to stay. Large drops in the oil and electronics industries have affected Japan in the past couple of years, yet firms in these fields in Japan only trim back their earthquake programs. Export industries in Japan have had to adjust to the major change in exchange rates the past year. In the past year the yen has increased by 50% versus the dollar, yet export firms with earthquake programs seem to be able to keep these safety efforts intact.

Government Aid

Thirty-nine percent of the companies received no aid, 1% received governmental aid in the form of engineering expertise, and 16% received emergency planning help. Local government was most likely to be the source of the aid.

Hazard Ranking

The four primary hazards in terms of concern and level of effort were, in descending order, fire, earthquakes, medical emergency, and hazardous materials. Considerably below these four hazards were bomb threats and terrorism, flooding, and utilities outage.

SCEPP SURVEY

A survey of individuals who attended SCEPP (Southern California Earthquake Preparedness Project) conferences or who had requested SCEPP booklets was made by James Goltz of the SCEPP staff (Goltz, 1985). Some of the conclusions of the portion of the evaluation study that dealt with the users of the corporate planning guidebook follow:

- Emergency response is a much higher priority than disaster recovery. (Only 4% indicated that recovery planning would be attempted.)

- Many reported they felt their organizations were totally unprepared for an earthquake (moreso than among the city and county samples).

- Lack of budget or lack of top management priority were the major barriers to more vigorous earthquake programs.

- The Red Cross and disaster planners in other companies were the most common sources of aid.

- Security was most often tasked with the central earthquake role (19%), followed by health and safety (15%), facilities (14%), personnel (12%), management (12%), planning (9%), and corporate services (8%).

- Thirty-eight percent of those who read the SCEPP guide obtained approval to set up a committee or have staff assignments made; of this 38%, committees or staff assignments were actually made in the case of 70% of them. In other words, in 26% of the cases staff assignments were actually made.

Section 4
PROFILES OF EARTHQUAKE PROGRAMS OF COMPANIES IN CALIFORNIA

This section presents, topic by topic, some instructive examples of earthquake programs of California companies. While only a few firms are singled out here by name, many others could also be cited for their innovations in this field. The examples have been selected for the suggestions or lessons they may provide to other companies in California or Japan.

SAFETY AUDITS

A frequent organizational problem faced by larger companies is their decentralized or divisional operating framework. Even at a single site or in a single building, different divisions of a corporation may be found, and implementing corporate-wide safety policies can be a major task. The problem becomes more difficult when facilities are located at multiple sites.

An example of a successful approach toward reducing the problems associated with decentralization is provided by Hewlett-Packard, headquartered in Palo Alto, California, and with facilities located in other states as well as in other countries. An annual safety audit is performed at each facility by corporate health and safety supervisors. The results of the audit are processed centrally, and the implementation also carries the weight of the corporate management behind it. Good safety audits are acknowledged by letters from senior management, and, contrariwise, deficiencies are also acknowledged by this avenue, and a followup inspection is scheduled.

Recently, efforts have been made to devise nationwide criteria that would clearly indicate which facilities should have emergency plans and other precautions for which specific types of natural hazards. While fire, hazardous materials spills, and workplace accidents are universal hazards to be included within a facility's safety plan, earthquakes, hurricanes, and some other natural hazards have a relatively clearly defined geographic distribution. As one basis for devising the threshold criteria that indicate where a particular hazard is applicable, the Federal Emergency Management Agency **National Survey Instructions** (FEMA TR-84), an annually-updated training manual, is available. Maps indicate the areas where the FEMA natural hazards vulnerability survey of essential facilities (such as fire stations) is indicated, and these same areas can be taken as one definition of the

areas where a company should consider a hazard. For earthquakes, the Uniform Building Code seismic zones 3 and 4 (the two highest zones on a five-level scale) are the underlying basis for the FEMA map. Other standards were used to devise the FEMA higher risk zones for hurricanes, non-hurricane wind storms, tornadoes, and floods.

NONSTRUCTURAL PROTECTION

Chevron Oil Field Development Company in La Habra, California, is composed of a campus of office, lab, shop, and support buildings, including 85 individual laboratory rooms. Because of the extensive amount of chemical lab facilities, the threat of earthquake-caused hazardous materials spills was given special attention in the nonstructural protection program. Many interesting details of an engineering nature could be discussed in connection with this example, but the points of more relevance here concern the successful way in which the technical solutions have been implemented in the organization.

While each laboratory room contains some unique equipment, many repetitive items are handled with standard details. Such repetive items include gas cylinders, bottles of chemicals on shelves, overhead lights, and storage lockers or cabinets. These routine solutions have been integrated into the ongoing facility engineering and maintenance operations to the extent that quantities of the necessary nonstructural protection hardware are always on hand and are ordered in bulk. Reducing the bulk of the nonstructural restraints required to repetitive solutions is essential if the program is to be simple enough to maintain quality control in the design, installation, and subsequent maintenance or inspection of the protective measures.

Safety inspections routinely include a checklist of nonstructural earthquake safety items, along with the other workplace safety items previously included within the safety program. This also seems to be a valuable lesson applicable to other types of facilities as well. While special surveys devoted solely to earthquake hazards may be appropriate when a program is first established, subsequent re-inspections should be combined with an ongoing schedule of multi-purpose safety surveys.

Safety inspections by the facility engineer or safety engineer of the facility are conducted with a "we're here to help make your workplace safer" attitude, rather than a bureaucratic regulation-enforcement attitude, which could cause a defensive attitude on the part of the occupants of labs. The extent to which scientists in

some of the labs have devised and implemented their own innovative nonstructural protection measures is quite impressive. In some cases, ordinary lab hardware, such as tubes that drip fluids into flasks during experiments, are modified slightly to perform the additional role of earthquake restraint. The attitude of the occupant of the space that is to receive nonstructural earthquake protection is an important matter to consider. If there is a resentment against the slight inconveniences involved in lifting bottles over shelf restraints, or re-latching restraint chains, it is difficult to supervise the employees often enough to ensure unwilling compliance. If the employees have not been educated as to the likelihood of hazardous nonstructural damage in earthquakes, they may have misconceptions about the need for the measures. For example, one of the most common misconceptions is that heavy equipment cannot be moved by an earthquake, whereas inertial earthquake forces are greater when items of greater mass are involved.

While many modern buildings with suspended ceilings have lay-in fluorescent light fixtures without any positive connections these possible sources of overhead danger have been thoroughly dealt with at this Chevron facility. Two hanger wires, connected to diagonally opposite corners of each fluorescent fixture are the typical solution. In cases where a duct or other above-ceiling element interferes with the placement of these wires, the fixture is positively connected to the main T-bar hung ceiling framework members. The implementation of this above-average degree of nonstructural protection, rather than the technical aspects, is the aspect of most interest. The company's electricians are the ones who routinely install or perform maintenance on these items, and so it is these individuals who are trained to routinely incorporate earthquake protection into their work. This is a successful example of devising a reliable delivery system for what otherwise might be merely a good idea that only exists on paper in a report or manual.

The Chevron example has been cited to point out some of the ways in which the technical aspects of nonstructural protection can be carried out more reliably if the human relations and quality control aspects of the task are emphasized. Another of the many firms with extensive nonstructural earthquake protection programs, IBM, provides some other lessons.

At its San Jose, California research facility, about 10,000 employees work at the 500-acre site, and a variety of hazardous materials is present. Some of the nonstructural retrofits have been of a large scale nature, relating to large tanks and piping systems, for example. Where possible, standard details are devised for repetitive items, and the contractors who perform the work can be field-directed to make adaptations to fit particular conditions. (A common situation is the piece of equipment that cannot be moved to allow for the installation of hold-down bolts or

bracing struts, and there may be insufficient clearance between the equipment and a wall or other obstruction to install the bracing scheme without some customizing to fit the particular geometry involved.) An idea whose merit will be apparent to anyone who has had a few years' experience with a nonstructural earthquake protection program is the use of labels stating "Earthquake Bracing - Do Not Remove." Maintenance and relocation can result in the removal of the bracing hardware for more than half the equipment and furnishings in a facility in a ten-year period, and unless the hardware is properly re-installed, the level of protection would greatly decline. It is obvious that steel must be kept painted to avoid weakening by rust, but it may be less obvious that hardware must be protected from the even more rapid deterioration that may be caused by the occupants of the building.

Automatic natural gas and chemical process shutoff valves are a common nonstructural retrofit feature at IBM. This, again, is a solution that has a human dimension as well as a straightforward nuts and bolts aspect. Bumping against a seismic shutoff valve may activate it, causing unwanted gas shutoffs, and signs and training may be required to ensure that this does not become a problem.

STRUCTURAL PROTECTION

Although no precise data are available to document the point, the company that has done the most to structurally evaluate and strengthen its buildings is probably IBM. Approximately half of the more than 40 buildings at the San Jose site have been structurally strengthened to some degree for earthquake purposes, and some of these projects are major multi-million dollar reconstructions. The sophistication of the engineering analysis employed to determine the need for seismic strengthening is as high as is typically found in any project other than large power plants. In some cases, the additional bracing required has been combined with adding to the building around its perimeter, thus accomplishing an increase in needed building space along with the increase in seismic safety.

The vulnerabilities of existing buildings stem from either older buildings, built prior to more recent codes, or designs that might meet the minimum of modern codes but that are deficient in some respect in meeting the general intent of the code to resist the largest of California earthquakes without collapse. In addition, when non-redundant facilities are involved and the industry is one in which there is great competition and tight production schedules, avoiding major disruption after an earthquake is a concern, and this is not directly dealt with by the code, whose criteria only extend to life safety. For these reasons, IBM found it necessary to have consultants develop in effect an internal seismic building code that can be used

as a companion to local building codes to ensure that IBM's goals as well as the minimum code requirements are met. Guidance is provided on a global scale, so that overseas construction projects are subject to the same central policy, adjusted to account for the variation in seismicity around the world. At present, this is an exceptional example, though in future years it may become more common for companies to realize that facilities they build or lease that have been designed only to meet the minimum requirements of the building code may not meet the criteria or expectations of the company.

TRAINING

There are many examples of earthquake training among companies, but one which is above average and provides several lessons is GTE (General Telephone). The tools used to train employees include two professional quality video tapes. One deals with earthquakes at the workplace, and the other with earthquake preparedness at home. A brochure on each topic is also distributed. This dual strategy of trying to protect employees and their families whether the earthquake occurs during an employee's on-shift time or during the other three-fourths of the time is extended to the topic of emergency supplies, which is covered in a separate section.

Emergency preparedness coordinators conduct training sessions with employees, and discussion and questions are specifically encouraged. There is a great difference between the relatively passive approach of distributing written materials to employees and expecting them to read and absorb the information, as compared to bringing them together in small groups to watch video tapes with a trained instructor who encourages discussion. The employees are considered the corporation's most essential asset, and without protection of employees, there would thus be no real corporate earthquake protection program.

GTE's earthquake program, including its training materials and approach, have had a great influence on other companies' efforts. Other companies could also be singled out in this regard to make the point that most of the learning that goes on in this field is companies learning from other companies who have a headstart and greater experience. Through informal contacts or through the auspices of trade groups or disaster organizations such as the Red Cross, the Business and Industry Council on Emergency Preparedness Planning (BICEPP), the Southern California and Bay Area Regional Earthquake Preparedness Projects (SCEPP and BAREPP), there has been a great deal of openness in sharing the lessons and "tricks of the trade" that the firms with the stronger earthquake programs have accumulated.

ALTERNATIVE HEADQUARTERS

Companies of national or international scale could be severely affected on a corporate level even if only one facility--the headquarters--is affected by an earthquake. The earthquake need not cause major damage to the headquarters itself, if, as is commonly the case, this building or group of buildings is in the midst of a densely built-up urban area. Utility outages, street closures caused by damage to other buidings, and possible fires or hazardous materials spills in the vicinity could affect the operability of the headquarters.

Levi Strauss, headquartered in San Francisco, is one of the firms that has devised an alternative headquarters plan. If for any reason the headquarters complex on the northeastern waterfront of San Francisco cannot be used, another large Levi Strauss facility in another district of San Francisco would be temporarily used for this purpose.

To help solve the problem of letting employees know about the alternative headquarters activation procedures, Levi Strauss distributes wallet-sized cards to employees with the alternative headquarters plan summarized thereon, along with other information to be used after an earthquake disaster.

The seven largest banks in California operate two clearinghouses to facilitate the exchange of thousands of checks every work day. One is in the San Francisco area, the other is in the Los Angeles area. Checks drawn on an account at one bank and deposited to an account at another are physically exchanged, while all the bookkeeping is handled at large computer centers. Because reverting to the former method of manual processing of checks is no longer feasible, and because an earthquake could cause damage or functional loss at one or more of the banks' computer centers in either San Francisco or Los Angeles, the clearinghouse plan is as follows. If two or more of the banks cannot operate their computer centers, then that city's clearinghouse will be temporarily closed, and approximately 500-600 of the more essential workers will be flown to the other city's data processing facilities. Because about 400 miles separate the two urban regions, the same earthquake cannot cause disruption in both areas.

EMPLOYEE ID CARDS

While many companies issue identification cards to employees, these are for internal use only. If the need arose to show identification to law enforcement officers to try to cross police lines, the usual ID card might not work. With this

potential problem in mind, special law enforcement-approved essential employee disaster ID cards have been developed, especially for the large banks with downtown headquarters. The system was originated in Los Angeles and has been further developed through the efforts of the California Earthquake Task Force.

Because the seven largest California banks have a backup plan to relocate key data processing employees from the Los Angeles Area to the Bay Area, or vice versa if the disastrous earthquake stikes the Bay Area, ID cards might be needed to allow these key employees to get to airports, and this is another stimulus for the law enforcement-approved disaster ID card idea.

COMMUNICATIONS

Because widespread telephone outages are likely to persist for more than a day following a large earthquake, non-telephone communications links have been established by some companies for this specific purpose. Other firms have found that their existing radio capability, which might include walkie-talkie units and auto units linked through one or more repeaters, are adequate for their needs.

One of the more innovative earthquake emergency systems was devised by Woodward-Clyde, a firm with geotechnical involvement in the earthquake field. (The following description pertains to the plan in effect when the firm was headquartered in downtown San Francisco; it has since relocated.) Although the firm did not have a pressing post-earthquake need to communicate with other branches around the state or country as might a corporation in the financial services sector, the possible isolation of employees from their families for a day or more was considered a major issue. The large bridges that cross San Francisco Bay are generally considered adequately earthquake-resistant, but these bridges connect with approach spans and surface highways sited on poor, Bay-margin soils, and so there is a strong chance that San Francisco employees would be unable to drive their cars or take public transportation to their homes across the Bay. In the absence of telephone communications, this isolation would probably cause considerable household anxiety.

Woodward-Clyde purchased a radio system that consisted of a station on one of the floors it leased in a high-rise building in San Francisco's Embarcadero Center, and a half dozen radios in employees' homes distributed around the Bay Area. With each radio provided with a generator (the electricity would probably go out in an earthquake), this created a region-wide earthquake-resistant communications system. Employees were provided with copies of the earthquake plan to keep at home. This

plan details the location of the employees who maintain the radios at their residences. By traveling only a short distance, one could reach the nearest house equipped with a radio and communicate with the headquarters in San Francisco.

A more common countermeasure used by companies is to identify the employees who are amateur radio operators and to integrate them into a company plan. Generators are sometimes purchased to enable the employees' radio equipment at home to operate after an earthquake.

Fireman's Fund purchased a radio that, with repeaters, could communicate from the corporate headquarters (formerly San Francisco) to Sacramento. From Sacramento, ordinary communications would probably be intact.

EMERGENCY SUPPLIES

Personal emergency supplies (food, water, blankets, etc.) and rescue or other special equipment have been stockpiled by many firms. The quantities are usually quite manageable. For example, in a typical high-rise building whose company has implemented this countermeasure, one metal locker would contain the supplies for one floor.

Pacific Gas and Electric Company stores some hand-operated cutting and lifting tools in its headquarters building, while most lockers with emergency supplies are limited to food, water, first aid, personal hygiene, battery-powered lighting, and other supplies that resemble camping equipment.

GTE's innovative program provides to employees through payroll deductions the same packaged kit of emergency supplies that are purchased by the company for the use of employees at work. Employees are encouraged to purchase these kits at wholesale rates to keep in their cars or at home.

In the case of a hospital, emergency supplies may be required on a much larger scale. The chain of privately owned Kaiser hospitals in northern California has been especially concerned with backup water supplies. Emergency water conservation procedures that have been developed include economization of X-ray film developing techniques and even surgery scrub procedures by doctors and nurses. Plans have been devised to deploy a portable plastic-lined swimming pool in the parking lot to provide a rapid way for tanker trucks to deliver water.

Extra litters have been purchased and stored in stairwells. It was found that a durable but inexpensive cardboard variety of stretcher had an unexpected virtue: because they were of little value, they were never stolen, whereas other emergency supplies such as flashlights often disappear.

Various techniques are used by companies to try to control vandalism and pilferage. One basic technique is to seal lockers or boxes with easily removable but visible straps, so that if the supplies are tampered with, at least it will be quickly discovered. Another method is to lock the storage container and give keys to designated employees. (If this plan is used, it is necessary to plan for the possibility that the earthquake could occur at any time of day, and that some employees during a given shift may be on vacation or otherwise absent. One San Francisco Bay Area school hides a key on each emergency supply locker to deal with this problem.)

EVACUATION

Evacuation in the event of an earthquake is similar to evacuation for fire, bomb threat, or hazardous materials emergencies, but there are some considerations unique to earthquakes.

If a building is evacuated after an earthquake out of concern that it may be hazardous to the occupants, at what point should it be re-occupied? Aftershocks are the rule, not the exception, with earthquakes (except perhaps for some deep focus earthquakes, and these are not pertinent to California). It may seem to be an easy decision to call an evacuation, but this decision sets the stage for the decision concerning re-entry. In some facilities, evacuation in itself creates an emergency situation, such as in the case of a facility whose function is essential or whose occupants are difficult to evacuate. A hospital presents both difficulties.

The Kaiser Permanente's northern California regional group of hospitals has developed a plan to quickly bring consulting structural engineers to its facilities after major earthquakes to perform rapid safety evaluations. This system would probably be much quicker than the public system of post-earthquake safety inspections, which utilizes building inspectors aided by volunteer members of the Structural Engineers Association of California (SEAOC) from other areas of the state unaffected by the earthquake.

Another seismic consideration is the safety of the exterior areas to which building occupants would be directed. One large research and development establishment, which employed an earthquake consultant to review its emergency

plans, found that some of the half-dozen exterior areas designated as regrouping sites in the event of an evacuation were under overhead electrical lines or over high pressure gas lines. A slight adjustment of the location of these areas was possible to avoid those potential hazards. Unless it is absolutely necessary, it is generally wise to use the same evacuation routes and evacuation destination for all emergencies, because this simplifies the training of employees and accommodates the emergency response countermeasure to the likely behavior of the occupants.

When occupants are directed to leave the building, there are some further issues concerning the mechanics of this process. Wheelchair-confined individuals pose a special problem, because the elevators should not be used after a major earthquake until they are checked. (In California, seismic shutdown requirements are incorporated into state law, and the most likely eventuality is that the elevators would all open their doors at the nearest floor and stay locked in that position until a qualified person inspects them and uses a key to re-activate them.) In the event of a fire, elevators should also be avoided, so for either emergency there would be the need to transport the wheelchair-confined down stairs. Products are commercially available that resemble seats with handles, allowing a person to be carried down stairs much more conveniently and safely than in a wheelchair. Some companies keep one such evacuation device at each wheelchair-confined employee's workspace.

Another important element in this system is the identification of individuals with various disabilities. Chevron, for example, has each employee fill out a short form concerning the emergency plan at the headquarters buildings in San Francisco, to ensure that disabilities are recorded and that the employee has been adequately briefed on the disaster plan. This form also provides documentation of compliance with the State's General Industrial Safety Orders, which require the employer to inform all employees of emergency procedures, especially concerning evacuation.

Either because of sight or hearing disabilities, or simply because individuals may be in remote areas such as storage areas or restrooms when an earthquake occurs, there must be a way to ensure that building occupants realize they are supposed to evacuate. Occupants may also be trapped or injured. An occupant could be trapped simply by a jammed door, for example.

One means of ensuring that all occupants have left the building is the sweep technique, where a warden or supervisor for each floor or other identifiable space quickly goes through each room to visually check. Since the power would probably go out in a major earthquake, and since the backup power generator or battery-lights probably can only dimly illuminate hallways and large open areas but not each individual workspace or room, the people doing the sweep would need flashlights.

Two methods of accounting for individuals who have evacuated a building are often used. At some of the buildings at one heavy industrial plant, employees must sign in and out when entering or leaving the building, and so this provides an accurate roll sheet. At one large research and development facility where the employees often go from their own building to another during the day without a clock-in or sign-in system, the plan calls for the individuals who group at each evacuation area to write their names on cards and hand them to the manager of that area, thus providing a roll sheet. This procedure, if done immediately, avoids the problem of uncertainty over whether missing employees are truly missing or have just gone home to check on their households. At California public schools, the teacher is the last one to leave a classroom as it is evacuated, and he or she takes the roll book along before leaving.

MUTUAL AID

In the City of Santa Clara, about two dozen of the largest companies have joined with the city to establish an emergency radio system. The emergency services office provides, in effect, the central exchange, while each firm purchases its own radio and keeps it where it is monitored 24 hours a day. Through this network, one firm could quickly communicate its need for an emergency resource, such as a generator or hazardous materials spill absorbent material, to the other companies. Even in an earthquake, it is unlikely that all the companies would experience serious problems of the same type.

INSURANCE

Earthquake insurance is required if earthquake losses are to be covered, because standard residential, commercial, and industrial policies exclude coverage for this peril. While companies may set their own premium rates, the Insurance Services Office (ISO) earthquake risk rating and premium guidelines indicate an annual premium of about ½% of the value for a typical commercial or light industrial building. The guideline rates vary greatly for various classes of construction (combinations of types of walls floors, roofs, design basis or earthquake code requirements in effect when the building was constructed, etc.). Major buildings are individually rated by engineers employed or retained by the insurer.

The earthquake insurance countermeasure is relatively insignificant, and this pattern has become more pronounced in recent years. A California state law effective 1 January 1985 required all property insurers in the state to offer

earthquake insurance to their residential customers. This increased the percentage of homeowners with earthquake insurance from about 5% to slightly over 10% and occurred at the same time that interest rates were dropping; thus, there were lower earnings on invested premiums, and exposure to liability and law suit settlement or judgment costs were increasing. While the property insurers assumed greater risk--about double--in the residential field, they have reduced their risk exposure in the commercial field. The California Insurance Department's estimate of probable maximum commercial loss for a great Los Angeles earthquake, for example, declined by a billion dollars from 1983 to 1984 because less coverage was in effect.

REFERENCES

McClure, Frank E., 1984, "Development and Implementation of the University of California Seismic Safety Policy," **Eighth World Conference on Earthquake Engineering**, Earthquake Engineering Research Institute, 1984.

Committee on Earthquake Engineering Research, **Earthquake Engineering-1982,** National Research Council, 1982.

Federal Emergency Management Agency, **National Earthquake Hazards Reduction Program Five-Year Plan, Fiscal Years 1985-1989**, 1985.

Goltz, James, **The Transferability of SCEPP's Products: A Report of Evaluation Findings**, SCEPP, 1985.